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Power to the CEO? Sources of CEO Power and Its Influences on Strategic Choices and Firm Performance

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Abstract

Power relations in the upper echelon have been a focal point in strategic management literature. However, the dynamic environment requires rapid decision making, raising the question of whether to centralize power in the CEO. In that respect, this thesis aims to identify the sources of CEO power and its impact on strategic choices and firm performance. A total of 22 empirical and conceptual papers are categorized into a review framework based on Finkelstein's (1992: 507-510) power dimensions to compare earlier studies and disclose differences in operationalization and research approaches. Additionally, this paper introduces a new dimension of CEO power by incorporating principles of leadership psychology into the corporate-governance-power literature. Considering the power composition, this thesis analyzes three strategic decisions and the resulting firm performance by explaining findings from an agency- and stewardship perspective. The results demonstrate that CEO power is multifaceted, and variations in operationalization impair comparability of literature. Furthermore, powerful CEOs exhibiting stewardship behavior should be granted autonomy to drive firm performance while those acting as agents require close monitoring and balance from an equally influential board.

Keywords: CEO power; Power dimensions; Review framework; Corporate governance; Strategic choice.

1. Introduction

Jeff Bezos, Jamie Dimon, and Elon Musk. Known for their unconventional strategic decisions, these chief executive officers (CEO) are listed among the most powerful ones, driving their companies' performance incomparably high (Bosilkovski, 2018). Their success stories raise the question of whether power centrality enhances firm outcome or remains the exception. Literature often has a pessimistic view and argues that powerful CEOs have a detrimental effect on firm performance (Haleblian & Finkelstein, 1993: 859; Jiraporn, Chintrakarn, & Liu, 2012: 141). However, today's agile environments, especially in times of crisis, require rapid decision making and determined actions (Han, Nanda, & Silveri, 2016, 400). To stay competitive, firms deploy different corporate governance systems, thereby the role of the CEO relative to other executives and the distribution of power is an essential aspect that has been a focus of strategic management literature (Adams, Almeida, & Ferreira, 2005, 1403). This thesis contributes to research in that field, by scrutinizing whether to leave all *power to the CEO*.

Consistent with the literature on this topic (Haleblian & Finkelstein, 1993: 848; Haynes & Hillman, 2010: 1151; Tang, Crossan, & Rowe, 2011: 1480), the thesis follows Finkelstein's (1992: 506) understanding of power "as the capacity of individual actors to exert their will". The individual actor is the CEO, who usually holds the most powerful position in a company (Daily & Johnson, 1997, 98). CEO power is also referred to as CEO dominance (Brown & Sarma, 2007: 363; Tang et al., 2011: 1480) or CEO centrality (Jiraporn et al., 2012, 140).

This thesis aims to disclose the sources of CEO power and investigates the influences of CEO power on a company's strategic choices and firm performance under consideration of extant literature and empirical study findings.

To begin with, Section 2 provides a theoretical and conceptual background to guide through and support the findings of this thesis. More precisely, Section 2.1 contrasts the agency theory (Jensen & Meckling, 1976) with the stewardship theory (Davis, Schoorman, & Donaldson, 1997) to offer a broader view on the utilization of power in the context of strategic choices. Section 2.2 introduces Finkelstein's (1992:

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508) power dimensions as a review framework. In particular, this section should explain the methodology and adapt the more general framework to the context of CEO power.

The research question of this paper is addressed in Section 3 while applying the concepts introduced in the previous sections. Thereby, Section 3.1 presents sources of CEO power and organizes them into the four power dimensions introduced by Finkelstein (1992, 508), namely structural power, ownership power, expert power, and prestige power. The categorization of power into these four dimensions is preferable due to the broad implementation of Finkelstein's approach in former literature (Chikh & Filbien, 2011: 1223; Haynes & Hillman, 2010: 1155; Tang et al., 2011: 1487) and the confirmation that this classification is empirically valid (Daily & Johnson, 1997, 98). Under the mentioned review framework, this section studies papers that are structured according to all power dimensions or focus only on a limited number of dimensions and discusses the use of different measures. Moreover, the framework also tries to allocate research papers that do not follow this classification. Furthermore, a new additional dimension - internal power - is suggested to expand the existing framework by Finkelstein (1992, 530). After analyzing a CEO's power composition, Section 3.2 focuses on three strategic choices a company's CEO can take and examines the role of power in these choices and its influences on firm performance. Various findings should be explained with the help of either the agency theory or the stewardship theory, depending on the context. The highlighted choices include strategic change, capital structure decisions, and acquisition decisions. The reason why these three strategic decisions are analyzed, lies on the fact that these choices are focal points in most conceptual or empirical papers that are frequently cited or published in top journals. This section only includes papers that either examine the influence of CEO power on one of the strategic choices, or papers which add the resulting impact on firm performance to their study. Papers that investigate the direct influence of CEO power on firm performance do not contribute to answering the research question and can, therefore, not be considered within the scope of this thesis.

While the previous chapters aim to collate the principal literature findings, Section 4 offers a more practical insight. A case study of the CEO of Tesla, Elon Musk, should exemplify the sources of power of a current CEO and put the previously analyzed strategic choices into a practical context. Section 5 discusses the main findings of the thesis and mentions some limitations. Consequential further research opportunities are derived in that regard. Finally, Section 6 concludes this thesis and attempts to answer the posed research question.

2. Theoretical Background and Review Framework

2.1. Agency Theory vs. Stewardship Theory

2.1.1. Agency Theory

The agency theory is often cited whenever managerial behavior is of greater significance. Originated from organizational economics, the agency theory contributes to strategic management research by explaining managers' decisions (Donaldson, 1990, 377). Jensen and Meckling (1976, 308-309) define the agency relationship as a contractual agreement between two parties. The principal - the owner or stockholder in most cases - delegates some decision-making authority to the agent, who is the CEO in the context of this thesis. The agent is morally responsible to act on the shareholders' behalf. As both parties are presumably utility maximizers, the theory suggests that the agent will deviate from the principal's best interest when the opportunity arises (Davis et al., 1997, 22). This attributes to the assumption that agents are rational, opportunistic, and self-interested actors (Donaldson, 1990, 371-372). Agents' decisions that reduce the welfare of the principal are referred to as agency costs. They can be minimized by board independence and monitoring of agents, a market for corporate control, and agent equity ownership (Dalton, Hitt, Certo, & Dalton, 2007, 40). Thereby, agents should be incentivized to align their interests with the principals.

In accordance with agency theory, powerful CEOs whose interests diverge from the shareholders' welfare have the means to assert their decisions and are likely not acting upon the principal's benefit (Combs, Ketchen Jr, Perryman, & Donahue, 2007, 1301-1302). On these grounds, agency theory offers an interesting foundation for research on CEO power, especially on the influences of power on CEOs' strategic choices and firm performance.

Although agency theory provides an insight into the agent-principal relationship, some authors argue that the assumption of self-interested agents is not always accurate and does not fully capture the complexity of organizations (Eisenhardt, 1989, 71). Hence, this thesis presents another contradicting view to broaden the theoretical foundation for the research question: the stewardship theory.

2.1.2. Stewardship Theory

Stewardship theory is derived from organizational behavior research (Donaldson, 1990, 377). Contrasting to agency theory, the interests of the actors are not divergent but convergent. In stewardship theory, the stewards are depicted as collectivistic, pro-organizational, and trustworthy (Davis et al., 1997, 20). Their utility is maximized when they protect and maximize the principal's wealth. Thus, even when personal interests deviate from the organizational needs, stewards would align their decisions to shareholders' benefits (Davis et al., 1997: 24-26; Donaldson, 1990: 377). With an intrinsically motivated manager that realizes personal gains through putting organizational needs first, control and monitoring could destruct performance and lower the stewards' motivation. Unlike suggested by agency theory, stewards perform best when granted autonomy and trust (Davis et al., 1997, 25).

Juxtaposing the stewardship theory and the agency theory, Davis et al. (1997, 27-31) characterize three contrasting psychological factors, namely motivation, identification, and the use of power. As research on this thesis revolves around

Table 1: Comparison of Agency Theory and Stewardship Theory. Based on Davis et al. (1997, p.37).

	Agency Theory	**Stewardship Theory**
Origin	Organizational economics	Organizational behavior research
Actors	Rational, self-interested, risk averse	Rational, collectivistic, pro-organizational, tustworthy
Relationship	Principal-agent Interest divergence	Principal-steward Interest convergence
Motivation	Extrinsic	Intrinsic
Identification	Disassociation from organization	Identification with organization
Power	Institutional	Personal

CEO power, these three factors are shortly highlighted to further the understanding thereof.

Firstly, agents are extrinsically motivated by quantifiable rewards, whereas stewards seek personal growth and self-actualization.[1] Secondly, agents avoid taking responsibility for organizational problems and do not identify with the company. Stewards, by contrast, attribute overall success or failure to themselves and thus work toward organizational goals. Lastly, power poses a critical aspect in the principal-manager relationship (Davis et al., 1997, 31). In a principal-agent relationship, power motives stem from the legitimate position in the firm. Power in principal-steward relationships is based on personal characteristics and firm culture.

This comparison between both theories already shows the importance of considering multiple theories in strategic management research. Otherwise, generalizability is not feasible (Eisenhardt, 1989, 71). Table 1 summarizes the mentioned main differences between the introduced theories.

2.2. Review Framework: Finkelstein's Power Dimensions

Power is a phenomenon that is difficult to measure (Finkelstein, 1992, 511). Early literature relied on perceptual measures of power that comprise prevailing views of actors in an organization but alleviate objective results and validity. Hence, more objective measures were developed that consider the managers' formal positions and informal relationships within and across firm. These indicators, however, can only provide indirect information as they are detached from the actual sources of power (Finkelstein, 1992, 511). To harness the benefits and limit the adverse effects of both types of indicators, it is expedient to consider perceptual as well as objective measures. This approach was followed by Finkelstein (1992, 511). Therefore, this thesis uses Finkelstein's (1992: 507-510) dimensions of top managers' power as a framework to present different sources of power and empirically valid measures thereof. The four defined dimensions are structural power, ownership power, expert power, and prestige power. Figure 1 provides an overview of the dimensions and breaks them down into the individual measures used by Finkelstein (1992, 512-516). A closer examination of the individual aspects follows in the subsequent sections. Many researchers rely on these measures and engage in research on all four introduced power dimensions (Chikh & Filbien, 2011: 1223; Daily & Johnson, 1997: 98; Oler, Olson, & Skousen, 2009: 431), whereas others purposely exclude some dimensions (Adams et al., 2005: 1408; Haleblian & Finkelstein, 1993: 851; Sheikh, 2019: 362; Tang et al., 2011: 1487).[2] While this framework initially examines top managerial power, this thesis narrows it down to only CEO power. It reviews the literature on sources of CEO dominance as the CEO is believed to hold the most powerful position in an organization (Daily & Johnson, 1997, 98). This should contribute to a further cohesive analysis of CEO strategic choices and firm performance in the subsections of Section 3.2.

The review framework aims to disclose literature about CEO power transparently. It integrates 22 research papers that contain the keywords *CEO power, dominance,* and *centrality*. Through the detailed breakdown of each dimension, differences between the research approaches become apparent. The varying measures capture different aspects of power, which impede comparability and could affect the results. This literature review might help to recognize correlations between the papers and gives an overview of different measures used by the literature. A summary of all analyzed papers, that attempt to measure CEO power, is presented in Appendix 1. It discloses which power dimensions each author uses and provides additional annotations.

According to Finkelstein (1992, 508-510), structural power is the most cited type and refers to hierarchical or formal power. It can directly be obtained from the formal position within an organization. Ownership power is determined by the ownership position in the firm and the relationship to the founders. Another power source is the ability to handle uncertainty of the company's external environment and the manager's expertise in firm-specific topics, also referred to as expert power. Finally, prestige power derives from personal reputation or status.

Together, these four dimensions form important organizational sources of management power (Finkelstein, 1992, 510). Often, the operationalized measures are combined to

[1] In the following, the term *agents* refers to agency theory, while the term *stewards* denotes stewardship theory.

[2] The reasons for an exclusion of one dimension from the research will be discussed in the respective subsection of Section 3.1.

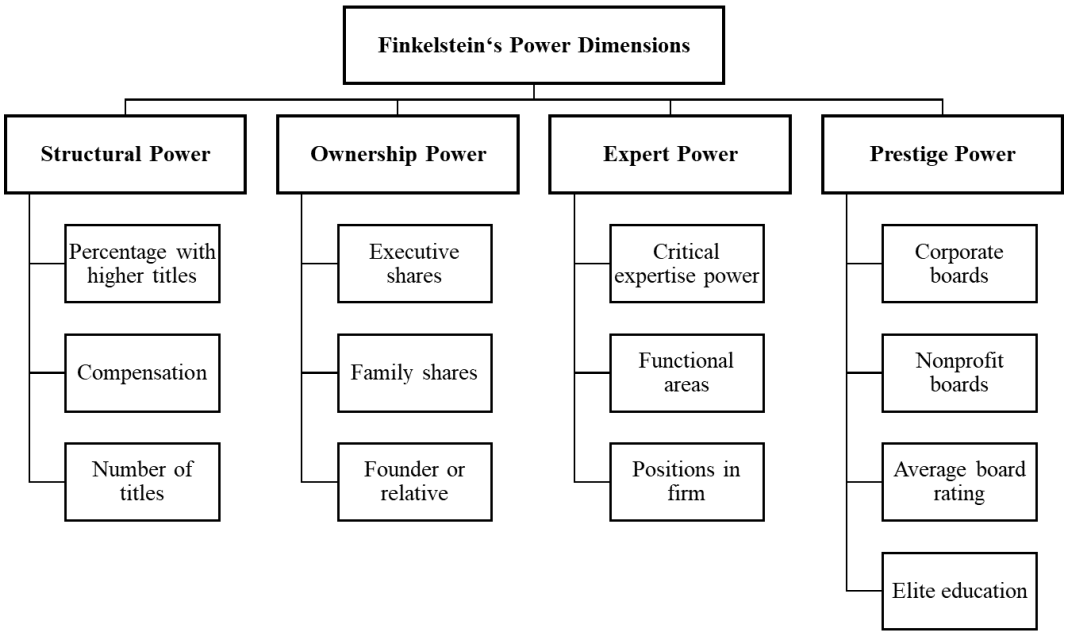

Figure 1: Finkelstein's Power Dimensions and Measures. Own Illustration.

one single power index by various researchers who examine the influences of CEO power on strategic choices and firm performance (Haleblian & Finkelstein, 1993: 851; Haynes & Hillman, 2010: 1155; Tang et al., 2011: 1488). Although some reviewed papers are not structured according to Finkelstein's power dimensions or use different measures for CEO power, this thesis tries to categorize them accordingly in this framework and provides a comprehensive literature review on the sources of CEO dominance. Each dimension will be first attuned to the context of CEO power and examine literature that uses the same or similar measures to Finkelstein's (1992: 510) to quantify it. Then, additional measures will be added, and varying viewpoints will be discussed.

3. Sources of CEO Power and Influences on Strategic Choices and Firm Performance

3.1. Sources of CEO Power

3.1.1. Structural Power

Structural Power relates to the formal position within a company and is also referred to as hierarchical or legitimate power (Daily & Johnson, 1997, 99-100). Due to their role, CEOs already have high structural power over other executives (Finkelstein, 1992, 509). Hence, independent of their behavior, subordinates attribute value and accuracy to CEOs' choices (Daily & Johnson, 1997, 100). In addition, structural power can also appear indirect, in the form of information advantages or resource control over other managers. Finkelstein (1992, 509, 512) argues that greater structural power correlates with greater control over co-workers' actions and less dependence on them. Table 2 summarizes all measures used by the analyzed literature. Finkelstein (1992, 512) suggests three variables to measure structural power as presented in Figure 1.

Percentage with higher titles

Percentage with higher titles captures the hierarchical authority of a manager in the top executive team. The CEO gets a rating of 0, and the rating increases with decreasing power of the manager (Finkelstein, 1992, 512). Two analyzed papers use this indicator (Haleblian & Finkelstein, 1993: 852; Tang et al., 2011: 1489). As this thesis concentrates on CEO power only, this measure is briefly addressed for the sake of completeness but will not be further investigated.

Compensation

The variable *compensation* measures the CEO's total cash compensation relative to the other top executives. It expresses the CEO's standing in the firm and captures the CEO's relative power (Finkelstein, 1992, 512). Some researchers directly refer to and adopt Finkelstein's compensation variable (Daily & Johnson, 1997: 99, 101; Haleblian & Finkelstein, 1993: 851-852; Tang et al., 2011: 1487-1489). Others use this measure without explicit reference (Brown & Sarma, 2007, 363). Primarily more recent authors, like Chintrakarn et al. (2015, 106) and Jaroenjitrkam et al. (2020, 730), alter this variable to measure CEO power related to compensation following Bebchuk et al. (2011, 202): *CEO pay slice (CPS)*. Bebchuk et al. (2011, 202) define CPS as the CEO's captured fraction of the top-five executives' total sum of compensa-

Table 2: Measures of Structural Power. Own Illustration.

Author	Measure/Variable
Finkelstein (1992)	Percentage with higher titles, compensation, number of titles
Haleblian and Finkelstein (1993)	Percentage with higher titles, compensation, number of titles
Daily and Johnson (1997)	CEO duality, interdependent directors, compensation ratio measure
Adams et al. (2005)	CEO concentration of titles
Brown and Sarma (2007)	CEO compensation
Oler et al. (2009)	Board chair
Haynes and Hillman (2010)	Duality, non-affiliated director, interdependen directors
Bebchuk, Cremers, and Peyer (2011)	CPS
Chikh and Filbien (2011)	CEO duality
Dutta, MacAulay, and Saadi (2011)	Excess pay
Tang et al. (2011)	Percentage with higher titles, compensation number of titles
Jiraporn et al. (2012)	CPS
Tien, Chen, and Chuang (2013)	CEO duality, directorship
Baldenius, Melumad, and Meng (2014)	Influence over board composition
Chintrakarn, Jiraporn, and Singh (2014)	CPS
Chintrakarn, Jiraporn, and Tong (2015)	CPS
Han et al. (2016)	CPS, CEO duality, triality, dependent directors
Li, Munir, and Abd Karim (2017)	Title, CPS
Sariol and Abebe (2017)	CEO duality
Sheikh (2019)	CPS, CEO duality, triality, board independence
Jaroenjitrkam, Yu, and Zurbruegg (2020)	CPS, CEO pay gap, CEO chair duality

tion. It is a proxy that measures the CEO's relative relevance regarding abilities, contribution, or power (Jiraporn et al., 2012, 146). Higher values of CPS signify greater power. Alternatively, Jaroenjitrkam et al. (2020, 730) complement CPS with *CEO pay gap*, the difference in compensation between the CEO and the median of the top five executives. Daily and Johnson (1997, 100) propose that highly compensated CEOs - relative to other managers – might have the means to influence the board of directors. Hence, this could increase their structural power.

Number of titles

Finkelstein's (1992: 512) last introduced variable is the *number of titles*. It states the number of titles the manager has, while more titles indicate higher power. Especially CEOs who also serve as board chairperson were found to be more powerful than those who do not (Harrison, Torres, & Kukalis, 1988, 223). Two analyzed papers directly use this variable (Haleblian & Finkelstein, 1993: 851-852; Tang et al., 2011: 1487, 1489). Most researchers specify the measure and use *CEO duality* instead. CEO duality is a binary variable that takes the value 1 if the CEO serves as board chairperson and 0 otherwise (Daily & Johnson, 1997, 106). It strengthens structural power and increases decision-making ability as board- and executive power is centralized in the CEO (Chikh & Filbien, 2011:1223; Tien et al., 2013: 428). Oler et al. (2009, 435) measure the same phenomenon under the proxy *board chair*. An extension of the CEO duality variable, which approximates Finkelstein's (1992: 512) measure, is introduced by Adams et al. (2005, 1409): *CEO concentration of titles*. The dummy variable indicates whether the CEO simultaneously also holds the title of board chairman and president with the value 1, and 0 otherwise. Han et al. (2016, 376) and Sheikh (2019, 363)employ both aforementioned variables under *CEO duality* and *CEO triality*.

Further insights into structural power

The board composition is an aspect that has to be considered when examining the CEO's structural power (Daily & Johnson, 1997, 100-101). The board has a monitoring and control function over the executives. Depending on the board composition, the CEO has varying influence. If the CEO appoints the directors – interdependent directors – they might show loyalty and thus, increase the CEO's structural power (Baldenius et al., 2014, 64). Contrarily, independent directors – not nominated by the CEO – can mitigate this power base (Sheikh, 2019, 363). Additionally, just as CEOs can act as board chairperson, Tien et al. (2013, 427-428) argue that they may serve as executive directors instead. Likewise, the board's control function is limited, and CEOs enjoy greater dominance.

3.1.2. Ownership Power

Ownership power emerges from the CEO's ability to act on behalf of the shareholders (Finkelstein, 1992, 509). Thereby, a pivotal factor is the manager's standing in the agent-principal relationship. CEOs with significant shareholdings are likely to be more powerful, as they can influence decisions, reduce uncertainty from the board, and gain

Table 3: Measures of Ownership Power. Own Illustration.

Author	Measure/Variable
Finkelstein (1992)	Executive shares, family shares, founder or relative
Daily and Johnson (1997)	CEO shareholdings, founder status
Adams et al. (2005)	CEO founder
Oler et al. (2009)	Shares owned, founder of the firm
Haynes and Hillman (2010)	CEO equity holdings
Chikh and Filbien (2011)	Family firm, CEO ownership
Tang et al. (2011)	Executive shares, founder or relative
Han et al. (2016)	Ownership, founding family
Li et al. (2017)	Founder, ownership
Sariol and Abebe (2017)	CEO founder status
Park, Kim, Chang, Lee, and Sung (2018)	Ownership
Sheikh (2019)	Founding family
Jaroenjitrkam et al. (2020)	Ownership

ownership control (Park et al., 2018, 923). Also, being the founder or the relative of a firm's founder might raise the CEO's ownership power. Through the strengthened interaction and long-term relationship with the board members, the CEO can exercise control. Finkelstein (1992, 513) introduces three indicators of ownership power that are delineated in Figure 1. Table 3 presents all reviewed literature that measures this dimension.

Executive shares

The variable *executive shares* is the most direct measure of ownership power and reveals the percentage of a company's shares owned by an executive and immediate family (Finkelstein, 1992, 513). Out of all analyzed papers, Tang et al. (2011, 1489) were the only researchers to use precisely this variable. Similarly, but adjusted to the context of CEO dominance, Daily and Johnson (1997, 106, 108) define their measure *CEO stock ownership* as the percentage of the company's outstanding shares held by the CEO. Oler et al. (2009, 435) and Chikh and Filbien (2011, 1228) also follow this approach. Some authors construct a dummy variable that takes the value 1 if the CEO's shareholdings are above a certain threshold, namely above 20% for Jaroenjitrkam et al. (2020, 731) and 5% according to (Park et al., 2018, 926), or if the CEO's stock ownership exceeds the industry median (Han et al., 2016, 376).

Family shares

The measure *family shares* captures the percentage of a firm's shares owned by the manager's extended family. The family functions as a foundation of the executive's support system, therefore this variable comprises an additional ownership power aspect (Finkelstein, 1992, 513). However, other authors did not adopt this indicator for their research. One reason could be the lack of disclosed data in the firms' proxy statements (Tang et al., 2011, 1488).

Founder or relative

Ownership power may also be enhanced by the CEO's relationship to other influential executives. Finkelstein (1992, 513) captures this phenomenon with the categorial measure *founder or relative*. There are two types of associations: a) the CEO is the firm's founder or related to the founder; b) the CEO shares the same last name as another executive, indicating a family relationship. Daily and Johnson (1997, 106) and Tang et al. (2011, 1489) apply this variable without modification, whereas several authors reduce it to record only the first association (Chikh & Filbien, 2011: 1228; Han et al., 2016: 376; Sheikh, 2019: 363). Association b) could bias the measure as some names are very common, thus sharing the same name does not necessarily confirm a family relation (Finkelstein, 1992, 513). Others find a binary variable that states the CEO's founder status (Adams et al., 2005; Oler et al., 2009: 435; Sariol & Abebe, 2017: 1408).

3.1.3. Expert Power

Unlike the two dimensions mentioned above, structural and ownership power, expert power emerges from informal factors. Thus, it does not depend on the CEO's hierarchical position in the organization (Oler et al., 2009, 433-434). Rather, it relates to the CEO's ability to deal with environmental uncertainty (Daily & Johnson, 1997, 102-103). Relationships within and across the firm borders may enable the CEO to address those uncertainties more efficiently. Moreover, extensive firm-specific knowledge and considerable functional experience could decrease dependence on others and allow for control over the task environment (Daily & Johnson, 1997, 102-103). Together, these sources might enhance expert power and expand the CEO's capacity to influence strategic choices (Finkelstein, 1992, 509-510). Finkelstein (1992, 513-515) determines expert power with

Table 4: Measures of Expert Power. Own Illustration.

Author	Measure/Variable
Finkelstein (1992)	Critical expertise power, functional areas, position in firm
Haleblian and Finkelstein (1993)	Critical expertise power, functional areas, position in firm
Daily and Johnson (1997)	Number of functional areas
Oler et al. (2009)	Tenure, prior functional experience (number of prior positions)
Chikh and Filbien (2011)	Tenure, acquisition experience
Tien et al. (2013)	Tenure
Han et al. (2016)	Tenure
Sariol and Abebe (2017)	Tenure
Park et al. (2018)	Tenure
Sheikh (2019)	Tenure
Jaroenjitrkam et al. (2020)	Tenure

three variables, which can be found in Figure 1. For a list of all variables used by the analyzed authors, see Table 4.

Critical expertise power

To create this variable, Finkelstein (1992, 514) first identifies the core environmental requirements of companies. Then, he assesses which functional areas the managers are conversant with. *Critical expertise power* is then derived by allocating the requirements with the executive's experience. For instance, in the context of acquisitions, the requirements for critical expertise could lie in the CEO's prior acquisition experience, as measured by Chikh and Filbien (2011, 1224). Haleblian and Finkelstein (1993, 852-853) also use this variable to indicate expert power.

Functional areas

Managers with experience in a range of functional areas might be better at handling different stakeholders (Finkelstein, 1992, 515). Hence, the variable *functional areas* counts the different fields an executive gained experience in. It is applied by Haleblian and Finkelstein (1993, 853) and Daily and Johnson (1997, 107), too.

Positions in firm

The breadth of interactions with stakeholders increases with the number of positions a manager has had within the firm (Finkelstein, 1992, 515). Contacts established in earlier years (Haleblian & Finkelstein, 1993, 853) and knowledge gained in prior positions (Oler et al., 2009, 434) may help the CEO manage environmental uncertainty and enhance expert power.

Further insights into expert power

More recent literature covers another aspect of expert power that has not been captured by Finkelstein (1992, 513-515). While he considers the manager's prior positions in a company to measure expert power, he does not take into account the years that an executive has already served as the CEO. The manager's tenure as a CEO seems to be related to the degree of obtained power (Park et al., 2018: 923; Tien et al., 2013: 427). Thereby, several factors act simultaneously. Longer tenure provides more opportunities to establish valuable relationships with important decision-makers (Oler et al., 2009, 434). It may also increase the CEO's competence and expertise (Park et al., 2018, 923). Due to accumulated firm-specific knowledge, the CEO might exert influence on the board (Tien et al., 2013, 427) and weaken its monitoring ability (Sheikh, 2019, 363). These factors lead to the assumption that longer CEO tenure correlates with higher CEO power (Han et al., 2016, 376). To measure this indicator, several authors use the variable *tenure* that counts the number of years the CEO has held the position (Chikh & Filbien, 2011: 1228; Jaroenjitrkam et al., 2020: 731; Park et al., 2018: 926; Sariol & Abebe, 2017: 41; Tien et al., 2013: 432). Others construct a dummy variable equal to 1 if the CEO tenure is above the industry median and 0 otherwise (Han et al., 2016: 376; Sheikh, 2019: 363).

As mentioned in Section 2.2, some authors do not measure all four power dimensions. Adams et al. (2005, 1408) only focus on structural power and include aspects of ownership power. Tang et al. (2011, 1487-1488) argue that the aforementioned dimensions are more proximal measures of CEO power than expert power or prestige power. Further, expert power measures are often associated with ambiguity and lack of data which puts validity into question and are therefore excluded from their research.

Table 5: Measures of Prestige Power. Own Illustration.

Author	Measure/Variable
Finkelstein (1992)	Corporate boards, nonprofit boards, average board rating, elite education
Haleblian and Finkelstein (1993)	Corporate boards, nonprofit boards, average board rating, elite education
Daily and Johnson (1997)	Service on corporate boards, nonprofit boards, degrees from elite educational institutions
Oler et al. (2009)	Elite education, other boards
Chikh and Filbien (2011)	Elite education, outside boards

3.1.4. Prestige Power

This review framework examines prestige power as the last identified power dimension by Finkelstein (1992, 508) Like expert power, it derives from informal sources, such as personal prestige or status (Oler et al., 2009, 434). The manager's reputation might act as a facilitator in dealing with uncertainty from the institutional environment (Finkelstein, 1992, 510).[3] The two focal components of prestige – the role of outside directorship and education – are captured by Finkelstein's (1992: 515-516) four indicators that are displayed in Figure 1. Table 5 contains a list of authors that measure prestige power.

Corporate boards

This variable reflects the number of corporate boards of directors, on which a manager sits (Finkelstein, 1992, 515). Service on other boards can help handle inter-organizational dependencies and encourages interaction with other prestigious executives (Daily & Johnson, 1997, 102). Intensive exchange with other board directors might enhance the CEO's knowledge and provide important information timely that otherwise would not be accessible (Finkelstein, 1992, 510) Additionally, social networks with other high-status actors can enhance the CEO's reputation (Haleblian & Finkelstein, 1993, 852). *Corporate boards* is often used to measure prestige power (Chikh & Filbien, 2011: 1228; Daily & Johnson, 1997: 106; Haleblian & Finkelstein, 1993: 852). A higher number of directorships should imply higher prestige power for the respective executive (Finkelstein, 1992, 515).

Nonprofit boards

Like corporate boards, this variable measures the number of boards a manager serves on. But here, it records nonprofit board memberships. While this can create relationships and ease information exchange, it might also enhance the CEO's reputation as community service is essential for membership in the managerial elite (Finkelstein, 1992, 515). Daily and Johnson (1997, 106) and Haleblian and Finkelstein (1993, 852) seem to differentiate between for-profit and nonprofit directorships in their research as well.

Average board rating

Average board rating averages the stock ratings for all companies that the manager has external directorship in (Haleblian & Finkelstein, 1993, 852). It is an additional indicator of the executive's prestige. By measuring the firms' financial standing, directorship in a renowned organization should reflect the CEO's own prestige (Finkelstein, 1992, 515-516). This variable has not received further attention from other researchers.

Elite education

The educational background could also serve as an indicator for prestige power (Finkelstein, 1992, 516). Some schools are commonly perceived as elite and prestigious, and their reputation transfers to the individual. Having attended such an elite educational institution enables meeting other influential executives and establishing valuable connections (Daily & Johnson, 1997, 102). The variable *elite education* can take values from 0 to 3, indicating whether the manager had no formal higher education at all, graduated from a non-elite school, attended an elite school for one degree, or completed undergraduate and graduate education at an elite institution (Finkelstein, 1992: 516; Haleblian & Finkelstein, 1993: 852). Finkelstein (1992, 538) provides a list of elite educational institutions. However, it should be noted that this list only points out universities in the United States. Depending on the geographical context, other institutions might deserve closer attention. Chikh and Filbien (2011, 1228), for instance, research in a French context, thus, they deem attendance at a prestigious French school as an appropriate reference for *elite education*. Most authors modify this measure into a dichotomous variable with the value 1 if the CEO holds at least one degree from an elite institution and 0 otherwise (Chikh & Filbien, 2011: 1228; Daily & Johnson, 1997: 107; Oler et al., 2009: 435).

[3] The institutional environment encompasses the society that can support or legitimate the company, like governments, financial institutions, and further external actors (Finkelstein, 1992, 510).

Further insights into prestige power

Out of all power dimensions, prestige power is ignored the most by literature. It is harder to operationalize and the data basis is often insufficient (Tang et al., 2011, 1487-1488). Moreover, it is not as effective in predicting executive effects in firms (Sariol & Abebe, 2017, 41). Han et al. (2016, 375) and Sheikh (2019, 362) omit the prestige dimension with the rationale that it is not a proximal measure relative to the other dimensions. Adams et al. (2005, 1408), Park et al. (2018, 926), and Tien et al. (2013, 426) do not provide further reasoning for neglecting this dimension.

3.1.5. Expanding the Framework: Internal Power

The previous sections show that Finkelstein's (1992: 508) four power dimensions capture the multidimensional characteristic of power. Many researchers follow the same approach or use similar variables in their CEO dominance analyses. Power is difficult to quantify and can often only be measured indirectly via various proxies. Moreover, there is no unified variable that captures it completely. Hence, studies vary based on the definition and measurement of CEO power. While many authors do not directly associate their power measures to one of the four dimensions, this thesis allocates them accordingly. Throughout the examination of literature for the review framework, a limitation of Finkelstein's (1992: 510) approach became apparent. The four dimensions define organizational sources of CEO power. However, power can also emerge from the CEO's personality traits. Based on the findings gathered from reviewing the literature, this thesis introduces personal sources of power in a new additional dimension to expand the framework: Internal power.

Internal power derives from personal sources and comprises personality and behavioral traits. Different concepts such as CEO overconfidence (Brown & Sarma, 2007, 361), hubris (Park et al., 2018, 920), entrenchment (Baldenius et al., 2014: 61; Finkelstein & D'Aveni, 1994: 1079), charisma (Khurana, 2004, 154), and narcissism (Chatterjee & Hambrick, 2007, 355) are mentioned by other authors and could attribute to a CEO's power base. In contrast to the aforementioned dimensions, internal power characterizes the CEO and is often not expressed as a power relation between the executives (Tang et al., 2011, 1481).

Nevertheless, it should be noted that there is no clear separation of the internal power sources from some of the other dimensions. Furthermore, this new dimension is even harder to assess and is thus only introduced as a proposal that could be further researched.

Overconfident CEOs overestimate their own abilities and outcomes regarding their decisions (Brown & Sarma, 2007, 361-363). Hence, they behave irrationally (Hackbarth, 2008, 843). They influence strategic decisions due to their inner conviction regardless of the accuracy of their assessment. Thereby, they either attribute greater potential to decisions or fail to perceive some risk factors involved in their strategic choice (Hackbarth, 2008, 845). While CEO power might derive from overconfidence, this does not imply that all dominant CEOs are overconfident (Brown & Sarma, 2007, 364). This is an important notion because it shows that managers do not all have the same personality traits. Some might enhance their power base through personal sources, but it does not necessarily influence each CEO's strategic choice. Therefore, overconfidence should be included whenever the context suggests. Closely connected thereto is CEO hubris. It is a cognitive bias expressed in a CEO's excessively high self-confidence and pride (Hayward & Hambrick, 1997, 106). Hubristic CEOs could be detrimental to firm performance as they believe that there is no misconduct in their actions and that they pursue shareholder interest, even if it involves value-destroying decisions (Park et al., 2018, 919). However, quantifying personality traits is difficult (Brown & Sarma, 2007, 363). Hayward and Hambrick (1997, 113-114) identify three proxies to measure CEO hubris based on recent organizational success under the CEO, media appraisal for the CEO, and compensation relative to the second-highest paid executive. The latter is similar to measures of structural power.

When CEOs choose to pursue their own interests rather than maximizing shareholder value, they are entrenched (Weisbach, 1988, 435). Baldenius et al. (2014, 59, 61-63) argue that an entrenched CEO can exert power when combined with high discretion. Managerial entrenchment is, in that sense, not really a source of CEO power but contributes to the powerful CEO's selection of a strategic choice and influences the firm's performance. Literature has researched the relationship between entrenchment, power, and strategic decision (Baldenius et al., 2014: 61; Bebchuk et al., 2011: 213; Finkelstein & D'Aveni, 1994: 1080; Weisbach, 1988: 435). Therefore, it is shortly mentioned here. Especially Finkelstein and D'Aveni (1994, 1080) highlight its positive association with CEO duality, which was introduced as a source of structural power earlier.

Charismatic or narcissistic CEOs tend to take ventured actions (Tang et al., 2011, 1481). Narcissism makes them believe that they have a certain power level and influence over others (Chatterjee & Hambrick, 2007, 355). Like overconfident managers, narcissistic CEOs likely overestimate positive outcomes and have an optimistic view of their actions. They have an inflated self-image and seek attention and approval (Chatterjee & Hambrick, 2007, 357), which could contribute to a powerful CEO's strategic decision making and implementation. Contrarywise, charismatic leaders receive power as others believe in the CEOs' abilities and overrate their impact (Khurana, 2004, 26-27). They are granted greater autonomy and face high expectations from others (Khurana, 2004, 154) which might contribute to their bold actions.

This section should highlight the importance of analyzing the CEOs' personality and investigating whether it enhances their power base. As a basic introduction into internal power, this thesis could initiate further research to find possible measures to operationalize these personal sources. Whenever it is appropriate, authors should consider these personality traits in their research on CEO dominance and influences on

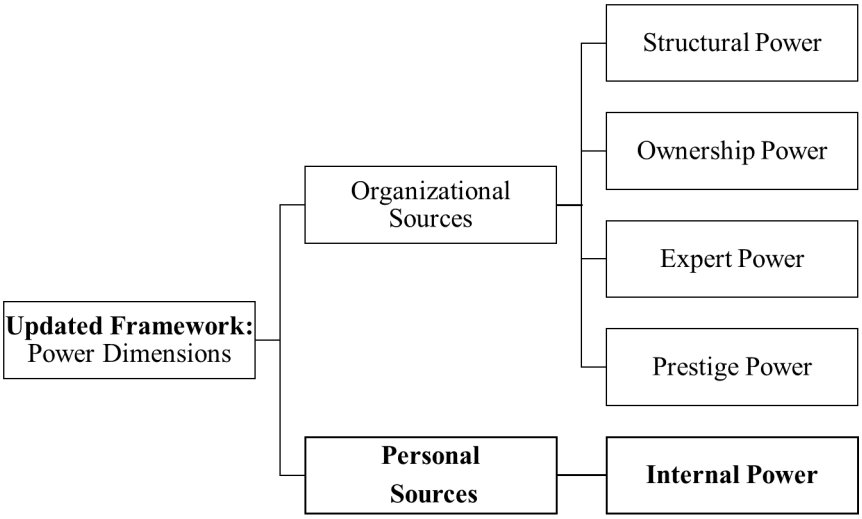

Figure 2: Updated Framework: Power Dimensions. Own Illustration.

strategic outcomes alongside Finkelstein's (1992: 508) organizational sources of power. This thesis, therefore, suggests expanding the framework by adding the dimension of internal power. Figure 2 presents an updated illustration of the power framework.

3.2. Influences of CEO Power on Strategic Choices and Firm Performance

3.2.1. Strategic Change and Firm Performance

Thus far, this thesis has provided an overview of the multiple facets of CEO power. Power is multidimensional and the different sources together influence CEOs' strategic choices in various situational contexts (Finkelstein, 1992, 507). To generate an understanding of how such an influence might look like, and consequently, what impact it might have on firm performance, three strategic choices will be examined, starting with strategic change.

Strategic change comprises two components: Strategic variation refers to the departure from a firm's past resource commitments. Strategic deviance, by contrast, implies a deviation of resource allocation from the industry central tendency (Carpenter, 2000, 1182). The absence of strategic change – conformity – is the tendency to follow the established strategy within an industry (Finkelstein & Hambrick, 1990, 487-488). Many firms follow the central tendency because it enhances organizational legitimacy, reduces uncertainty, and eases access to resources (Geletkanycz & Hambrick, 1997, 660-661), which leads to the emergence of an industry norm (Tang et al., 2011, 1482). It acts as a reference point for executive decision-making and often channels varying opinions (Tang et al., 2011, 1483). In return, conformity does not allow for superior performance. Instead, firms setting themselves apart from the competition are more likely to succeed (Tang et al., 2011, 1484). Hence, some organizational actors would want to deviate from industry norms. Their ability to push through their decision might depend on their power relative to the others involved in decision-making (Tang et al., 2011, 1483). In particular, the focus lies on the CEO vis-à-vis the board.

According to agency theory, CEOs acting as agents are risk-averse and self-interested (Eisenhardt, 1989, 59-60). With strategic change comes high uncertainty. The variation of existing strategy or deviation from the norm requires additional effort and poses new risk factors (Carpenter, 2000, 1182), whereas commitment to the status quo is likely to be the safer option (Haynes & Hillman, 2010, 1151). Besides, CEOs could be opposed to strategic change, as it has the potential to impact their pay or employment negatively (Carpenter, 2000, 1182). The agent's interest diverges from the company interests, represented by the board that promotes strategic change as a result of weak performance or an agile environment (Haynes & Hillman, 2010, 1160). Hence, CEOs may commit to the existing strategy and choose conformity over strategic change. If CEO power is higher relative to board power, the CEO's decision might prevail (Haynes & Hillman, 2010, 1151). Haynes and Hillman (2010, 1150-1152) test the influence of board capital on strategic change and find out that CEO power moderates these effects. A diverse board therefore produces less strategic change under high CEO power. Interestingly, they figured while disaggregating the influences of CEO power and board capital, both powerful CEOs and diverse boards have a positive main effect on deviation, indicating a preference to deviate from the norm (Haynes & Hillman, 2010, 1158). This leads to the assumption that CEOs might oppose the board as a way to exert power (Haynes & Hillman, 2010, 1159) which is consistent with the agency perspective of principal and agent having differing goals (Eisenhardt, 1989, 58).

Corresponding to Haynes and Hillman's (2010: 1158) notion that powerful CEOs' might prefer to deviate from in-

dustry norms when the choice is not based on a response to the board's decision, Tang et al. (2011, 1480) contemplate the situation where the CEO promotes strategic deviance and moderate the effects with the board. As mentioned above, industry norms often act as a reference point for the top management teams' (TMT) decision-making. To assert deviating, the CEO must have enough power to weaken the impact of the industry's central tendency and to counteract (Tang et al., 2011, 1483). The firm's choice to deviate thus reflects the unilateral preference of the dominant CEO (Eisenhardt & Zbaracki, 1992, 25). This tendency is consistent with Daily and Johnson's (1997: 100) finding that CEOs can exercise power due to their formal position. From an agency perspective, CEOs have an information advantage combined with expertise, which allows them to make decisions (Shapiro, 2005, 276). Assuming that CEOs act as stewards allows for the thought that CEOs might want to deviate from the norm to enhance firm performance by setting the strategy apart from competitors. When granted trust (Davis et al., 1997, 25), they could use their critical knowledge for their firm's benefit.

It is difficult to argue whether deviation results in better or worse performance than conformity (Deephouse, 1999, 160). It should be noted that performance implications relating to deviation and persistence should include environmental uncertainty and be adjusted to the focal industry (Geletkanycz & Hambrick, 1997, 675-676), which hinders generalizability in this context. However, similar strategies are likely to produce similar performance. Strategic change, by contrast, is riskier. Thus, it can be argued that deviance tends to result in extreme outcome, either extremely high or extremely low performance, whereas conformity rather yields average performance (Tang et al., 2011, 1484).

However, Tang et al. (2011, 1485) argue that a powerful board could weaken the influence of dominant CEOs on strategic deviance and firm performance. To get the board's approval, the TMT must ensure that deviating is in the firm's best interest, regardless of the accuracy of this claim. A powerful board may be able to reduce the information asymmetries through effective monitoring and detect diverging interests. Hence, the TMT might be afraid to lose the board's trust and rather not propose the CEO's deviant strategy (Tang et al., 2011, 1485). While the moderating effect of boards on CEO power-strategic deviance was not statistically significant, Tang et al. (2011, 1493, 1496-1497) found support that the influence of powerful CEOs on firm performance is more positive when coupled with powerful boards, whereas in combination with less powerful boards the effects are more negative.

This leads to the assumption that a balance of power yields the best outcome. Considering previous literature results, it appears that dominant CEOs would prefer deviating from the norm or changing past strategic orientation, either because it reflects their interest or due to an alignment of interests, such as linking CEO payment to strategic change (Carpenter, 2000, 1194).

3.2.2. Capital Structure Decisions and Firm Performance

Modigliani and Miller (1958, 268) argued that under perfect capital market conditions, the market value of a firm is independent of the choice of capital structure. Since then, literature has tried to explain that frictions and market imperfections do matter in finding the optimal capital structure (Li et al., 2017, 1).[4] Recently, especially the influences of managerial traits and relative power in this context have received greater attention. Thereby, agency theory has gained strong empirical support (Jiraporn et al., 2012, 140).

The central tenet of agency theory is that the capital structure is determined by agency costs that arise from the separation of ownership and control (Fama & Jensen, 1983, 301-302). In firms with agency conflicts, CEOs might rather adopt leverage levels that enhance their benefit instead of maximizing shareholder-value (Jiraporn et al., 2012, 140). While agency theory recognizes a departure from the optimal capital structure, it is equivocal whether agency costs lead to an adoption of leverage below or above the optimum (Chintrakarn et al., 2014, 564). On the one hand, CEOs might adopt little leverage because interest payments constrain the availability of free cash flow for consumption (Jiraporn et al., 2012, 140). Besides, debt financing increases the likelihood of bankruptcy, and consequently, dismissal (Chintrakarn et al., 2014). Another reason could be the CEO's under-diversification. Adoption of lower leverage could reduce firm risk (Jiraporn et al., 2012, 144). On the other hand, CEOs could consolidate their voting power by increasing the leverage level as it reduces the total value of equity (Stulz, 1988, 26-27). Furthermore, CEOs might adopt higher leverage when they engage in empire building (Li et al., 2017, 3).

Leverage is a means of alleviating agency costs. By raising debt, agency conflicts can be mitigated as CEOs have to increase ownership. Moreover, increased leverage urges executives to align their interests and be more efficient (Jiraporn et al., 2012, 143-144). Dominant CEOs have the ability to assert their preferences and thus influence the firm's choice of capital structure in a way that benefits their personal interests. To circumvent these disciplinary mechanisms, powerful CEOs might choose to reduce leverage, expressing an inverse association between CEO power and leverage level (Jiraporn et al., 2012, 150). This suggests that CEO power is negatively associated with the adoption of leverage.

To test this relationship, Jiraporn et al. (2012, 148) run a regression analysis with the firm's leverage level as the dependent variable and CPS to measure CEO power, while controlling for firm-specific characteristics. The results show a negative and significant coefficient for CPS, supporting the proposition.

However, Chintrakarn et al. (2014, 564) argue that the association between CEO dominance and capital structure is non-monotonic. Thus, leverage choice might depend on the

[4] Agency based models suggest that firms should adopt more debt to be profitable (Li et al., 2012: 140).

degree of power a CEO obtains. According to them, leverage positively correlates with CEO power at lower levels. This association turns negative beyond a certain threshold, indicating that CEOs choose sub-optimal capital structure when their power is sufficiently consolidated (Chintrakarn et al., 2014, 565). They find an inverted U-relationship. For lower levels of CEO power, the CEO has less ability to manipulate the capital structure. Thus, the firm adopts higher leverage to align shareholders' and agents' interests and reduce agency costs. But with sufficient power, the CEO has enough discretion to reduce the debt level and avoid disciplinary and control mechanisms (Li et al., 2017, 4). Chintrakarn et al. (2014, 565) use CPS to capture CEO dominance. Their descriptive analysis shows that the average CPS is 0.338. Hence, the average CEO's compensation represents 33,8% of the top five executives' compensation. To analyze the impact of CEO dominance on leverage choices, they run a fixed-effects regression analysis with total debt ratio as the dependent variable and CPS, as well as the quadratic term of CPS as measures for CEO power. The coefficients are both significant but positive for CPS and negative for the squared term. These results reveal that the influence of CEO power on leverage turns from positive to negative at a certain turning point. They calculate that the negative association between CEO power and leverage only accrues after the CPS level exceeds 0.343 (Chintrakarn et al., 2014, 565-566). Thus, agency problems lead to self-serving behavior only if the CEO possesses enough power. Li et al. (2017, 10) confirm the nonlinear relationship with their analysis of the association between CEO power and leverage choice in the context of emerging markets, particularly Chinese small and medium-sized enterprises. Similarly, they conduct a regression analysis with capital structure as the dependent variable and control for firm-specific characteristics. To capture CEO power, however, they construct a power index out of the four variables: founder, title, ownership, and compensation pay slice (Li et al., 2017, 4-5).[5] They find that - with 0.262 - the average CPS is much lower than for Western firms (Li et al., 2017, 7). Nonetheless, the results are equivalent.

Since more dominant CEOs tend to choose sub-optimal leverage and consequently exacerbate agency conflicts, it is conceivable that it might adversely impact firm value. Especially capital structure changes should have a more negative effect on firm performance and reduce firm value if the CEO is more powerful (Jiraporn et al., 2012, 156). Based on Chintrakarn et al. (2014, 565), one could argue that for lower power levels, performance does not differ much from other firms but it could deteriorate as the CPS threshold is exceeded.

3.2.3. Acquisition Decisions and Firm Performance

Because acquisition decisions are one of the most important investment decisions for a company (Chikh & Filbien, 2011, 1222), this paper investigates the influences of CEO power on them as a final strategic choice. The most apparent motive for takeover is the creation of synergies to enhance firm value (Brown & Sarma, 2007, 360). Stewardship theory suggests that the CEO will act on behalf of the shareholders and maximize their wealth (Davis et al., 1997, 24). However, empirical studies show that the takeover is, on average, value destructive for the acquiring firm's shareholders (Brown & Sarma, 2007, 360). Nevertheless, CEOs might still pursue an acquisition because they gain personal benefits (Oler et al., 2009, 430). According to agency theory, CEOs have the potential to act in self-interest as their actions and motive behind it cannot be fully controlled (Fama & Jensen, 1983, 304). Through the takeover, firm size increases, which in turn can lead to decreased employment risk (Oler et al., 2009, 432) and higher compensation (Dutta et al., 2011, 259). Additionally, it can enhance the CEO's influence, wealth, and status (Brown & Sarma, 2007, 360). Especially engaging in diversifying acquisitions would be beneficial for the CEO but also aggravate agency conflicts. Through increased complexity and lack of transparency, the information-asymmetry is enlarged, and managers have the potential to maximize their welfare (Oler et al., 2009, 432).

By the definition of power in this thesis, powerful CEOs have the capacity to impose their decisions (Finkelstein, 1992, 506) and consequently pursue their interests. This allows for the assumption that CEO power is positively associated with the likelihood of a firm conducting an acquisition.

While Brown and Sarma (2007, 370, 376) find support for the influence of CEO power on firm acquisition behavior, they further argue that CEO dominance is especially important in pursuing diversifying acquisitions. A weakness of their study is the conclusion that a more powerful CEO is generally more likely to conduct an acquisition without differentiating between the sources of power. Brown and Sarma (2007, 359) test their hypothesis only with one measure for CEO power based on executive compensation. As seen in Section 3.1.1, this variable only captures the structural power dimension. Besides, they do not address whether powerful CEOs are more likely to engage in value destructing acquisitions. Oler et al. (2009, 431) show that different power sources have varying implications by breaking down the relationship between CEO dominance and acquisition decisions to each of the four power dimensions. They find support for each of the following claims (Oler et al., 2009, 436). First, they suggest that critical knowledge and an influential network should similarly facilitate the conduction of acquisitions. Hence, the probability of an acquisition announcement is positively associated with expert and prestige power (Oler et al., 2009, 434). Next, they hypothesize that the probability of an acquisition announcement decreases with structural power. CEOs who simultaneously are board chairs are already overloaded with information and are occupied enough. Last, ownership might incentivize the CEO to act for the firm's benefit, and CEOs who are also the company's founder would rather prefer to keep the original structures. Thus, the likelihood of an acquisition announcement is expected to decrease

[5] The power index partially recalls the multidimensional character of CEO power by including structural- and ownership power sources.

with CEO ownership power (Oler et al., 2009, 434-435).

Further, Oler et al. (2009, 434-435, 437) test for the relatedness between the acquiring firm and the target for each power source, which provides information about the likelihood of pursuing value destroying takeovers, such as diversifying acquisitions that could have a negative effect on firm performance. Overall, their results allow the presumption that higher relatedness positively correlates with higher CEO power on all power dimensions. However, their hypotheses are only partially supported, or in the context of structural power not supported. Empirical results by Dutta et al. (2011, 276) show that market participants tend not to act negatively to acquisition announcements by firms with powerful CEOs, indicating that these takeovers are likely not value-destructive. Moreover, the acquirer's long-term performance is not significantly adversely affected by the powerful CEO's acquisition decision.

This suggests that although dominant CEOs decide whether to pursue an acquisition for their personal welfare, they do not tend to conduct value-destroying takeovers (Dutta et al., 2011, 276). This might reflect the trade-off between dominant CEOs' motives behind an acquisition. They could act as agents who are incentivized to align interests through linking compensation or personal reputation to firm performance. Contrarily, powerful CEOs might maximize firm welfare as stewards, as it also enhances their own benefits. For instance, if the CEO is also the corporate founder of the firm.

4. Add-On: Case Study of Elon Musk

This paper has disclosed sources of CEO power and examined three different strategic choices which are influenced by a dominant CEO under consideration of conceptual and empirical study findings. An analysis highlighting the role of CEO power in a company should exemplify a practical application of the developed theoretical findings. After comparing current cases of firms with powerful CEOs that pursued all three strategic choices, this thesis portrays Elon Musk, the CEO of Tesla, Inc.

Elon Musk is an entrepreneur, engineer, inventor, and investor (Kurtuy, 2021). While he possesses some degree of formal structural power due to his position as Tesla's CEO, his compensation does not really reflect his dominance. As of 2020, he does not receive any cash base salary. Before then, he would have earned 23,760$, which is the Californian minimum wage requirement, but he never claimed it (Amend. No. 1 Annual Report Tesla, 2020, 13). All executive officers at Tesla receive a relatively low base salary. However, the CEO's ratio compared to the median annual total of the other executives is 0.00:1 now and was 0.41:1 in 2019. Musk's compensation is tied to Tesla's performance (Amend. No. 1 Annual Report Tesla, 2020, 6), which aligns the CEO's and firm's interests. Elon Musk is a director and he used to be chairman of the board but had to step down due to SEC allegations regarding a tweet in April 2019 (Amend. No. 1 Annual Report Tesla, 2020, 4). Without this CEO duality, the board has better monitoring and control functions over him. However, Elon Musk seems to have a high degree of ownership power. One source thereof is his shareholdings. He owns 22.4 % of shares outstanding of the common stocks. For comparative purposes, all 12 current executives and directors together, including the CEO, own 24.3% (Amend. No. 1 Annual Report Tesla, 2020, 25). Besides, Musk is also one of the founders, the largest stockholder of the firm, and he has a brother on the board who might be particularly loyal. The CEO is experienced in different functional areas, which expresses his expert power. He is CEO, chief technology officer, chairman at SpaceX, and chairman at SolarCity. He (co-)founded multiple companies, such as The Boring Company, Neuralink, PayPal, and Zip2, all operating in different industries. Moreover, his tenure as Tesla's CEO is 13 years, and he has been CEO of SpaceX since 2002 (Amend. No. 1 Annual Report Tesla, 2020, 1). His prestige power is demonstrated through his directorship at Endeavor Holdings since April 2021. Furthermore, Musk holds a bachelor's degree in physics and business from the University of Pennsylvania, a private Ivy League school (Amend. No. 1 Annual Report Tesla, 2020, 1).[6] Lastly, Elon Musk might derive some internal power from his personality traits. He seems to be overconfident and optimistic, which could be seen in his grand visions and choice of ventures, like spacecraft manufacturing at SpaceX and advancing the development of sustainable electric vehicles at Tesla. Also, his compensation is entirely tied to Tesla's performance, which could be interpreted as high confidence in the firm's success and also attracts attention to his name. He has frequently been in the news for various achievements (Kurtuy, 2021) and was temporarily the richest person in the world (Frank, 2021).

Elon Musk has accumulated power through all introduced dimensions and thus influences the firm's strategic choices. The following insights concern Musk's actions as CEO of Tesla. Tesla is an example of positive deviance from the industry norm. It revolutionizes the car manufacturing industry and contributes to sustainable, emission-free mobility (Tesla, 2021b). Moreover, Tesla is highly innovative and departs from the standards on all levels, like the car design, the online distribution (DeGraff, 2015), and the engagement to build all-electric vehicles. Musk himself is frequently the driving force behind innovation and leads the designs, manufacturing and engineering of the company's vehicles and other products (Tesla, 2021a).

To analyze Tesla's capital structure under Elon Musk as CEO, the quarterly debt/equity ratio over the time period 2016-2020 is calculated (de Wet, 2006, 2). All relevant data is retrieved from Tesla's quarterly and annual reports, and

[6] Ivy League schools are some of the most prestigious universities, also mentioned in Finkelstein's (1992: 538) list of elite educational institutions.

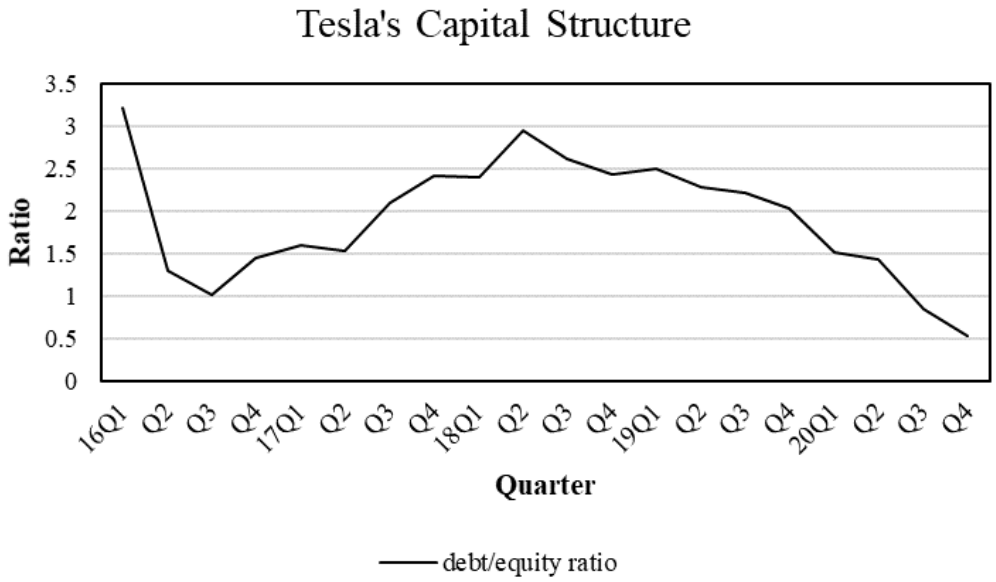

Figure 3: Tesla's Capital Structure. Own Illustration.

the ratio is calculated as shown in Equation (1):

$$\text{debt/equity ratio} = \frac{\left(\begin{array}{c}\text{current portion of debt and finance leases} \\ + \text{ debt and finance leases, net of current portion}\end{array}\right)}{\text{total stockholders' equity}} \quad (1)$$

The precise numbers are presented in Appendix 2. Figure 3 plots the associated graph. Tesla's debt/equity ratio was highest in the first quarter (Q) of 2016 with 3.21, indicating that the leverage was 3.21$ of debt to 1$ of equity. In the next two quarters, the ratio strongly declined to 1.01 but increased again during 2016 Q4 - 2018 Q2, with a new peak at 2.95. Since then, Tesla's debt/equity ratio almost monotonically decreased and reached 0.85 in 2020 Q3. At this point, debt was lower than equity for the first time. This trend seems to continue as the ratio dropped to 0.53 in 2020 Q4. The development of the ratio since 2018 Q2 is consistent with findings of the literature. The proportion of equity increases with Elon Musk as a powerful CEO. Thereby, risk can be reduced (Jiraporn et al., 2012, 144), and lower leverage dilutes the control- and disciplinary mechanisms (Li et al., 2017, 4). Nevertheless, this observation should not induce false conclusion. While a correlation is noticeable, it does not imply a causal effect of CEO power on Tesla's capital structure. Other factors, like the industry, development of the share price, and other external influences also play a role in Tesla's choice of capital structure.

Lastly, this section investigates Elon Musk's acquisition behavior by looking at the widely discussed takeover of SolarCity, a company that specialized in solar energy generation, in June 2016. It was an all-stock transaction worth over $2.5 billion (Song, 2019, 536). Tesla's official motives for the takeover were expanding the product range, enhancing efficiency, and cost reduction while SolarCity should boost its marketing methods (Guo, 2019, 286). Additionally, management believed that the acquisition would create synergy effects. But at the takeover announcement, Tesla's stock price immediately dropped over 10%, leaving shareholders skeptical (Kolodny, 2019). Apparently, Elon Musk knew that SolarCity had liquidity issues at the time of the takeover and still pursued the acquisition without informing the shareholders (Kolodny, 2019). Instead, he overestimated the financial welfare to get them on board. Hence, it can be argued that this acquisition was mainly driven by Musk to gain personal benefits and reflected a conflict of interests between the CEO and shareholders (Song, 2019, 537). As Elon Musk was the main shareholder and chairman of SolarCity during that time, he could consolidate his power in both companies (Guo, 2019, 286) and increase his stock ownership of Tesla's common stocks (Song, 2019, 537). Meanwhile, predominantly minority shareholders sustained damage through this takeover. It was very risky, as SolarCity had huge debt, and profitability was not in prospect for a long time (Song, 2019, 537-538).

The case study of Elon Musk shows that the theoretical findings of extant literature are still applicable to current CEO practices. His power can be retrieved from the power dimensions by Finkelstein (1992, 508) and his personality shows signs of possible internal power sources that were introduced as an expansion of the framework. Moreover, the propositions regarding the strategic choices could be largely supported by his and the firm's actions. Nevertheless, this is only one example of a well-known CEO and does not guarantee an externally valid fact as the unique composition of CEO, firm, and action within an environment yields disparate observa-

tions. Still, the case study provides insights into the integration of theory and practice and offers a method of studying powerful CEOs.

5. Discussion and Outlook

After analyzing conceptual and empirical papers about CEO power and providing a case study that applies theory to practice, this section discusses the main findings of this thesis. Finkelstein's (1992: 508) four power dimensions were used as a review framework to organize literature on this topic. Thereby, each section disclosed different sources of power and discussed the utilization of various variables to measure it. The analysis shows that many authors operationalize CEO power with the same variables. However, the extent and composition of the measures for CEO dominance differ, which can be seen in Tables 2–5. More recent literature tends to focus on one or few measures per dimension, whereas older papers adopt more. Besides, the tables also show which variables prevail in recent studies. For structural power, CPS and CEO duality seem to be primarily used, which are slight modifications of Finkelstein's (1992) measures. Ownership power is still mostly operationalized with ownership and founder status. In contrast, the new source CEO tenure is considered for expert power. Prestige power still consists of elite education and directorship on outside boards. Appendix 1 reveals that structural power is the most cited dimension, either alone or in combination with the other three. It also points out that prestige power is omitted by most authors, especially lately in newer research, as it is not effective in predicting executive influences in the firm (Sariol & Abebe, 2017, 41), and the database is often insufficient (Tang et al., 2011, 1488). This trend has already become visible in Table 5.

Finkelstein (1992, 510) remarks on a limitation of this framework which also became apparent while reviewing the literature. The power dimensions only include organizational sources without consideration of the CEO's personality traits. Hence why this thesis expands the framework by introducing internal power as a fifth dimension. However, these sources are difficult to operationalize, and it would be beyond the scope of this paper to further investigate their role in CEO dominance.

While analyzing the influences of CEO power on three strategic choices and firm performance, it appears that the CEO does have an impact and that the degree thereof is enhanced by power but simultaneously reduced by equally powerful adversaries, like the board. Effective monitoring aligns the CEO's and the firm's interests to produce better performance (Tang et al., 2011, 1497). Regarding capital structure decisions, agency theory suggests that dominant CEOs choose suboptimal leverage levels (Chintrakarn et al., 2014, 564). Empirical studies find that less dominant CEOs adopt higher leverage while powerful CEOs tend to reduce the debt level as soon as their power is sufficiently consolidated (Li et al., 2017, 4). Finally, dominant CEOs seem to pursue acquisitions for their own benefits but they do not tend to conduct value destructing takeovers (Dutta et al., 2011, 276). The case analysis of Elon Musk reflects the findings of the literature.

Before highlighting the contributions to the literature in Section 6, this section points out some limitations of this thesis and derives further research opportunities.

Firstly, the focus on CEO power only does not fully cover the impacts on firm outcome. Further research could investigate the interplay between a dominant CEO and the TMT. Moreover, the shortly addressed interaction between powerful CEOs and boards in Section 3.2.1. should receive further attention. Corporate governance (Sheikh, 2019, 359), powerful boards (Pearce & Zahra, 1991, 149), and market power (Jaroenjitrkam et al., 2020, 720) could have moderating effects on CEO power that may impact the CEO's strategic choices.

Secondly, the concept of CEO power is difficult to quantify, and results depend on the choice of proxies to measure the sources (Brown & Sarma, 2007). Hence, generalizability and comparability of different studies are restricted. Future research could disaggregate the construct of power and study the individual influences thereof on a CEO's strategic choices (Oler et al., 2009, 431). This might offer some managerial implications as it helps to identify where interests need to be aligned.

Thirdly, especially nowadays, there is an urge for self-portrayal and attention-seeking in a fast and well-connected environment. CEOs attain some degree of fame which might reinforce the need to include internal power in further research. Together with the high accessibility to critical information and an international network, future research could investigate whether the importance of some sources is shifted nowadays.

Finally, the agency theory turned out to be the theoretical foundation that derives and explains most of the empirical findings cited in this thesis. Although the need to oppose the agency perspective with the stewardship theory was recognized, the lack of implementation of the latter in extant literature narrowed the insights thereof in this paper. Literature should start to more frequently adopt this stewardship view in explaining executives' actions to capture the complexity of organizations better (Eisenhardt, 1989, 71). This again would provide insightful managerial implications.

6. Conclusion

This thesis aimed at identifying the different sources of CEO power and determining how it influences strategic choices and firm performance. To answer the research question, it first provided a review framework following Finkelstein's (1992: 508) work. Within this framework, 22 research papers were organized according to four power dimensions, and similarities and differences in their approaches were identified. Each section included a summary of the authors who address the respective power dimension. The framework showed how multifaceted CEO power is and

made transparent which authors try to capture this complexity, omit a certain dimension, or apply only one source. Appendix 1 provides a list of all analyzed papers. As far as is known, this compilation of CEO power literature under one review framework has not been done by previous authors yet, and thus constitutes this paper's main contribution to the literature. In a second step, this thesis expanded the framework by adding the internal power dimension. Sources derived from personality traits should not be neglected by research on the dominance of CEOs as they could influence the actual exercise of power (Brown & Sarma, 2007, 364). Together, these five dimensions contribute to a CEO's power and influence strategic decisions. Hence, this thesis provided the investigation of CEO power sources before further analyzing the association between CEO dominance and selected strategic choices. In each case, CEO power seems to impact strategic decision-making, which can also be seen in the case study of Tesla's CEO, Elon Musk.

On the one side, the agency theory suggests that agents maximize their welfare, although this could adversely affect firm value (Combs et al., 2007, 1301-1302). Powerful CEOs have the means to assert their will and could thus be detrimental to firm performance. They could impede strategic change to ensure their employment and compensation or promote it when their pay is coupled to performance (Carpenter, 2000, 1182). Furthermore, they might adopt suboptimal leverage choices. Powerful CEOs could alleviate debt to dilute monitoring and disciplining, which increases agency costs (Jiraporn et al., 2012). Finally, power plays an important role in acquisition behavior. Especially less justifiable takeovers that only serve for the CEO's empire-building are mostly value-destructive for the shareholders (Brown & Sarma, 2007, 360). On the other side, the stewardship theory emphasizes the virtue of centralizing power in CEOs. With aligned interests, they could enhance performance (Davis et al., 1997, 25) as decision-making is consolidated and faster. A bold CEO with high expertise might surmise a needed deviation from industry norms and encourage strategic change. Only with sufficient power, this decision can be asserted (Tang et al., 2011, 1483). The analysis of capital structure decisions revealed that powerful CEOs exacerbate agency conflicts and reduce firm value (Jiraporn et al., 2012, 142), a fact that does not leave much room for a stewardship explanation. Lower levels of power might be less obstructive as an interest alignment could be achieved externally through adopting more leverage (Chintrakarn et al., 2014, 565). Lastly, literature argues that powerful CEOs do not necessarily conduct destructive takeovers for their own welfare (Dutta et al., 2011). Oler et al. (2009, 431) highlight that the source of power differently impacts the CEOs acquisition behavior. CEOs with high ownership power might want to maximize firm welfare and are less likely to conduct acquisitions (Oler et al., 2009, 434-435).

The juxtaposition of the driving forces behind a powerful CEO's decision-making raises the question of whether to leave *power to the CEO*. Different contexts yield disparate answers and literature does not reach an agreement (Tang et al., 2011, 1497). Based on the findings delineated in these sections, this thesis concludes that powerful CEOs should be monitored to identify their motives. As steward behavior becomes clear, they should be granted the needed autonomy to drive firm performance, whereas self-interested agents need to be disciplined by an equally powerful board. Human action is inconclusive, hence, there is no universally valid answer to the question but the right strategic interaction with powerful CEOs might open up new opportunities.

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Logical Reasoning in Management: From "Philosopher Kings" to Logical Managers?

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Abstract

To what extent does a manager's logical reasoning ability impact their managerial responsibility? This study delves into the significance of logical reasoning ability in the realm of management. To accomplish this objective, I developed a logical reasoning assessment whose internal consistency was confirmed. Subsequently, I conducted an online survey with a sample of 83 managers ($M_{age} = 39.6$; $SD_{age} = 11.77$). The econometric model ($R^2_{adj} = 0.431$) revealed a cubic relationship, indicating an influence that logical reasoning ability might have on management responsibility. Notably, managers who pursued formal science education exhibited the highest proficiency in logical reasoning. Conversely, neither age nor GPA exhibited any significant correlation with logical reasoning ability among managers. A comparative analysis of managers' logical reasoning performance against previous studies involving students yielded noteworthy findings, indicating that university students outperformed their managerial counterparts. Whilst acknowledging the study's limitations, these findings shed light on the relevance of logical reasoning ability in the management domain, offering valuable insights and a starting point for both researchers and practitioners.

Keywords: Logical reasoning; Managerial decision making; Formal logic; Management research.

1. Scope and Problem

Plato famously proposed the notion of the "philosopher king". "Making political decisions requires judgement and skill", thus the role of the leader should be performed by philosophers (Wolff, 2006, p. 67) Relating Plato's argumentation to business context – with logic being the fundamental philosophical method (Burgess, 2016) - it would be interesting to know if there is a relationship between logical reasoning ability and a manager's success.

Although there is a lot of literature on managerial decision making, investigations focusing on the special managerial decision-making domain of logical reasoning (Suedfeld, 1992) are rare. This paper wants to make first findings and build first intuitions concerning logical reasoning in management. Consequently, taking management responsibility as a proxy of success and seniority of a manager - because of its uncomplicated observability and intersubjective comparability - following research question is posed.

Research Question *How logically sound is managerial decision making and how does it influence management responsibility?*

2. Background and Related Work

Before exploring the proposed research question quantitatively, I intensively researched available literature. However, as already touched on in the introduction, there is very limited academic research on managers' logical reasoning ability and its relationships. Subsequently, the following literature review for the econometric model will - in some cases – refer to studies concerning intelligence (or: IQ). In those cases, intelligence will be taken as an indicator for logical reasoning ability and its relationships; as intelligence tests also test mental abilities and partly consist of logical reasoning assessments (Wechsler, 1958).

2.1. Quantitative Research and Hypotheses

Beginning with the research question; there has been no research on logical reasoning ability's influence on management responsibility or similar. However there have been

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several investigations on intelligence (IQ) and its causal relationship with management success. Firstly, Hunter and Hunter (1984) have shown that IQ has been a valid predictor of job performance in all academic investigations. Moreover, Schmidt and Hunter (1998) found out that general intelligence can not only predict job performance of low-qualified workers, but also job performance of highly qualified managers. And intelligence is a good predictor of performance because – according to Schmidt, Ones, and Hunter (1992) – more intelligent workers are able to acquire more job-relevant knowledge (at a faster speed) than less-intelligent workers. According to (Schmidt & Hunter, 1998, p. 270), the managerial career advancement resulting from managerial performance can be measured in "management rank" which can be interpreted as management responsibility. Therefore, my first hypothesis is that logical reasoning ability can be associated as a predictor of management responsibility.

> **Hypothesis 1** *Logical reasoning ability influences management responsibility.*

Apart from the relationship between logical reasoning ability and management responsibility, studies concerning related influential relationships have been found. For example, a 2021 study published in *Brain Imaging and Behavior*, connected participants to MRI (Magnetic Resonance Imaging) devices and requested them to solve logical reasoning tasks (which were very similar to the ones proposed in this paper). Not only it was found out that the score was related to their age. But also, the relationship could be traced back to age-related differences in the anterior cingulate cortex and inferior frontal gyrus (Ziaei, Bonyadi, & Reutens, 2020). As the managers brain structures should be equivalent to the test subjects in the mentioned study, we can expect strong correlation between a manager's logical reasoning ability and age. responsibility.

> **Hypothesis 2** *There is a correlation between a managers age and his/her logical reasoning ability.*

As a manager's logical reasoning ability could be highly related to the educational background, I additionally convey research on logical reasoning ability's educational dynamics. One recent study shows that altering logical reasoning ability is difficult, even if people are exposed to formal logic. Studying formal logic in college for one semester does not significantly increase logical reasoning ability for students who have had no/little contact to formal logic. However, if the participants were already experienced in formal logic, the study indicates a significant increase in logical reasoning ability through a one semester class on formal logic (Inglis, Attridge, & Aberdein, 2016). Therefore, I assume, if managers went through years of studying a formal science discipline (Mathematics, Analytic Philosophy, and similar) they should be performing better at deriving valid and sound inferences.

> **Hypothesis 3** *Managers who majored in formal science are the best in logical reasoning.*

Furthermore, Lehman and Nisbett (1990) found that (4-year) university-level education on natural science significantly increases the (conditional) logical reasoning ability. This effect is apparently mostly explained by the increased number amount of mathematics classes in natural science programs. Expanding the set of managers from Hypothesis 3, it is also assumed that managers who have majored in highly mathematical subjects (STEM: Science, Technology, Engineering, Mathematics) will perform better at logical reasoning than managers who do not have this analytical background.

> **Hypothesis 4** *Managers majored in STEM are better at logical reasoning than other managers.*

As several studies have shown a positive relation between GPA and IQ (Deary, Strand, Smith, & Fernandes, 2007; Sternberg, 1999), there may be a strong correlation between logical reasoning ability and GPA.

> **Hypothesis 5** *GPA score and logical reasoning ability are correlated.*

Finally, research regarding the seniority of educational degrees obtained or year of schooling is very clear. Firstly, there has been ongoing research claiming very high correlation between IQ and the years of education attained (Neisser et al., 1996). And secondly, one recent study even claimed having above-average IQ comes with a 10 times higher chance of receiving a Masters degree (Bergman, Corovic, Ferrer-Wreder, & Modig, 2014). Conclusively, the increased seniority of a degree that a manager obtained is assumed to come with an increased logical reasoning ability.

> **Hypothesis 6** *The more senior the degree the higher the logical reasoning ability.*

Due to the limited quantitative research on logical reasoning ability's or deductive reasoning ability's influence on management responsibility or management success, the literature review will in the following focus on theoretical research about logical reasoning in management and the assessment of logical reasoning ability.

2.2. Logical Reasoning in Management

Logical reasoning is essential for professional decision making in management (Holvikivi, 2007). According to Thompson Heames and Harvey (2006), a 21st Century Global Manager must be rigorously trained in logical reasoning. Most prominently, Braverman (1971) derived that real life managerial situations, independent of their complexity, can be unraveled and broken down to their core elements through a reduction process, where logical reasoning can be applied to find solutions. The sum of those partial solutions yields an overall solution. But what exactly is logical reasoning? Human reasoning has been described as a mental process that "yields conclusion from percepts, thoughts, or assertions" (Johnson-Laird, 1999, p. 110). Its subcategory

- logical reasoning - can be seen as a thought act yielding *truthful conclusions*, given premises (Halpern, 2013, p. 176). Logical reasoning relies on formal logic, like George (Boole, 1854, p. 1; Ch. 1) described in his groundbreaking work on mathematical logic.

> *The design of the following treatise is to investigate the fundamental laws of those operations of the mind by which reasoning is performed; to give expression to them in the symbolic language of a Calculus"*
>
> *∼ George Boole, An Investigation of the Laws of Thought (1854)*

The role of formal logic in logical reasoning will be explained in the following.

2.2.1. Formal Logic

Terms like "that sounds logical" or "I don't understand your logic" are frequently used in everyday conversations. Now, one might ask what logic actually entails. This subchapter will give a very basic conception of the formal logic abstractions to be dealt with when discussing logical reasoning (ability). When scientifically investigated and formalized, logic is called formal logic. It found its first formal scientific treatment by ancient philosopher Aristotle, differentiating deductive reasoning from "intuitive reasoning" and describing it with attention on form (Aristotle & Irwin, 2019; Kleene & Rasiowa, 1954).

Today, formal logic is a subdivision of philosophy (and other formal sciences like mathematics) and a modern-day definition would see formal logic as "*the science of deduction*" (Jeffrey & Burgess, 2006, p. 1), or more precisely "*the systematic evaluation of arguments for internal cogency*"; with internal cogency as "*deductive validity*" (Smith, 2003, p. 1). The next subchapter will answer what an argument – according to Kahane, Hausman, and Boardman (2021) – and deductive validity entails.

Argument

An argument in formal science is a set of statements, consisting of premises and a conclusion. An exemplary argument, informally stated:

> *"Since it's wrong to kill a human being, it follows that abortion is wrong, because abortion takes the life of a human being." (Kahane et al., 2021)*

It can be deconstructed to a set of statements;

> *1. It's wrong to kill a human being.*
>
> *2. Abortion takes the life of a human being.*
>
> *∴ 3. Abortion is wrong. (Kahane et al., 2021)*

where 1. and 2. are premises that lead to the conclusion 3 (symbolized by the "∴" symbol which stands for "therefore"). To get a better understanding of the context, following statements would not qualify for making an argument.

> *Open the door.* (command)
>
> *Who's the boss here?* (question)
>
> *Thank goodness!* (expression of emotion) *(Kahane et al., 2021)*

Some special statements that imply a conditional relationship between propositions and will be important later on, are called conditional statements (e.g. "If A then B."). In the case of "If A then B." A is called the antecedent and B the consequent.

Coming back to "deductive validity"; what makes an argument valid? An argument is valid when it fulfills one central condition. Its conclusion must be true in every case in which all its premises are true. So, the validity of an argument is independent of whether the premises are true or not. Furthermore, arguments can have another important property, "soundness". An argument is "sound" if it is valid, **and** its premises are true (Jeffrey & Burgess, 2006, p. 5). Therefore, soundness ensures the truth of the conclusion. For a true argument, validity can be seen as necessary and soundness as sufficient condition.

Deduction and Induction

Deduction has been mentioned frequently; but what exactly does deduction – or a deductive argument - describe? A deductive argument is a type of argument that can – given its premises are true – guarantee the conclusion to be true. Consequently, deductive arguments can be valid (and sound). A prominent example for a deductive argument is a syllogism which is a deductive argument consisting of two premises that lead to one conclusion (Kahane et al., 2021). Most deductive arguments in this paper will be in the form of syllogisms.

A key distinction between two types of logical arguments is made, with the first one being just discussed and the second one being "inductive" arguments. Inductive arguments **do not guarantee** truth of the conclusion assuming true premises; instead, they **just provide evidence** for the truth of the conclusion. In contrast to rule-based inference (deduction), induction is based on cumulating observations to create general rules. Following table explains both types of arguments in a comparison.

The deductive argument in this example clearly illustrates that if the premises 1 and 2 are true, the conclusion 3 must true. In contrast, the conclusion argued in the induction example is not necessarily true, given the truth of its premises. Assuming, 1. the brake is hit and 2. the car is slowing down, we cannot assert the conclusion to be a general rule. What if this (or any other) car has a defective break? Then this conclusion would not hold true. Even if – instead of one car - all cars manufactured to date would be considered for the premises, there would never be complete certainty that the rule holds for the next car to be tested. Inductive arguments can be strong or weak, depending on the quality evidence that comes with the premises. Only deductive arguments can

Table 1: Deductive and Inductive Argument examples

Deduction	Induction
1. When you hit the brake of a car, it will slow down. 2. This car's brake is hit. ∴ 3. This car is slowing down.	1. This car's brake is hit. 2. This car is slowing down. ∴ 3. When you hit the break of a car, it will slow down.

be sound (or valid). The point to be made was that due to the "problem of induction", in the rational science of formal logic, there is only place for deduction.

2.2.2. Rules of Inference & Formal Fallacies

Deduction assures truth in conclusions given true premises. But how exactly is this guaranteed? By Rules of Inference. They describe fundamental laws for valid and sound inference in formal logic. Conditional syllogisms are syllogisms whose premises contain conditional statements (such as "if... then..."). Being in the main focus of studies on logical reasoning (Johnson-Laird, 1999) and being important in later stages of this paper, two rules for conditional syllogism inference and their respective fallacies are explained. As the usual denotation in formal language (propositional and predicate logic language) is out of scope of this work, the following is described in informal fashion and illustrated by examples.

Table 2 displays the most frequently used inference rules, Modus Ponens and Modus Tollens and their formal fallacies (Inglis & Simpson, 2007). In this syntax, with p and q represent any proposition, so that proposition p is the antecedent and q the consequent of the argument. The "Affirmation of the consequent" fallacy misleads reasoners to think that Modus Ponens can be inversely applied, just as "Denial of the antecedent" misleads to think that Modus Tollens can be inversely applied. In both cases the conclusion is wrong. The right conclusion is that we cannot know. Applied to the examples, firstly we cannot know if the pandemic is over or not, as the economic uprise could be caused by something else than the end of the pandemic. Secondly, we cannot know if Elon Musk is in regret or not, as there could be other regret causing factors.

2.2.3. Deductive Reasoning Ability

Deductive Reasoning is the process of finding conclusion through mental inference rules and premises. The implicit proofs formed in the process, are analogous to explicit proofs of formal logic (Rips, 1983, p. 40). With deduction logical truth of conclusions can be objectively verified. And propositional inference can be derived by following propositional calculus (rules of inference); which is proven to be complete (Johnson-Laird, 1999). That is why – in empirical research – logical reasoning ability is almost without exception measured in the form of deductive reasoning ability (Johnson-Laird, 1999; Niu, Zhang, & Yang, 2007; Yang & Bringsjord, 2003).

2.3. Assessing logical reasoning ability

Logical Reasoning Ability is measured by assessing a person's ability to reason deductively. In the following, different ways of assessment established by previous research are discussed.

Particular/Universal & Affirmative/Negative Syllogisms for Children

Kathleen Galotti and her team investigated the development of deductive (and inductive) reasoning ability in children from grade 2, 4 and 6 (Galotti, Komatsu, & Voelz, 1997). 16 syllogisms with child-appropriate content were offered, differentiated in two dimensions, 1. "particular" or "universal" and 2. "affirmative" or "negative". Particular syllogisms yielded a conclusion that referred to a single case, in comparison to universal syllogisms where conclusions referred to all cases. As a second step syllogisms were divided into ones with negating and affirming premises. Exemplary questions are displayed in Table 3.

Conditional Syllogisms based on Rules of Inference

In his book *The Development of Cognitive Anthropology*, D'Andrade (1995) offers a section on "Logic and the psychology of reasoning". He not only describes numerous logical reasoning tasks, but develops his own test based on rules of inference & formal fallacies.

Tasks are based on conditional syllogisms and divided into four categories: Modus Ponens, Modus Tollens, Affirmation of the consequence, and Denial of the antecedent. In total, 25 different tasks of all categories (with arbitrary and realistic content) were introduced to participants (American undergraduate students). Four exemplary tasks are visualized in Table 4. D'Andrade followed a popular approach, creating a testing methodology similar to Rips (1983), St.B.T. Evans et al. (1995) (influencing Inglis and Simpson (2007)) and Dugan and Revlin (1990). More so, Holvikivi (2007) was influenced by D'Andrade's approach. Testing Finnish university students, she borrowed three questions (out of four) from D'Andrade.

Categorical Syllogisms and Logical Ordering

Bronkhorst, Roorda, Suhre, and Goedhart (2019) and his team conducted a logical reasoning study without conditional syllogisms. Instead, logical ordering and categorical syllogism tasks were used. Categorical syllogisms are syllogisms that contain categorical propositions (propositions of

Table 2: Modus Ponens, Modus Tollens, Affirmation of the consequence, and Denial of the antecedent examples

	Modus Ponens	Modus Tollens
Rule of Inference	1. If p then q 2. p ∴ 3. q	1. If p then q 2. Not q ∴ 3. not p
Example	1. If this paper is exceptional, the readers will be more than happy. 2. This paper is exceptional. ∴ 3. The readers will be more than happy.	1. If Guido Imbens wins his second Noble Prize, Stanford honours it with a statue. 2. Guido Imbens is not honoured with a statue. ∴ 3. Guido Imbens did not win his second Noble Prize.
Corresponding Fallacy	"Affirmation of the consequence" 1. If p then q 2. q ∴ 3. p (Right conclusion: ∴ 3. Maybe p, maybe not p.)	"Denial of the antecedent" 1. If p then q 2. not p ∴ 3. not q (Right conclusion: ∴ 3. Maybe q, maybe not q.)
Example	1. If the pandemic is over, economies face uprise. 2. Economies are facing uprise. ∴ 3. The pandemic is over.	1. If Elon Musk buys Twitter, he regrets it. 2. Elon Musk does not buy Twitter. ∴ 3. Elon Musk is not in regret.

Table 3: Questions from Galotti et al. (1997)

	Particular	Universal
Affirmative	1. All Poggops wear blue boots Tombor is a poggop. Does Tombor wear blue boots?	2. All daxlets are squishy. All squishy animals like to yell. Do all daxlets like to yell?
Negative	3. No risomes play checkers. Zapp is a risome. Does Zapp play checkers?	4. All berbers wiggle. No wiggly animals wear hats. Do all berbers wear hats?

the form "all" or "some"). These tasks were presented to pre-university students with and without content; and are summarized in Table 5. The logical ordering example finds its solution in a) and the categorical syllogism – being invalid - can be answered with "No".

The Selection Task

In 1968 Wason (1968) famously proposed the "selection task", a comprehensive task based on conditional inference rules. One popular version, illustrated by D'Andrade (1995) is described in Figure 1.

Between 80 and 90 percent of undergraduate students fail to find the correct solution: turning over 3 and E (D'Andrade, 1995; Wason, 1968; Wason & Johnson-Laird, 1972).

3. Methodology

As to my best knowledge, no research has been conducted on the relationship between logical reasoning ability and management responsibility and no data regarding logical reasoning ability of managers is publicly available, a survey was conducted. This survey was designed to not only collect observational data on logical reasoning ability, but also other variables that are essential to answer the hypotheses.

3.1. Data Collection

I collected the data through a web survey published via Google Forms. However, audience (the sample) that was obtained this way is heavily dependent on the researcher's own network (people with whom researcher is connected with on the platform). This is in no means random. Thus, I chose to abandon the first dataset; and after extensive academic review, the survey was redistributed via *Amazon Mechanical Turk*. *Amazon Mechanical Turk* is a crowdsourcing marketplace that offers businesses and individuals to outsource intellectual tasks, inter alia, survey participation[1]. Requesters" publish tasks (called "Human Intelligence Task" or "HIT") – for instance, a research survey - which is being filled out by "MTurkers". This way of observational data aggregation has

[1] https://www.mturk.com

Table 4: D'Andrade (1995) questions

	Modus Ponens	Modus Tollens	Affirmation of the consequent	Denial of the antecedent
Task	1) GIVEN: If James is a watchman then James likes Candy. SUPPOSE: We find out that James is a watchman. THEN: (a) It must be the case that James likes Candy. (b) Maybe James likes Candy, maybe he doesn't. (c) It must be the case that James doesn't like Candy.	2) GIVEN: If this rock is a garnet then it is a semiprecious stone. SUPPOSE: This rock is not a semiprecious stone. THEN: (a) It must be the case that this rock is a garnet. (b) Maybe this rock is a garnet or maybe this rock is not a garnet. (c) It must be the case that this rock is not a garnet.	3) GIVEN: If it is raining then the roof is wet. SUPPOSE: The roof is wet. THEN: (a) It must be the case that it is raining. (b) Maybe it is raining and maybe it is not. (c) It must be the case that it is not raining.	4) GIVEN: If Jim cut himself then Jim would be bleeding. SUPPOSE: We found out that Jim did not cut himself. THEN: (a) It must be the case that Jim is bleeding. (b) Maybe Jim is bleeding and maybe he is not. (c) It must be the case that Jim is not bleeding.
Solution	(a) It must be the case that James likes Candy.	(c) It must be the case that this rock is not a garnet.	(b) Maybe it is raining and maybe it is not.	(b) Maybe Jim is bleeding and maybe he is not.

Table 5: Categorical Syllogisms and Logical Ordering

	Logical Ordering	Categorical Syllogism
No Content	1) If $P > Q$, $R < Q$, and $R > S$ What does apply to P and S? a) $P > S$ b) $P < S$ c) Cannot be determined.	2) Premise 1: All A are B. Premise 2: Some B are C. Conclusion: Some A are C.
With Content	3) We know the following about the ages of Peter, Quint, Rosie, and Sally: - Peter is older than Quint - Rosie is younger than Quint - Rosie is older than Sally What can be said about Peter and Sally? a) Peter is older than Sally b) Peter is younger than Sally c) You cannot tell	4) Premise 1: All roses are flowers. Premise 2: Some flowers fade quickly. Conclusion: Some roses fade quickly. Indicate whether this conclusion necessarily follows from the given premises.

been applied and discussed frequently by fellow researchers. According to a review commissioned by the Journal of Management, Mechanical Turk offers 4 main advantages to researchers: "(a) large and diverse participant pool, (b) ease of access and speed of data collection, (c) reasonable cost, and (d) flexibility regarding research design choice" (Aguinis, Villamor, & Ramani, 2020). In the same breath it is prone to a diverse set of problems. In this study, appropriate mitigation techniques to these concerns, as proposed by Aguinis et al. (2021) and Hauser, Paolacci, and Chandler (2019), will be applied.

Firstly, participants' (referred to as "MTurkers") lack of attention can lead to measurement errors. Thus, an attention check was integrated to the survey and 15% additional partic-

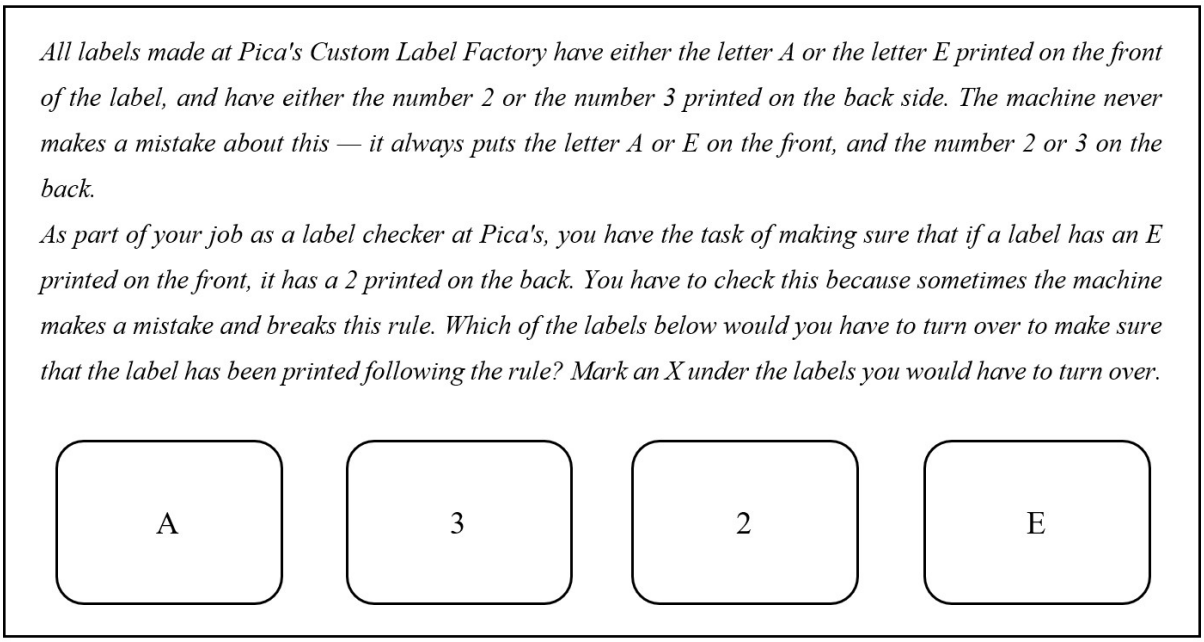

Figure 1: Selection Task

ipants were acquired to compensate for potentially excluded participants. To avoid bots, qualitative open-ended questions were included as qualitative attention checks. A last countermeasure to inattention was the conciseness of the survey; aiming at 5-7 minutes working time. Inconsistency in English language fluency within the participant base is another frequent concern. To ensure consistency, the participant pool was restricted to the United States.

And in order to avoid sample selection bias, the pool was not only limited to "Job Function – Management", but participants were also paid above minimum wage.

Moreover, nonnaiveté is a big issue when conducting surveys with "professional participants who have completed many social science studies and are likely to respond differently because of this experience.". As there is not a lot research on logical/deductive reasoning ability, in our case it can be assumed that exceedingly few participants have frequently done a similar test. Accordingly, this study is not susceptible to nonnaiveté. Lastly, only MTurkers with a HIT Approval Ratio of over 97% were displayed the survey. The HIT approval ratio describes how often a MTurker's tasks were approved (as done correctly) by the requesters, from all tasks the MTurker did. Peer, Vosgerau, and Acquisti (2013) suggests a threshold of a minimum of 95% HIT approval ratio to ensure data quality and attentiveness. All in all, most prominent problems with data collection via *Amazon Mechanical Turk* could be overcome. And due to random assignment of managers, the survey data can be seen as sampled randomly.

3.2. Econometric Model

To understand if and how logical reasoning ability influences management responsibility, an econometric regression model is established.

Dependent Variables

The dependent variable is the amount of management responsibility. It is conceptualized as the number of employees a manager has supervisory power over, if the manager does not actively interact with the employee. As seen in (1), if the manager directly manages i employees and those employees themselves manage j employees, the manager has Management Responsibility over all those employees, i over j; until the lowest level k-th employee is reached.

$$Management\_Responsibility = \sum_{i,\ j,\ldots,k=1}^{n} employee_{i,j,\ldots,k} \tag{1}$$

Independent Variables

The first independent variable to be considered is logical reasoning ability ("LRA"). Its exact measurement scheme will be discussed in 3.2.2. Furthermore, following independent variables were included in the model, to avoid omitted variable bias, or in broader terms, endogeneity.

Age: As a person's age is correlated with its logical reasoning ability (Ziaei et al., 2020) and Age can be assumed to be a predictor of management responsibility, Age is included as independent variable.

Gender: Ehindero (1982) found out that depending on the content, men or women can be better in logical reasoning tasks. Therefore, there might be some relationship between

gender and logical reasoning ability. As gender might also have an effect on management responsibility, it is included as a binary variable "Male".

Major & Highest Degree Obtained: As the educational background is a determinant of management responsibility and – as derived in Chapter 2 - might be correlated with logical reasoning skills, the primary major and highest degree obtained are entered as binary variables. Following Dummy Variables were included for major were included: "Natural" (Natural Science: Physics, Chemistry, Biology & related), "CS" (Computer Science), "Formal" (Formal Science: Mathematics, Analytic Philosophy & related), "SocialSci" (Social Science) "Engin" (Engineering) and "Humanities" (Liberal Arts & Humanities); with "Biz"(Business) as reference line. And for major these dummy variables were included: "Bachelor", "Master", "MBA", "PhD" and "No_Degree", with "HighSchool" (High School Diploma / Abitur) as reference line.

GPA: The effect educational background has on management responsibility (Schmidt & Hunter, 1998) – and the likely high correlation between logical reasoning skill and educational success (as derived for Hypothesis 5) - wouldn't be fully accounted for if the GPA wouldn't be taken into account. "GPA" is measured on the American scale, with 4.0 (A) as best and 1 (D-) as worst.

Parents Academic Background: If genetic influence wouldn't be considered in the model, the estimators would be biased because it is likely parental academic background a) has an explanatory effect on management responsibility and b) correlates with logical reasoning ability. Dummy variables for the parental degrees include: "P_Bachelor", "P_Master", "P_PhD" and "P_No_Degree"; with "P_HighSchool" (Parental High School Diploma / Abitur) as reference line.

Control Variables

Circumstances in which the manager was raised: The circumstances in which the manager was raised could be highly correlated with logical reasoning ability (due to differing quality of education) and predict management responsibility (e.g., due to parents' business relationships). In order to compensate for this effect, the control variable "Circumstances" is included to the regression. On a scale from 1 to 5 participants are requested to indicate the circumstances they were raised in (relative to their country of residence).

Career Motivation: As the general motivation to have a successful management career most likely predicts management responsibility and could be correlating with logical reasoning ability, it must be introduced to the model as independent variable. However, motivation is hard to observe objectively by an online survey. Therefore, the amount of average work hours per week "WorkHours" – likely highly correlated to general motivation - is included as control variable. The possible simultaneity (between average hours of work and management responsibility) is negligibly as it is not modeled as exogenous explanatory, instead as endogenous control variable.

All variables are summarized in Table 6 and the resulting regression model is displayed in equation (2).

$$\begin{aligned} &ManagementResponsibility_i \\ &= \beta_0 + \beta_1 \times LogicalReasoningAbility_i + \beta_2 \times Age_i \\ &+ \beta_3 \times Male_i + \beta_4 \times Natural_i + \beta_5 \times C5_i + \beta_6 \\ &\times Formal_i + \beta_7 \times SocialSci_i + \beta_8 \times Engin_i + \beta_9 \\ &\times Humanities_i + \beta_{10} \times Bachelor_i + \beta_{11} \times Master_i \\ &+ \beta_{12} \times MBA_i + \beta_{13} \times NoDegree_i + \beta_{14} \times GPA_i \\ &+ \beta_{15} \times P\ Bachelor_i + \beta_{16} \times P\ Master_i + \beta_{17} \\ &\times P\ Phd_i + \beta_{18} \times P\ No\ Degree_i + \beta_{19} \\ &\times\ Circumstances_i + \beta_{20} \times Work\ Hours_i + u_i \end{aligned} \quad (2)$$

3.2.1. Internal Validity

In the following, biggest threats to the statistical model's internal validity and (the resulting) legitimacy of the Least Squares Assumptions will be discussed. The consequent process is heavily influenced by the approach of Stock and Watson (2014, Chapter 9).

1. Omitted Variables

After extensive research and reflection, variables which were likely to be correlated with an independent variable and explaining the dependent variable were included to the model. In this way it can be assumed the estimators won't be biased because of omitted variables.

2. Misspecification of Functional Form

To avoid functional form misspecification, the functional form will be estimated analyzing the scatterplots of the dependent variable and independent variables, and by introducing other types of functions if needed.

3. Measurement Error in the Regressors

Errors in independent variables – i.e., caused by participants' misunderstanding about the format of answers - are mitigated by pre-formatting answers. For example, Age is limited to integers in the range 18 – 99.

4. Sample Selection

The sample drawn for this investigation consists of "Managers" from "United States of America". Importantly the participants are not selected by the examiner, as the survey is displayed to random managers on the platform. This is only true insofar Amazon Mechanical Turk represents the (Managers from United States) population well. Going further, another limitation to sampling might be that the survey platform was not chosen randomly.

5. Simultaneous Causality

Simultaneous Causality refers to the issue which arises when independent variables not only cause the dependent variable, but also vice versa. Following relationships are prone to simultaneity.

Logical Reasoning Ability & Management Responsibility: It can be argued that management responsibility is not only caused by logical reasoning ability but also causes the independent variable. For instance, it could be presumed that increasing management responsibility leads better problem solving and logical reasoning skills. However, there is evidence indicating that logical reasoning ability is not very

Table 6: Econometric Model Variables

Dependent Variable	Numerical Independent Variables	Binary Variables	Control Variables
Management_ Responsibility	*LRA*	Gender: Male	*Circumstances*
	Age	Major: *Natural, CS, Formal, SocialSci, Engin, Humanities*	*WorkHours*
		Degree: *Bachelor, Master, MBA, PhD, No_Degree*	
		Parental Degree: *P_Bachelor, P_Master, P_PhD, P_No_Degree*	

prone to environmental factors. D'Andrade summarizes that a majority of cognitive scientist are convinced of a "inbuilt capacity" to "logical reasoning" (D'Andrade, 1995). As logical reasoning ability seems to be an innate ability that is unlikely to be altered through external factors, ergo I assume this ability is very unlikely to be caused by management responsibility.

Educational Background & Management Responsibility: The key assumption made here is that primary education is finished before management career. Some managers attain executive education. This education after becoming manager could be caused by management responsibility, as managerial incentive to gain an executive degree may be increase management responsibility ex post. However, it is assumed that executive degrees are very uncommon, thus negligible. This assumption assures that educational background is not simultaneously caused by management responsibility. This assumption is very much confirmed by the study as we will see in the results.Parental Educational Background & Management Responsibility: Another key assumption is made. Parents ended their primary education before start of manager's career. Similar to the potential issue measured above a managers career success (and corresponding management responsibility) could influence the parents decision to choose a degree. Nevertheless, it is assumed that parents studying after their children started their managerial career is very rare, thus negligible.

OLS Validity

Assumption 1: *The error term (given the independent variables) has conditional mean of zero*: Simultaneous causality and omitted variables are avoided - as all endogenous variables are eliminated. The first OLS Condition is satisfied.

Assumption 2 *The Random Variables are independently and identically distributed:* Survey participants are independent of the examiner. Random persons from the "American Manager" population are observed. Insofar *Amazon Mechanical Turk*'s sample is representative of the population, our observational data can be construed randomly sampled. Ergo, the second OLS Condition is satisfied.

Assumption 3 *Large outliers are rare*: As all numerical independent variables are capped by a maximum value; LRA, Age, GPA and Cicumstances_Raised all have finite kurtosis. In contrast, the numerical dependent variable Management_Responsibility does not necessarily have a finite kurtosis. Large outliers will be avoided by analyzing the visualized data (boxplot). The third OLS Condition is satisfied.

3.2.2. Logical Reasoning Ability Test

For the Logical Reasoning Ability Assessment, the previously discussed research (2.3) is considered. As a matter of fact, the 7-item test exclusively contains questions that were developed as part of peer-reviewed research. Four questions consider conditional syllogisms associated with "Modus Ponens", "Modus Tollens", "affirming the consequent", "denying the antecedent", as most studies on deductive reasoning feature conditional syllogisms of these four types (Johnson-Laird, 1999). The questions are identical to the ones presented in Table 4.

In order to diversify the set of deductive inference tasks, the logical ordering and categorical syllogism tasks (with content) from Bronkhorst et al. (2019) are included.

Question 7 is an attention check. All participants failing to solve it correctly will be excluded from the analysis. Finally, participants must solve the selection task, as illustrated in Figure 1. The complete survey is available in Appendix A, whereas the answers keys for logical reasoning test are denoted in Table 7.

3.3. Survey Method

Subjects As explained above, participants were pooled from *Amazon Mechanical Turk*, and filtered by a. HIT Approval Rate greater than 97%, b. Job Function: Management, and c. Location is the US. Cost per HIT consisted of $0.5 remuneration and $0.4 bonus for the job function "Management", plus 20% Amazon Mechanical Turk Platform Fee. Assuming 5 minutes working time per task, the MTurkers were paid $10.8/h.

Design The survey was created and published on the *Google Forms* platform, with all questions being presented in English.

Materials and Procedure After a short but precise introduction, it consists out of several demographic inquiry questions

Table 7: Answer Keys for the Logical Reasoning Test

Question	1	2	3	4	5	6	7	8
Answer	2.	1.	3.	2.	2.	1.	3.	1. & 4.

and leads to the 7-item logical reasoning ability assessment discussed before. The logical reasoning ability test section was clearly separated from the rest and had its own introduction, covering an example.

> *In the following tasks you are given 2 pieces of information that you must assume to be true.*
>
> *Having those in mind, you must decide which of the conclusions follows logically.*
>
> ————-
>
> *Example*
>
> *GIVEN: If my job is boring, I will quit. SUPPOSE: My job is boring.*
>
> *-> It must be the case that I will quit.*

Both introductions ensured misunderstandings to be rare and data reliability to be guaranteed. The complete survey can be obtained from Appendix A. After finishing the survey, they were given a "survey code" via Google Forms which had to be submitted on Amazon Mechanical Turk and validated, so that every participant could be traced back.

4. Results

In total n=83 managers participated in the survey. After dummy coding, the data was analyzed with the R statistical software (R Core Team, 2021). As discussed in 3.2.1.1, Management Responsibility is not guaranteed to be outlier-free. Therefore, firstly, the scatterplot of management responsibility is analyzed to eliminate potential outliers.

The outliers are identified as Management_Responsiblity > 100 and are excluded from the analysis. Furthermore, all entries with failed attention check are excluded.

With N=80 descriptive statistics of all investigated numerical variables are summarized in Table 8.

Comparing these preliminary descriptive findings to other research, can act as another indicator of the representative validity of the *Amazon Mechanical Turk* sample. For example, the average age of 39.6 years (SD = 11.77) is similar to the 44 years (Shore, Cleveland, & Goldberg, 2003) or 43.35 years (Scandura & Lankau, 1997) observed by fellow researchers. Also, the average amount of work per week, 40.42 hours (SD = 12.05), was similar to 48.9 hours (SD = 1.5) observed by Scandura and Lankau (1997). Lastly, participating managers' educational background – with 58.75% Bachelor, 18.75% Master and 1.25% for both MBA and No Degree (Appendix B) - seems to be similar to existing literature (Bachelor 49.1% and Master 13.75%) (Scandura & Lankau, 1997). Another important observation is that company size has a disproportionately high standard deviation of 158772.67. This was likely caused by outliers and will be considered if analyzed. GPA only has n = 70 observations, as some participants didn't respond with a GPA in the 1.0 – 4.0 scale. Finally, it is interesting to observe that on average managers achieved a bit more than half of the points possible in the Logical Reasoning Ability Assessment.

4.1. Internal Consistency

To continue the analysis a valid LRA variable, as a first step the logical reasoning ability assessment's internal consistency must be tested. Internal consistency– describing the extent to which items in a test measure the same phenomenon - is important when conducting (psychological) assessments of human capabilities (Tavakol & Dennick, 2011).

In this case Cronbach's Alpha, a prominent model in psychometrics, is computed as quality criterion to examine the internal consistency. It ranges from 0 to 1, with a score between 0.7 and 0.95 seen as acceptable indicator for internal consistency (Tavakol & Dennick, 2011).

The equation from Cronbach (1951), with n as number of questions, V_i as the variances of the score on each question and V_t as the variance of the total score, is indicated below.

$$\alpha = \frac{n}{n-1}\left[1 - \frac{\sum_i V_i}{V_t}\right] \tag{3}$$

The resulting $\alpha = .71$ (95% CI [0.61, 0.81]) of the 7-item test can be associated with good internal consistency (Streiner, 2003). Therefore, the data on LRA can be used as representative assessment of logical reasoning ability in the further analysis.

4.2. Econometric Model Findings

Before running the regression, to mitigate bias caused by inappropriate standard errors, the regression model must be tested for heteroskedasticity. The Breusch-Pagan Test for heteroskedasticity (Breusch & Pagan, 1979) yields p = 0.04; so that the nullhypothesis, assuming homoskedasticity, can be rejected. This finding can be corroborated by the visualization above (Figure 4). Comparing the observations LRA=3 with LRA=4, shows that equal variances of error terms cannot be assumed. Accordingly, the linear regression will be computed using heteroskedasticity-robust standard errors.

Although the model itself is statistically significant ($F(19, 50) = 3.55$, $p < .01$), surprisingly only five regressors are significantly different from zero (Table 10). And as the adjusted R^2 of 0.413 can be perceived as low; indicating the model to being prone to functional form misspecification, new nonlinear models are tested in order prevent this misspecification of the functional form. Next to the below mentioned

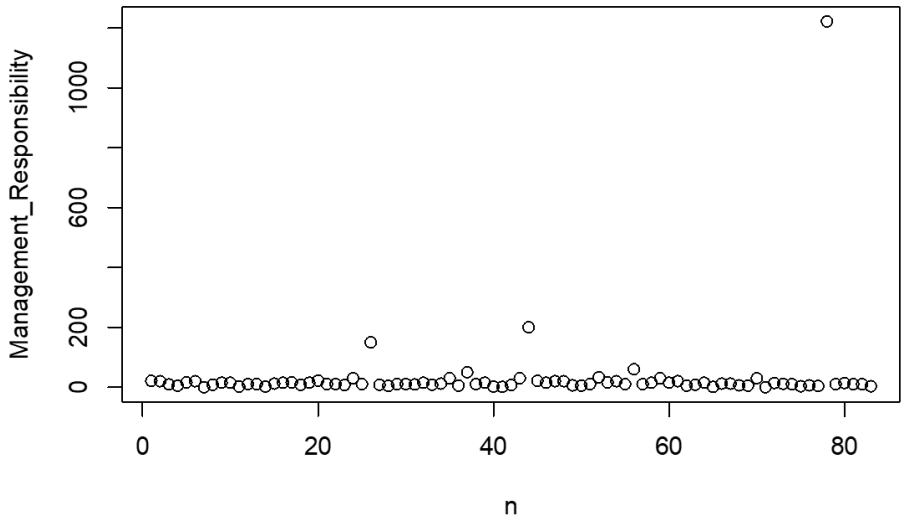

Figure 2: Management Responsibility Scatterplot

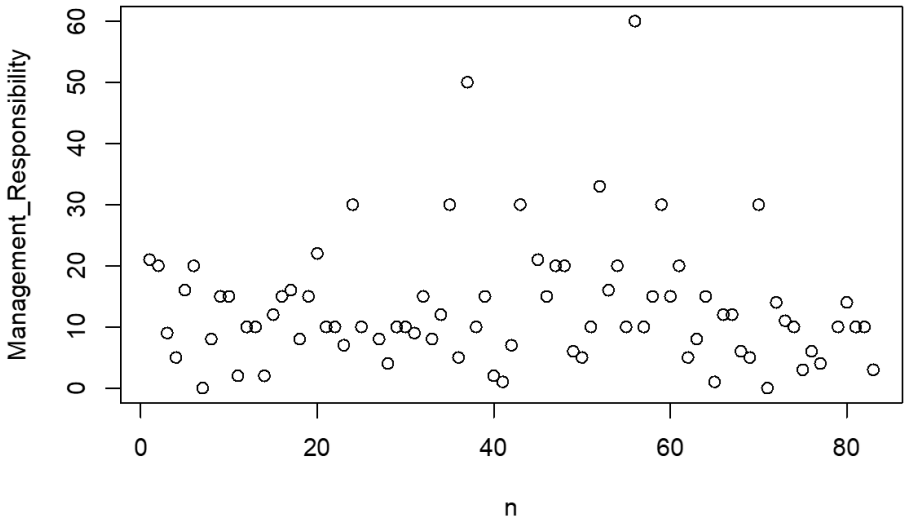

Figure 3: Management Responsibility Scatterplot without Outliers

Table 8: Overview – Numerical Variables

	n	*Mean*	*SD*	*Min*	*Max*	*Range*	*SE*
Management Responsibility	80	13.11	10.18	0	60	60	1.14
LRA	80	3.17	1.95	0	7	7	0.22
Age	80	39.60	11.77	24	63	39	1.32
GPA	70	3.46	0.66	1	4.90	3.9	0.08
Circumstances	80	3.26	1.08	1	5	4	0.12
WorkHours	80	40.42	12.05	10	100	90	1.35
Company_Size	80	33439.57	158772.67	1	1000000	999999	17751.32
Company_Age	80	31.60	31.52	1	150	149	3.52

Table 9: Output of Cronbach's Alpha computation

Lower	Alpha	Upper
0.61	0.71	0.81

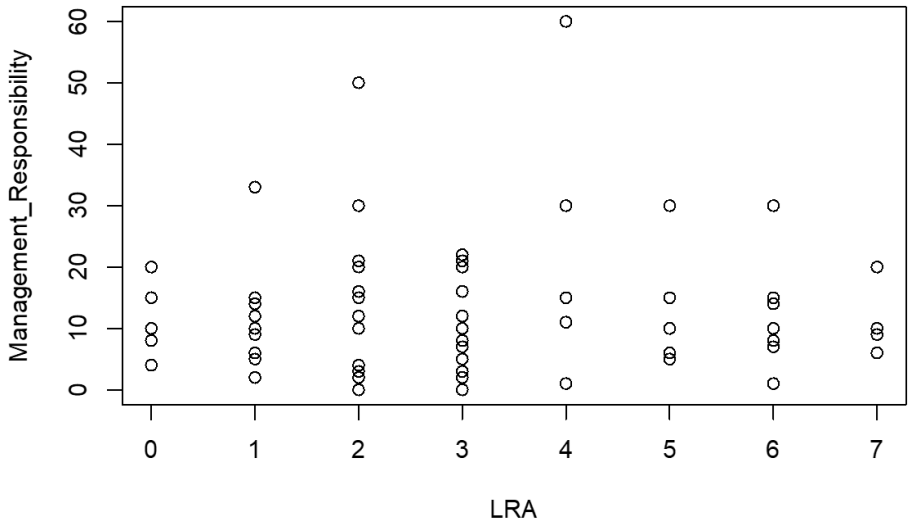

Figure 4: Management_Responsibility mapped against LRA

Table 10: Regression Output Model 1

Regression Analysis

t test of coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	-0.2192	7.4465	-0.03	0.9766	
LRA	0.4857	0.5635	0.86	0.3929	
Age	0.1112	0.0947	1.17	0.2460	
Circumstances	2.5553	1.1000	2.32	0.0243	*
WorkHours	0.2059	0.1106	1.86	0.0686	.
Male	2.1124	2.6680	0.79	0.4322	
CS	-1.8718	2.9549	-0.63	0.5293	
Natural	-2.1841	4.3030	-0.51	0.6140	
Formal	-0.0623	4.0629	-0.02	0.9878	
Engin	-3.9128	3.2638	-1.20	0.2362	
Humanities	-8.1564	3.9182	-2.08	0.0425	*
SocialSci	3.5158	3.2479	1.08	0.2842	
Bachelor	-4.6511	4.0782	-1.14	0.2595	
Master	-3.0174	4.3789	-0.69	0.4940	
No_Degree	-10.6549	6.5233	-1.63	0.1087	
MBA	38.9675	4.6315	8.41	3.8e-11	***
GPA	-1.7827	1.8294	-0.97	0.3345	
P_Bachelor	1.7516	3.3457	0.52	0.6029	
P_Master	-11.2146	3.2580	-3.44	0.0012	**
P_No_Degree	19.3329	13.2042	1.46	0.1494	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 8.04 on 50 degrees of freedom
(10 observations deleted due to missingness)
Multiple R-squared: 0.574, Adjusted R-squared: 0.413
F-statistic: 3.55 on 19 and 50 DF, p-value: 0.000169

general quadratic (4), general cubic (5) and depressed cubic (6) function, a log-lin/lin-log/log-log function was not formulated due to zero values in LRA and Management Responsibility resulting in discontinuous functions.

$$\begin{aligned} Model2: Management\ Responsibility_i \\ = \beta_0 + \beta_1 \times LRA_i + \beta_2 \times LRA_i^2 + \beta_3 \times GPA_i \\ + \beta_4 \times Circumstances_i + \beta_5 \times WorkHours_i \\ + Binary\ Variables + u_i \end{aligned} \quad (4)$$

$$\begin{aligned} Model3: Management\ Responsibility_i \\ = \beta_0 + \beta_1 \times LRA_i + \beta_2 \times LRA_i^2 + \beta_3 \times LRA_i^3 \\ + \beta_4 \times GPA_i + \beta_5 \times Circumstances_i \\ + \beta_6 \times WorkHours_i + BinaryVariables + u_i \end{aligned} \quad (5)$$

$$\begin{aligned} Model4: Management\ Responsibility_i \\ = \beta_0 + \beta_1 \times LRA_i + \beta_2 \times LRA_i^3 + \beta_3 \times GPA_i \\ + \beta_4 \times Circumstances_i + \beta_5 \times WorkHours_i \\ + BinaryVariables + u_i \end{aligned} \quad (6)$$

Table 11 shows that all models are significant at 1%-level (F_{Model2} (20, 49) = 3.56; $F_{Model\ 3}$ (20, 49) = 3.61) but have slightly differing values for Adjusted R Squared. Most variance in Management Responsibility can be explained by the variance in the independent variables of the (depressed) cubic model 4 (adjusted R squared = 0.431). Unfortunately, even with this best model less than 50% of the variation in the output can be explained. Despite this the cubic model yields LRA∧3 as estimator at the 10%-level (SE = 0.025, p = .051) Although it is not significant at the 5%-level convention, with p = .051, in our application the estimator can be interpreted as statistically significant. Logical Reasoning Ability is an estimator of Management Responsibility. The regression coefficient estimate of 0.049 indicates a positive relationship between. Thus, Hypothesis 1 cannot be rejected. Age (SE = 0.094, p = .096) and Circumstances (SE = 1.090, p = .077) are other explanatory variables that are significant at the 10%-level, with both having a positive relationship with management responsibility. According to the model, aging 1 year increases management responsibility by 0.157 employees on average. Furthermore, the amount of work per week (SE = 0.116, p = .032) is significant at the 5%-level, positively influencing management responsibility.

Finally, four binary variables are found to be significant; *Humanities* (SE = 3.92, p = .018) and *No_Degree* (SE = 6.36, p = .02) at a 5%-level, and *MBA* (SE = 4.42, p < .01) and Parents' Master (SE = 3.19, p < .01) at a 1%-level. Therefore, managers with the major *Humanities* have significantly different management responsibility as the reference category (*Business* major managers), analogically management responsibility of managers with *No_Degree* & *MBA* is different from High School Diploma managers and managers with a parental Masters degree are different from managers with parental High School Diploma. Otherwise put, on average, 1. managers with a humanities degree have 9 employee lower management responsibility than ones with business degrees, 2. managers with no degree have a 14 employee lower, 3. managers with an MBA have a 39.5 employee higher management responsibility than ones with high school diplomas, and 4. managers with parents that received a Masters degree have 11.6 employee less management responsibility.

4.3. Descriptive Statistics Findings

After discussing and computing the econometric model, remaining hypotheses will be answered through descriptive statistics.

4.3.1. Comparing Means

H3 Are managers majored in formal science the best logical reasoners?

The ANOVA-Test yields that the difference in LRA means between all majors is statistically significant (F (6, 73) = 4.3; p < .01). As seen in Appendix C, on average, managers with a formal science degree score highest on LRA ($\bar{x}$ = 5.57; SD = 1.72). Consequently, Hypothesis 3 cannot be rejected.

How much better are managers majored in formal science at logical reasoning?

A T-Test is executed, to investigate the mean difference between managers with formal science background and all other managers. Assuming equal variances (Levene's-Test: F (1, 78) = 0.72; p = .4), the T-Test yields that the compared means are statistically significant from each other (t (7) = -4; p < .01). Managers majored in formal science ($\bar{x}$ = 5.57; SD = 1.72) on average have a 2.52 point higher LRA score than other managers ($\bar{x}$ = 2.95; SD = 1.82)

To examine the effect size of these 2.52 points (telling how big the 2.52 point difference is in relation to the pooled standard deviation), *Cohen's d* is computed (Cohen, 2013). With d = 1.46 the LRA score difference between groups of managers is large (Lakens, 2013).

H4 Do STEM-major managers have higher logical reasoning ability than others?

STEM is computed as a binary variable of which value "1" can be associated with Natural Science, Computer Science, Formal Science and Engineering and "0" with all other majors. The mean in LRA between STEM managers and non-STEM managers has to be compared. The same procedure as above applies. First, it is ascertained if equal variances between the two samples can be assumed. Levene's-Test (Levene, 1960) indicates that the nullhypothesis of variance equality can be rejected (F (1, 78) = 7.67; p = .007). The subsequent T-Test yields that the compared means are statistically different with a confidence level of 10% (t (69) = -2; p = .09). Managers majored in STEM ($\bar{x}$ = 3.56; SD = 2.22) on average have a 0.759 point higher LRA score than Non-STEM managers ($\bar{x}$ = 2.8; SD = 1.6). Cohen's d = 0.4 shows that

Table 11: Regression overview, Model 1-4

Regression Results

	Dependent variable:			
	Management Responsibility			
	(1)	(2)	(3)	(4)
LRA	0.486	-2.320	1.260	-1.390
	(0.564)	(1.900)	(4.360)	(1.180)
	p = 0.389	p = 0.224	p = 0.773	p = 0.240
LRA_squared		0.437	-1.020	
		(0.272)	(1.530)	
		p = 0.109	p = 0.506	
LRA_cube			0.149	0.049*
			(0.146)	(0.025)
			p = 0.305	p = 0.051
Age	0.111	0.152	0.155*	0.157*
	(0.095)	(0.094)	(0.091)	(0.094)
	p = 0.241	p = 0.107	p = 0.088	p = 0.096
Circumstances	2.560**	2.060*	1.780*	1.930*
	(1.100)	(1.100)	(1.050)	(1.090)
	p = 0.021	p = 0.062	p = 0.089	p = 0.077
WorkHours	0.206*	0.242**	0.253**	0.249**
	(0.111)	(0.117)	(0.114)	(0.116)
	p = 0.063	p = 0.039	p = 0.027	p = 0.032
Male	2.110	2.280	3.130	2.570
	(2.670)	(2.530)	(2.810)	(2.520)
	p = 0.429	p = 0.368	p = 0.265	p = 0.309
CS	-1.870	-1.480	-1.700	-1.520
	(2.960)	(2.820)	(2.730)	(2.810)
	p = 0.527	p = 0.599	p = 0.536	p = 0.589
Natural	-2.180	-3.160	-2.600	-3.060
	(4.300)	(4.410)	(4.280)	(4.270)
	p = 0.612	p = 0.474	p = 0.544	p = 0.474
Formal	-0.062	-2.400	-3.250	-2.880
	(4.060)	(4.670)	(4.310)	(4.570)
	p = 0.988	p = 0.608	p = 0.451	p = 0.530
Engin	-3.910	-5.290	-6.080*	-5.670
	(3.260)	(3.570)	(3.500)	(3.580)
	p = 0.231	p = 0.139	p = 0.083	p = 0.114
Humanities	-8.160**	-9.050**	-9.590**	-9.300**
	(3.920)	(3.840)	(4.100)	(3.920)
	p = 0.038	p = 0.019	p = 0.020	p = 0.018
SocialSci	3.520	4.870	6.770	5.610
	(3.250)	(4.410)	(5.610)	(4.750)
	p = 0.280	p = 0.269	p = 0.228	p = 0.238
Bachelor	-4.650	-4.370	-5.350	-4.670
	(4.080)	(3.920)	(4.060)	(3.900)
	p = 0.255	p = 0.265	p = 0.188	p = 0.232
Master	-3.020	-3.020	-4.670	-3.560
	(4.380)	(4.260)	(4.420)	(4.260)
	p = 0.491	p = 0.479	p = 0.290	p = 0.404
PhD				
No_Degree	-10.700**	-14.000**	-15.700**	-14.800**
	(6.520)	(6.250)	(6.830)	(6.360)
	p = 0.022	p = 0.026	p = 0.022	p = 0.020
MBA	39.000***	39.500***	39.500***	39.600***
	(4.630)	(4.450)	(4.450)	(4.420)
	p = 0.000	p = 0.000	p = 0.000	p = 0.000
GPA	-1.780	-1.690	-1.530	-1.630
	(1.830)	(1.920)	(1.890)	(1.910)
	p = 0.595	p = 0.379	p = 0.419	p = 0.394
P_Bachelor	1.750	3.040	3.920	3.440
	(3.350)	(3.440)	(3.330)	(3.420)
	p = 0.591	p = 0.377	p = 0.239	p = 0.315
P_Master	-11.200	-11.600***	-12.800***	-12.000***
	(3.260)	(3.140)	(3.630)	(3.190)
	p = 0.396	p = 0.0003	p = 0.0005	p = 0.0002
P_PhD				
P_No_Degree	19.300	20.000	18.900	19.700
	(13.200)	(12.800)	(12.600)	(12.600)
		p = 0.118	p = 0.136	p = 0.119
Constant	-0.219	0.377	-1.070	-0.042
	(7.450)	(7.810)	(8.320)	(7.680)
	p = 0.977	p = 0.962	p = 0.898	p = 0.996
Observations	70	70	70	70
R2	0.574	0.592	0.600	0.596
Adjusted R2	0.413	0.426	0.424	0.431
Residual Std. Error	8.040 (df = 50)	7.960 (df = 49)	7.960 (df = 48)	7.920 (df = 49)
F Statistic	3.550*** (df = 19; 50)	3.560*** (df = 20; 49)	3.420*** (df = 21; 48)	3.610*** (df = 20; 49)
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 12: Correlation Overview LRA-Age and LRA-GPA

		Age	GPA
LRA	*r*	0.00418	0.0196
	t	0.04	0.2
	df	78	68
	p	1	0.9

Table 13: Overview of strong significant correlations

		r	p
HighSchool	Bachelor	- 0.573	<.001
Bachelor	Master	- 0.573	<.001
Humanities	No_Degree	0.436	<.001
HighSchool	P_HighSchool	0.419	<.001
HighSchool	P_Bachelor	- 0.523	<.001
P_HighSchool	P_Bachelor	- 0.85	<.001
HighSchool	Circumstances	- 0.417	<.001
P_Bachelor	Circumstances	0.463	<.001
MBA	Management_Responsibility	0.499	<.001

this difference is small (Cohen, 2013; Lakens, 2013). Consequently, Hypothesis 4 is supported.

H6 The more senior the degree the higher the logical reasoning ability?

Appendix C displays managers with a master's degree on average score highest on Logical Reasoning Ability ($\bar{x} = 4$, SD = 1.93), whereas managers with high school diploma score lowest ($\bar{x} = 2.88$, SD = 2.19); with MBA and No_Degree being excluded from the comparison as n=1. However, the ANOVA-Test (F (4, 75) = 1.55; p = .2) yields that the difference in means is not statistically significant. Hypothesis 6 can be rejected.

4.3.2. Correlations

To validate Hypotheses 2 and 5, Pearson Correlation Coefficient *r* and its statistical significance measures for a. LRA & Age and b. LRA & GPA are computed (Table 12). Unfortunately, both correlations a. (t (78) = 0.04 & p = 1) and b. (t (68) = 0.2 & p = .9) are not significant at all. Hypotheses 2 and 5 can be rejected.

To explore potentially important findings that were not part of the initially stated hypotheses, the correlation analysis is expanded. Table 13 represents a correlation matrix of all numerical variables from our dataset, filtered by Pearson Correlation Coefficient $r > 0.4$ and significance at the 5%-level.

Interestingly, MBA and Management Responsibility have a moderate (Schober, Boer, & Schwarte, 2018) but significant and positive correlation of r = 0.499 (p < .01). This means– to some extent - increased Management responsibility comes with increased likelihood of attaining a MBA, vice versa. Another finding is that better circumstances in which a manager was raised are associated with a higher likelihood attaining a bachelor's degree (r = 0.463; p < .01). Inversely, worse circumstances are associated with a higher likelihood only attaining a high school degree (r = -0.417; p < .01), vice versa.

4.4. Task Performance

Table 14 displays the percentage of correct answers per question. Managers performed best on question 2 (66.2%), 3 (58.8%) and 6 (65%), whilst only around a third of the participants could answer question 1 (36.3%) and question 4 (35%) correctly. The by far lowest score is associated with Question 8 where 91.25% of the managers were unable to solve correctly. This implies that managers did particularly well with Modus Ponens, Modus Tollens and logical ordering but faced great hurdles with the affirmation of the consequent and, especially, with the selection task. In the next chapter it will be discussed how far these results deviate from previous studies

4.5. External Validity

Data collection being executed with *Amazon Mechanical Turk*, following assumption has to be made to ensure external validity: The *Amazon Mechanical Turk* participant pool is a valid representation the population of U.S. managers. Apart from the assumption, "U.S. managers" can be generalized to "managers" which usual in management science (Hunter & Hunter, 1984; Slaski & Cartwright, 2002; Sternberg & Wagner, 1992)

On a final note, it is important to mention the limited external validity in regard to management responsibility. As the sample (excluding outliers) consists only of managers with responsibility of less than 100 persons, the sample does not represent more senior managers.Conclusively, the sample is externally valid – representing managers and their logical reasoning ability – insofar they have management responsibility of less than 100.

Table 14: Performance per Question

Question	Answered correctly (in %)
1	36.2
2	66.2
3	58.8
4	35
5	47.5
6	65
8	8.75

5. Discussion

In this section, the findings from chapter 4 will be discussed and set into the context of current literature as presented in section 2. Additionally, the limitations of this research will be critically considered, and potential further research will be proposed.

5.1. Comparing Results to Literature

After covering the first part of the research question, namely the influence logical reasoning ability has on management responsibility, this section is dedicated to the second part. How logically sound is managerial decision making in comparison to other populations?

As the logical reasoning ability assessment includes multiple questions that are identical to ones that were featured and applied in peer-reviewed papers, task performance can be compared.

Table 15 displays the results of this study, together with the findings of other studies focused on students' logical reasoning ability.

The results from last chapter can be confirmed by the other studies. US students also did well with the Modus Ponens task and Modus Tollens (96% correctly answered each).

And just like the managers, students struggled with the affirmation of the consequent task (53% of Finnish & 80% of US students answered correctly) and faced their biggest challenge in the selection task (which only 20%, respectively 10%, of US undergraduate students could master).

However, what comes to a surprise is the strong underperformance of managers. In every compared question, far less managers (on a relative scale) were able to answer correctly.

In conclusion, managers are worse than students in logical reasoning.

5.2. Summary of Results

All in all, a diverse set of findings could be made. Firstly, the developed logical reasoning assessment proved to be internally consistent. Secondly, although the proposed statistical model has low explanatory power, the econometric analysis yielded a positive cubic relationship between logical reasoning ability and management responsibility. Moreover, managers majored in formal science score highest in logical reasoning ability. The difference in LRA scores, comparing managers with formal science background to all other managers, is large. More so, managers with STEM majors perform better in logical reasoning tasks than others.

Thirdly, neither age nor GPA are correlated to the logical reasoning ability of managers. Instead with moderate significant correlation, it could be found that better raising conditions are associated with a higher likelihood attaining a bachelor's degree. Inversely, worse conditions are associated with a higher likelihood only attaining a high school degree.

Finally, comparing sample to literature the managers score worse than students. In every compared dimension, the managers from this study scored worse than university students that were exposed to the same tasks in previous studies. All implications the analysis gave us regarding the in the beginning argued hypotheses are summarized in Table 13.

5.3. Limitations

Omitted Variables

Endogeneity could not only stem from simultaneity, but also from omitted variables. To be considered as omitted, variables must necessarily be a) highly correlated with exogenous variables, like logical reasoning ability, and b) an predictor of management responsibility. Variables that could have been omitted include the following.

Tacit Knowledge & Emotional Intelligence: Both, tacit knowledge and emotional intelligence (referred to as "EQ") have not been included to the regression. Emotional intelligence is a predictor of management responsibility (Cavazotte, Moreno, & Hickmann, 2012). Unfortunately, there is no research on the relationship, not to mention the correlation, between emotional intelligence and logical reasoning ability. In contrast, the relationship (correlation) between emotional intelligence and IQ is researched; but there is equivocality whether the correlation is strong, weak, positive, negative or can be disregarded (Arteche, Chamorro-Premuzic, Furnham, & Crump, 2008; Furnham, 2009; Nath, Ghosh, & Das, 2015). Plus, although there has been research on the relationship between emotional intelligence and age, it only yielded weak a correlation between the two variables (Nikolaou & Tsaousis, 2002; Sjöberg, 2001). In light of those indications, together with the limited resources of this paper

Table 15: Logical Reasoning Assessment resuls in comparison to literature

Answered correctly (%) / Question	Managers	Finnish University Students (Holvikivi, 2007)	US University Students (D'Andrade, 1995)	US Undergraduate Students (Wason, 1968, from D'Andrade, 1995)	US Undergraduate Students (Wason & Johnson-Laird, 1972)
1	36.2	53	80	/	/
2	66.2	/	96	/	/
3	58.8	92	96	/	/
4	35	/	/	/	/
5	47.5	53	82	/	/
6	65	/	/	/	/
8	8.75	/	/	20	10

Table 16: Answered Hypotheses Overview

Hypothesis 1	Logical Reasoning Ability can be associated with management responsibility. The relationship is cubic.
Hypothesis 2	A manager's age is not correlated to his/ her logical reasoning ability.
Hypothesis 3	Managers majored in formal science score highest in logical reasoning ability. Additional Finding: There is a significantly large difference in LRA scores when managers with formal science background are compared to all other managers.
Hypothesis 4	STEM majored managers have higher LRA scores than other managers. However, this difference has limited statistical significance and has a small effect size.
Hypothesis 5	A manager's GPA is not correlated to his/ her logical reasoning ability.
Hypothesis 6	There is no significant LRA difference between managers with differing seniority in their degrees.

in mind, the idea of conducting an additional emotional intelligence test was discounted. Like emotional intelligence, tacit knowledge has been identified as predictor of management success by literature. However, researchers also discovered the correlation between managerial tacit knowledge and IQ to be negligible (Sternberg & Wagner, 1992). Assuming those findings represent the reality, no omitted variable bias would result from excluding these variables from the regression. Though, as the assumptions on tacit knowledge and emotional intelligence don't come with high certainty, their exclusion from analysis can be seen as limitation.

General Intelligence: General intelligence (Spearman, 1961) is very likely highly correlated with logical reasoning ability and age. It could also be an explanatory variable of management responsibility. Especially the second condition must have had been tested in order to rule out potential bias. However, conducting an extra intelligence test would be out of scope of this paper.

Genetic Factors: Although genetic influence has been controlled for, by including parental education to the regression, there may be genetic unobservable confounders correlated to logical reasoning ability and predicting management responsibility.

Data Collection

There are two limitations. Firstly, although approaching the data collection meticulously methodological, the sample of US-Managers from *Amazon Mechanical Turk* may not be representing the population. Secondly, due the limited resources the renumeration was around $10/h. This fact carries a big limitation. Critics could argue the data is biased

as managers with higher pay claims were excluded from the analysis. This can be considered as the biggest limitation of this paper.

Simultaneity

The findings are limited to the two assumptions made regarding reverse causality of managers' and their parents' educational backgrounds.

Causal Inference

All methods described in this paper are based on observational data and come with important limitations. Conclusively, assertions on causality are strictly denied.

Unobservable Time-Dependent Confounders

Unobservable factors like time-dependent changes in the educational system or time-dependent trends in the managerial job market may influence the established econometric models.

5.4. Further Research

Firstly, research could be conducted with the same research question as in this paper, but with extended resources. This would imply a) an inclusion of tacit knowledge and emotional intelligence assessments (and commensurate extension of the econometric model) plus, b) a larger sample including a representative number of managers with management responsibility over 100 people.

Secondly, and most prominently, an investigation of the importance of logical reasoning ability for managers is recommended. This would include the question whether logical reasoning ability is important for other measures of management success (apart from management responsibility). And further, it includes an investigation in which a) industries and b) managerial roles logical reasoning is most essential.Thirdly, combining quantitative with qualitative data, researchers could investigate the way the managers reason and how they solve logical reasoning tasks, depending on their background and current occupation.

Moreover, the significant and strong difference in LRA between managers who studied formal science manager in comparison to other managers was explored. But a causal statement cannot be made. The resulting recommendation is finding out if the formal science educational background leads to strong logical reasoning ability or if the relationship is inverse. Lastly, it would be crucial to know why managers in this study performed way worse when compared to students and their results from other studies.

6. Conclusion

Quantitative studies on logical reasoning in management are rare to non-existent. Accordingly, the relationship between management responsibility (or success) and logical reasoning ability of managers has not found lot of attention in literature so far. Making groundbreaking causal inference claims was not the aspiration of this paper. Instead, it aimed at finding first intuitions in this less researched yet important area of management literature.

Going back to the philosopher king metaphor, it could be shown that increased logical reasoning ability can be associated with increased management responsibility with limitations in mind (low R^2, low effect-size of the estimate). Moreover, managers with formal science experience seem to perform better in logical reasoning. Figuratively speaking, being experienced to think like a philosopher might be beneficial for a management career. After building first grounds in this field of study, it would be great if fellow researchers would investigate this or an adjacent topic (with the aim to explore causal relationships); with more resources, thus less limitations.

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Digital Transformation in Family Businesses

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Abstract

Nowadays, the impact of digital technologies on all businesses is inescapable for their managers and is receiving a great deal of attention in research and businesses. Digitalization as an ongoing process has just begun and will continue to drive many decision-making processes. So far, much research has been done on technical implementations and digital technologies as such, but there is still a lack of research on the decision-making processes around digitalization, especially in small and medium-sized businesses with limited resources, such as the economically important family businesses (FBs) in Germany. These FBs have a massive impact on value creation in Germany and include many global market leaders. Based on eleven interviews with family and non-family member Chief Executive Officers (CEOs) and employees, the thesis shows which drivers and barriers exist in the digitalization process in FBs and how they influence the process. Moreover, their influence on the digitalization of the business model is examined. The results of the thesis provide implications for how FBs can successfully master digitalization and use it to their advantage. Finally, the thesis suggests opportunities for future research in digitalization in FBs and on identified correlations in the cases.

Keywords: Digital transformation; Family business; Digitalization.

1. Introduction

Digital transformation is defined as the process of change through the integration of digital technologies in work processes, products and services, and the overall business model of organizations (Kammerlander, Soluk, & Zöller, 2020) and it is increasingly influencing the decision-making process of organizations (Karimi & Walter, 2015). In addition, digital transformation will continue for a long time to come, as the coming new generations of digital technologies will continue to drive the process of digital transformation (Oswald, Saueressig, & Krcmar, 2022). Moreover, it influences the overall long-term success of organizations (Bharadwaj, El Sawy, Pavlou, & Venkatraman, 2013) and provides many new business opportunities for organizations to develop their business model and value creation (Yoo, Henfridsson, & Lyytinen, 2010). Especially many organizations from the industrial sector, in particular, have immense potential through the integration of new digital technologies (Kammerlander et al., 2020), for example through new ways of bringing their products to the customers.

Furthermore, prior research underscores the success of businesses that have established digital technologies and continue to address societal and organizational challenges through highly innovative approaches (Bharadwaj, 2000; George, Merrill, & Schillebeeckx, 2021). Digital technologies based on hardware, software, and networks and built on binary digits (von Briel, Davidsson, & Recker, 2018), such as digital twins, artificial intelligence, or cloud computing, require all organizations to adapt their business models to successfully implement the new technologies (Spieth, Schneckenberg, & Ricart, 2014). Nevertheless, the introduction of digital technologies is associated with many challenges and represents a new area of business for organizations, which is associated with a lack of knowledge and in most cases requires external support (Kammerlander et al., 2020). In most organizations, entirely new capabilities need to be

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built, for instance, in IT or logistics, to deal with the newly implemented technologies (Nambisan, Lyytinen, Majchrzak, & Song, 2017), which pushes some organizations to the limits of their capacity and requires intensive efforts (Kammerlander et al., 2020).

De Massis, Audretsch, Uhlaner, and Kammerlander (2018) see FBs, which are characterized by the fact that the family exerts a considerable influence on the business policy of the company (Kammerlander et al., 2020), in particular affected by these challenges posed by digital transformation due to their limited financial resources. Furthermore, despite previous research, there is still a knowledge deficit regarding the drivers and barriers of digital transformation in general and in particular in the area of FBs and specifically in their business model innovation. However, for various reasons, such as their limited financial resources, FBs have a highly efficient conversion rate that measures input into output (Duran, Kammerlander, Van Essen, & Zellweger, 2016) and supports the high research interest in their business decisions.

In addition, the German Mittelstand, which comprises small and medium-sized businesses with sales of less than 50 million Euros and includes many of the German FBs (Kammerlander et al., 2020), accounts for an immense share of value-added and total economic output in Germany and thus influencing Germany as a business location overall. Moreover, the German Mittelstand, also known as small and medium-sized enterprises (SMEs) (Federal Ministry for Economic Affairs and Energy, 2020), is highly relevant for Germany as a business location as such. According to the Federal Ministry for Economic Affairs and Climate Action (BMWK), around 60% of jobs in Germany are created by the Mittelstand and around 99% of German companies belong to the Mittelstand (Federal Ministry for Economic Affairs and Energy, 2020). In addition, around 35.3% of Germany's total sales are generated by the Mittelstand, which underscores the great importance of these companies to the economic situation in Germany (Federal Ministry for Economic Affairs and Climate Action, 2020).

1.1. Research Question and Goal Setting

Given the importance of the FBs for Germany, the challenges associated with digital transformation, including the establishment of digital technologies, raise the following research question: How do the digitalization drivers and barriers in FBs promote or impede the overall digitalization process and, in particular, the business model transformation?

Answering this research question is important because business model transformation varies in different management systems, which requires further research on business model innovation in FBs because their business decisions differ from those in non-family businesses (Newbert & Craig, 2017). Furthermore, focusing on the digitalization drivers and barriers in FBs will help to get a more detailed overview of the business decisions and to investigate the digitalization process, which will help to better understand the transformation process of the FBs' business model. Business model transformation changes how the company creates value for its customers and how it acquires that value, which also defines the business model as such (Sorescu, 2017).

It is precisely the diversity of FBs that leads to many differences in the overall digitalization process and makes it relevant to further analyze several FBs in more detail. In addition, the owning families who hold and operate the FBs bring further diversity and, with their different backgrounds and knowledge (Kammerlander et al., 2020; Nordqvist, Hall, & Melin, 2009), can provide deeper insights into the digitalization processes and the basis for a successful FB in the long term. While previous research has examined business model innovation in general and has not differentiated between businesses other than their size and revenues, the objective of this thesis is to examine the processes within business model transformation in FBs. In addition, the driving and hindering factors of this process in FBs are examined, as well as the influence of the fact that these businesses are controlled or managed by a small number of families or just one family (Kammerlander et al., 2020).

1.2. Methodological Approach and Structure of the Thesis

To investigate the research question, a qualitative research study was conducted to obtain a detailed and accurate analysis of the cases related to the research question. For this purpose, eleven people of FBs, including family members, non-family member CEOs, and non-family member workers, were interviewed. The number of interviewees depended on the availability and cooperation of the FBs. Most FBs were located in the Heilbronn-Franconia area, as many FBs are located in this area and the close connection through my network within the Heilbronn-Franconia area ensured easier access.

To ensure the best possible insights, the FBs were of similar size in terms of revenue and number of employees. Moreover, the business areas of the FBs were different, as the focus was on the digitalization process and different knowledge backgrounds can provide a broader field of insights into the digitalization process. In addition, the interviewed employees must have worked in FBs that are 100% family-owned and thus control all day-to-day operations or have a strong say in the process to ensure that the research is as generalizable as possible to FBs.

The method of data collection was semi-structured interviews using a guideline. Depending on the preference of the interviewee, the interviews were conducted online via Microsoft (MS) Teams, by telephone, or in person. The interviews were conducted according to the following scheme: First, there was a short introduction, followed by the second section looking for the drivers and barriers of digitalization in FBs. The third section focused on the business model transformation process within FBs. The final fourth section of the interview guideline allowed the interviewee the opportunity to add further important points or improve the interview guideline, as well as a small conclusion and summary of the interview.

After analyzing the given inputs from the interviews, the results are presented and compared in this thesis. The structure of the thesis is divided into four sections: the theoretical framework, the research methodology, the results and findings, and the discussion and conclusion. The theoretical framework provides an overview of digital transformation in FBs. This part covers the drivers and barriers of digital transformation in FBs and, in particular, examines the connection with the fact that all the studied businesses are family-owned. The following section corresponds to the research methodology, and it contains the rationale for the qualitative research design and its structure, as well as the form of data collection with semi-structured interviews in more detail. Furthermore, it includes the data analysis to identify more patterns within the cases, (i.e., similarities or dissimilarities). Third, the results and findings from the analyzed FBs are presented to be discussed in the fourth part of the thesis, the discussion and conclusion. Finally, the discussion and conclusion summarize the main findings and results of the thesis and use them to provide a final answer to the research question. This section also explains the contribution of the thesis, draws implications for FBs' managers, and identifies future research topics in the field of digitalization in FBs that remained unanswered.

2. Theoretical Framework: Digital Transformation in Family Businesses

2.1. Digitalization Drivers in Family Businesses

Since digitalization has been a continuous process over the last decades and will continue to have a massive impact on the FBs' performance and success (Gómez, Salazar, & Vargas, 2017), it is very important to understand the drivers of digitalization to develop tailored solutions. Drivers of digitalization are commonly referred to as the circumstances that drive the development of digitalization or further extend the barriers to digitalization (Faber, 2019). These drivers can be, for example, economic opportunities, improved productivity, or a changed customer segment that now has to be supplied differently from the previous customer segment (Kammerlander et al., 2020). Moreover, they influence most of the business decisions and have an impact on most of the FBs' working processes (Soluk, Miroshnychenko, Kammerlander, & De Massis, 2021). Furthermore, for the successful introduction of digital technologies in FBs, it is important to know how they need to be deployed to properly meet the requirements of digitalization (Faber, 2019).

These digitalization drivers are highly relevant to accelerate digitalization as such and to ensure continuous development and overcome barriers within digitalization (Kammerlander et al., 2020). The goal of the thesis is to advance former research and find additional digitalization drivers within FBs. In addition, the diverse backgrounds and knowledge of the interviewed FBs provide a broader insight into the drivers within FBs to drive the digitalization process. Moreover, knowing the digitalization drivers can help to innovate the business model more efficiently and successfully and will be analyzed in more detail using the key elements of the Business Model Canvas (BMC).

2.2. Digitalization Barriers in Family Businesses

In addition to the knowledge of the digitalization drivers, a good understanding of the digitalization barriers is important to overcome these barriers smoothly and without major difficulties. In all the different phases of digitalization, the barriers can complicate or even prevent individual steps of digitalization (Kammerlander et al., 2020). Barriers are defined as all influencing factors that have an inhibiting effect on the digitalization of the FBs (Soluk & Kammerlander, 2020). These barriers may include limited financial resources, restrictive product features, or employee resistance to change (Kammerlander et al., 2020). However, to keep the complications to a minimum, it is very important to know exactly what the barriers to digitalization are. For example, addressing the barriers at an early stage could significantly reduce later high incremental costs or could significantly reduce the risk of a bad investment (Kotlar, De Massis, Frattini, Bianchi, & Fang, 2013). Furthermore, it is highly relevant to know the exact barriers of digitalization to address and overcome them as efficiently as possible so that the success of digitalization is not hindered (De Massis et al., 2018).

Getting a better overview of the digitalization barriers helps to improve digitalization as a whole, and therefore the thesis further advances former research by uncovering more barriers in the digitalization process of FBs. Due to the high diversity between FBs with all their different structures of production areas, workforces, and different proportions of the influence of the owning families, it is necessary to investigate more FBs. In addition, the barriers within the overall digitalization also help to further improve the business model transformation, which is of great importance for the overall digital transformation of the FBs.

3. Research Methodology

3.1. Qualitative Research Design

To answer the research question about the drivers and barriers of digitalization and how these affect the transformation of the FBs' business models, a qualitative research approach with multiple cases is best suited (De Massis & Kotlar, 2014; Eisenhardt, 1989). Since FBs differ in their production areas, hierarchy structures, decision-making processes, and many more business characteristics, a multi-case study was chosen to gain a broader insight into several FBs and avoid being limited by a single case study (Eisenhardt & Graebner, 2007; Nordqvist et al., 2009). The qualitative approach was chosen due to the lack of current research within specific FBs. Moreover, the qualitative approach gives a better and deeper insight into the different structures of FBs that could not be addressed by a quantitative approach, such as a survey (Eisenhardt & Graebner, 2007). Added to that, according to Bryman and Bell (2015), the qualitative research

design aims at understanding complex research questions, especially to answer 'how?' and 'why?' questions, which is of great importance for the analysis of the processes including their drivers and barriers of digitalization. Furthermore, the multiple-case format provides a rich and detailed description of specific manifestations of a phenomenon based on a large number of cases (Yin, 2003), which underscores the use of a qualitative research design with multiple cases.

The focus of this thesis is on the digitalization of FBs in the Heilbronn-Franconia area and on some outliers within a radius of 80 kilometers around Heilbronn due to their availability and accessibility. All FBs are either active in the manufacturing sector, the service sector, or the trade sector. These FBs are highly relevant to study for the following reasons to answer the research question accordingly with primary data (Eisenhardt & Graebner, 2007).

First, FBs in the Heilbronn-Franconia area are of great importance, as many of them are global market leaders in their most narrow and small market segments (Benz, Block, & Johann, 2021). Most of these FBs have been successfully managed for generations and are characterized by a high level of innovation, whether in production processes, product features, or business models (Schumm, 2020). The region Heilbronn-Franconia is one of the most successful economic regions in Germany (Benz et al., 2021; Glückler, Schmidt, & Wuttke, 2015) and is home to many FBs from a broad spectrum, such as the automotive industry, the glass industry, mechanical engineering, the packing industry, and many more (Suarsana & Glückler, 2016).

Second, most of the previously mentioned industries are currently in the process of transformation through the implementation of new digital technologies and are transforming their industrial value creation (Müller, 2019). Moreover, the topicality of the subject of digitalization threatens FBs that do not adopt new digital technologies to be overrun by transformed companies with their adapted business models (E. Weber, 2016).

Third, beyond the topicality of the issue for the FBs themselves, society is also highly affected by the digitalization of the FBs and the strategic plan initiated by the German government with the strategy paper Industrie 4.0 underlines the relevance for Germany as a business location (Niehoff & Beier, 2018). The strategy paper supports the transformation process of the German industrial sectors as such and emphasizes the importance of adapting new digital technologies within the export- and world market-driven German manufacturer sector (Niehoff & Beier, 2018). While FBs adopt digital technologies only within their established business models over many years, key partners are also affected by the slow integration or general lack of new digital technologies through their interaction with FBs and could suffer from their wait-and-see attitude (Kammerlander et al., 2020). The digitalization of FBs thus not only affects the FBs themselves but also has an impact beyond their spheres of influence (Hahn, 2020).

The sample of the thesis consists of eleven interviewees from seven FBs with different positions and backgrounds within the FBs. The interviews included family member CEOs, non-family member CEOs, and non-family member workers without a supervising function. The FBs were selected by the following selection criteria: 1.) FBs should be consistent with Chua, Chrisman, and Sharma (1999) definition of a business that is controlled and/ or managed by one or a small number of families and with the intention to pursuing the vision of the business through generations of the owning family or families (De Massis et al., 2018; Nordqvist & Zellweger, 2010). 2.) The FBs should be located in the Heilbronn-Franconia area and within a radius of 80 kilometers around Heilbronn. 3.) The FBs should be similar in size in terms of their sales of EUR 25 to 150 million and the number of employees from 200 to 1000.

The selection of FBs depended mainly on access to FBs and their availability. Therefore, the selection criteria were convenience sampling to ensure easy accessibility to the interviewees due to the limited time frame of the bachelor thesis (Creswell & Creswell, 2017; Iacobucci & Churchill, 2015). In addition, convenience sampling ensured a low-cost sampling method that was easy to conduct (Creswell & Creswell, 2017; Iacobucci & Churchill, 2015).

Due to my close connection to the Heilbronn-Franconia area and a large number of FBs in this area, the early focus was directly placed on this area. Moreover, Heilbronn-Franconia has shown an above-average growth of around 44 percent over the last 20 years and consists of eleven high-growth clusters (Kirchner, 2019). In addition, the region has very high competitiveness in the manufacturing sector, which is reflected in an export ratio of 51.4 percent (Kirchner, 2019). Through a call in the newsletter of the regional field hockey club, attached in Annex A, a large number of FBs in the area were reached and the first interviews were fixed. The interviews took place from July to August 2022 and the corresponding timeline of the interviews is attached in Annex B. In addition, my close connection to several owners of FBs ensured additional interviews. Moreover, other FBs were suggested to me during the interviews, and contacts were made. In terms of availability, a high approval rate was achieved, which simplified the overall search for interview partners. In addition, the interviews were conducted in German to further increase the consent rate for the interview requests, as most of the interviewees are native German speakers and preferred an interview in German. Because interviewees were assured of confidentiality in a consent form before the interviews, Table 1 below lists the anonymized interviewees of the case FBs in numerical order and provides additional information about the interviewees and FBs.

3.2. Data Collection: Semi-Structured Interviews

To develop an insightful and advanced interview guideline, several research papers were studied to obtain as much information as possible about the possible interview variations. After reviewing the literature on various interview techniques, the semi-structured interview format promised the most insightful data and was supported by several research papers with a perfect fit for the research question (Bry-

Table 1: List of interviewees and additional information.

	Interviewee	Family Business	Position	Employees	Sales in Mio. Euros
1.	INTV1	FB1	Family CEO	501-1000	25-50
2.	INTV2	FB1	Non-family employee	501-1000	25-50
3.	INTV3	FB2	Family CEO	501-1000	101-150
4.	INTV4	FB2	Non-family CEO	501-1000	101-150
5.	INTV5	FB3	Family CEO	201-500	51-100
6.	INTV6	FB4	Family CEO	501-1000	101-150
7.	INTV7	FB4	Non-family employee	501-1000	101-150
8.	INTV8	FB5	Family CEO	201-500	51-100
9.	INTV9	FB5	Non-family employee	201-500	51-100
10.	INTV10	FB6	Non-family CEO	201-500	25-50
11.	INTV11	FB7	Family CEO	201-500	51-100

man & Bell, 2015). As such, the semi-structured interview contributes to a high degree of objectivity by the interviewer due to its division into structured and unstructured interview parts (Bryman & Bell, 2015). In addition, the characteristics of a semi-structured interview provide a high level of trustworthiness due to the open nature of the interview, thus supporting a higher plausibility of the collected data through the interviews (Bryman & Bell, 2015; Mayer, 2012).

To develop a rigorous interview guideline, this was closely based on the findings of Bryman and Bell (2015), and Mayer (2012) and their development of a semi-structured interview guideline: First, the requirements for the use of a semi-structured interview guideline were examined. In the second step, the findings from the previous literature review on digitalization in FBs were written down and used to construct the interview questions. In the third step, a first version of the momentary interview questions was formulated to be tested in the fourth step, the pilot testing. After the interview questions went through two pilot tests and some improving changes were made, the most important interview questions were presented in the accompanying seminar for the bachelor and master thesis to further improve the interview guideline.

After the final guideline for the interviews with family member CEOs of the FBs was developed, two additional guidelines, one for the non-family member CEOs and one for the non-family member employees without supervising function, were developed. These additional guidelines were adapted accordingly to the particular interviewee (Mayer, 2012) or entirely new questions were added so that the interview guideline was always perfectly tailored to the interviewee to obtain the most insightful data possible (Yin, 2003). In addition, the interview guideline was continuously adjusted and updated after each interview during fieldwork to ensure the best possible results (Mayer, 2012). Furthermore, to increase the validity of the interviews, the interview guideline was sent out before the interview so that the interviewee could already look at the questions and make initial notes to enrich the data. The complete interview guidelines in the three different versions can be found in Annex C.

Nevertheless, to get a first overview of the concrete data collection based on the interview guideline, this is the final scheme according to which the interviews were conducted: First, there was a short introduction with basic information, the presentation of the research question, and a small overview of the interviewee, including the position in the FB and the professional career. The aim of the introduction was to create a trusting atmosphere and to collect missing basic information about the FB.

The second part addressed the drivers and barriers of digitalization in FBs and how they promote or impede digitalization. To increase the external validity of the collected data, a definition of digital transformation was given to bring all interviewees to the same level of knowledge. The second part of the interview lasted at least 20 minutes and aimed to understand the process of digitalization in FBs and to identify the specific drivers and barriers to investigate basic decision-making. In addition, the focus was particularly on the correlations with the FB as such and why these digitalization processes happened the way they did. Moreover, these drivers and barriers of digitalization in FBs help to develop a better understanding of digitalization and, in particular, of the digitalization of the business model. The knowledge of these processes within the FBs help to gain a deeper insight into the decision-making and transformation of FBs.

Third, the business model transformation process within the FBs was addressed and, in particular, the drivers and barriers of a digital business model were analyzed. The aim of the second main part of the interview was to take a closer look at the business model and to learn about the current business model and changes that have already been made. Moreover, the further development of the business model with its drivers and barriers was to be examined in a more differentiated manner. In this part of the interview, references to the general digitalization of the FBs were repeatedly made and linked.

The final fourth part allowed the interviewee the opportunity to mention further important points that have not yet been addressed. In addition, the interview topic should be reflected on a more abstract level and the interviewee could

give suggestions or feedback to further improve the interview guideline. Moreover, after the end of the interview, the first findings of the thesis could be presented and a discussion could follow. The goal of the discussion should be to either reinforce or invalidate previous findings, as well as to provide the interviewees with additional insights into the topic of the digitalization of FBs.

For example, in the version for family members, the following translated questions were asked (translated from German to English): How is the digitalization process promoted/impeded in your FB? Do you think this is influenced by the fact that you are a FB? How do you see the connection here to you as a FB and do you see any differences here to non-family-run businesses? How have you already digitized your business model and what further measures do you have planned? How is the process of changing your business model to a digitized one particularly driven by all the challenges?

3.3. Data Analysis

The vast majority of the interviews were recorded using either MS Teams or regular audio. Due to technical difficulties with the first two interviews, two recordings were lost, and in addition, two interviewees did not want to be recorded. Nevertheless, all interviews were documented and post-processing was conducted immediately following the interview to capture all key points and the most important quotes (Miles & Huberman, 2019). With the information gathered about the FBs before the interviews, some points from the interviews could be verified by taking notes on their websites or in their press releases (Creswell & Creswell, 2017).

The first step of the after-interview process was to code the data using the Gioia-Method according to Gioia, Corley, and Hamilton (2013) and conduct a within-case analysis according to Miles and Huberman (2019) to identify key elements within each case from the interview. After the within-case analysis was done for all interviews, a cross-case analysis of the data was conducted to compare these points across FBs and identify patterns (Miles & Huberman, 2019). After identifying the first-order codes, which were similar across FBs, they were classified into the overarching categories of second-order codes (Miles & Huberman, 2019). The final coding step involved linking second-order codes to aggregate theoretical dimensions (Miles & Huberman, 2019). For example, the second-order codes in which interviewees indicated the facilitating effect of the Corona pandemic, internationalization, and an increase in efficiency through digital communication channels were combined into a theoretical dimension called "Internal and External Connectivity." In addition, the aggregated theoretical dimensions were iteratively revised and tested for consistency (Eisenhardt, 1989) until sufficient coding consistency was obtained (R. P. Weber, 1990). Following the Gioia-Method (Gioia et al., 2013), seven drivers and six barriers emerged as theoretical dimensions, which are presented in Annex D as a data structure. Adherence to this procedure and the semi-structured interview guideline increased the overall reliability of the research (Yin, 2003).

4. Results and Findings

After a brief introduction to the digitalization drivers and barriers of FBs and a close look at the research methodology, the following section presents the results and findings of this thesis. First, the current state of digitalization in the sample FBs is analyzed using Soluk and Kammerlander (2020) three-phase system to provide a good overview of the different stages of digitalization and to ensure better generalizability. Subsequently, the main drivers of digitalization within the FBs are presented and further analyzed. Then, the barriers to digitalization within FBs are presented and further analyzed. After examining all these drivers and barriers with a view on the research question, the second section will focus on the impact of these drivers and barriers on the development and transformation of FBs' business models. To get a structured overview of the business model transformation, the BMC is used to analyze the impact of these drivers and barriers in a structured order.

4.1. Current Status Digitalization Sample FBs

Following Soluk and Kammerlander (2020) three stages, shown in Figure 1, and starting with the first stage, the "process digitalisation stage" (Soluk & Kammerlander, 2020, p. 691), there was positive feedback in the interviews regarding the progress within this stage. All interviewed FBs stated that digitalization within the work processes has already taken place and that only some areas within the FBs are still missing to fully complete the first phase. Among the most common responses was the digitalization of work processes through a digital Enterprise-Resource-Planning (ERP) system across almost all departments to manage company inventory more efficiently (Umble, Haft, & Umble, 2003). In addition, several other work processes are already digitalized by software, for example, in the Human Resources (HR) department with time recording systems and digital sickness reports or by digital Customer-Relationship-Management (CRM) software in which all customer data is stored. The current digitalization status of the FB from Interviewee6 (INTV6) is presented as follows:

"The high level of digitalization in our company is certainly also since we are a FB. Very early on, with a high digital affinity of individual shareholders, we invested and began to digitize work processes and services. [...] This enabled us to maintain our competitiveness early on, especially in Germany as a production location."

The great progress in the first "process digitalisation stage" (Soluk & Kammerlander, 2020, p. 691) was also affirmed by nine of the eleven interviewees. In addition, three of the interviewees already confirmed the completion of the first stage of digitalization within their FBs and that they are already focusing on the other two stages of digitalization.

The second stage, the "product and service digitalisation stage" (Soluk & Kammerlander, 2020, p. 693), is characterized less by internal digitalization processes and more by external processes. As the name suggests, the focus in this stage of digitalization is on what added value can be offered to the customer by digitizing the product and/ or service. INTV5 emphasized the business added value through the digitalization of the service and stated:

"With our newly created service offer through digital access to the customer in terms of maintenance work via Teamviewer, we can offer the customer enormous added value through a fast and much more efficient consultation for minor problems."

Nevertheless, only five of the eleven interviewees were able to confirm digital products or services in their FBs. While some FBs already offer several services online and use the close interface connection with customers and suppliers via IT-supported processes for their entire business processing, or use the new possibilities via social media and modern communication channels for more customer proximity, some FBs still lack the second stage of digitalization. For instance, INTV7 noted the dependency on the product features to determine whether product and service digitalization is possible or not:

"Our product must remain rather simple. Especially abroad, a digitized product is worse because our customers want a robust product with little digital content."

Supplementary to this statement, some FBs explained that they tend to focus on lightweight and low-cost products, which is in contrast to the digitalization of the product itself. In addition, many of the interviewees indicated that their small number of product series did not allow for further digitalization, as these product numbers were too small to digitize cost-effectively. Nevertheless, the interview guiding questions in the interviews showed that the vast majority of interviewees have already thought about digitizing their products and/ or services, and so far, either the customer demand or the technical requirements have not yet been met.

Concerning the third stage "the business model digitalisation" of Soluk and Kammerlander (2020, p. 695), only two of the seven interviewed FBs could confirm a very advanced digitalization of their business models. While the other FBs have not yet started digitizing their business models, these two FBs have mainly digitized their business model by digitizing their channels to the customer segments, their key activities, their customer segments, and even their value proposition. For example, INTV1, the family CEO of FB1, has completely transformed the channels to reach customer segments from an analog channel via in-person orders to a fully digital online ordering platform.

Moreover, FB2's non-family CEO even confirmed a complete transformation of the company's image and value proposition to broaden the company's base to fund the core business with new business opportunities. In addition, the non-family CEO of FB2 stated:

"For us, it is particularly important to address those customers who still want to use traditional [analog] products and are willing to pay for them, but we believe it is equally important to adapt to new customer groups and future target groups, especially through new digital opportunities."

Moreover, FB2's family CEO emphasized the help of digitalization through the analyzed data, which non-value-adding key activities of the business model can be removed or need to be improved. In addition, the digital capabilities for weekly monitoring of price and margin developments, as well as raw material costs, were highlighted by FB2's managing director as helping to counteract any eventualities and to guarantee a quick response to market-adjusted prices with a shorter response time.

In contrast to this, five interviewees affirmed, that they deliberately did not digitize their analog business model and their related products, as their customer segments do not demand or even reject this digitalization of the FBs' business models. Whereas their products continuously changed over the last decades, their business model was not affected by that. Furthermore, a common statement to this was that the FBs often rather wait for the necessary pressure by their customers to digitize, instead of proactively digitizing their business model. However, even these FBs agreed that more commerce should be conducted through digital relationships with customers in the future, such as sales through websites, but indicated that these are not currently their primary focus.

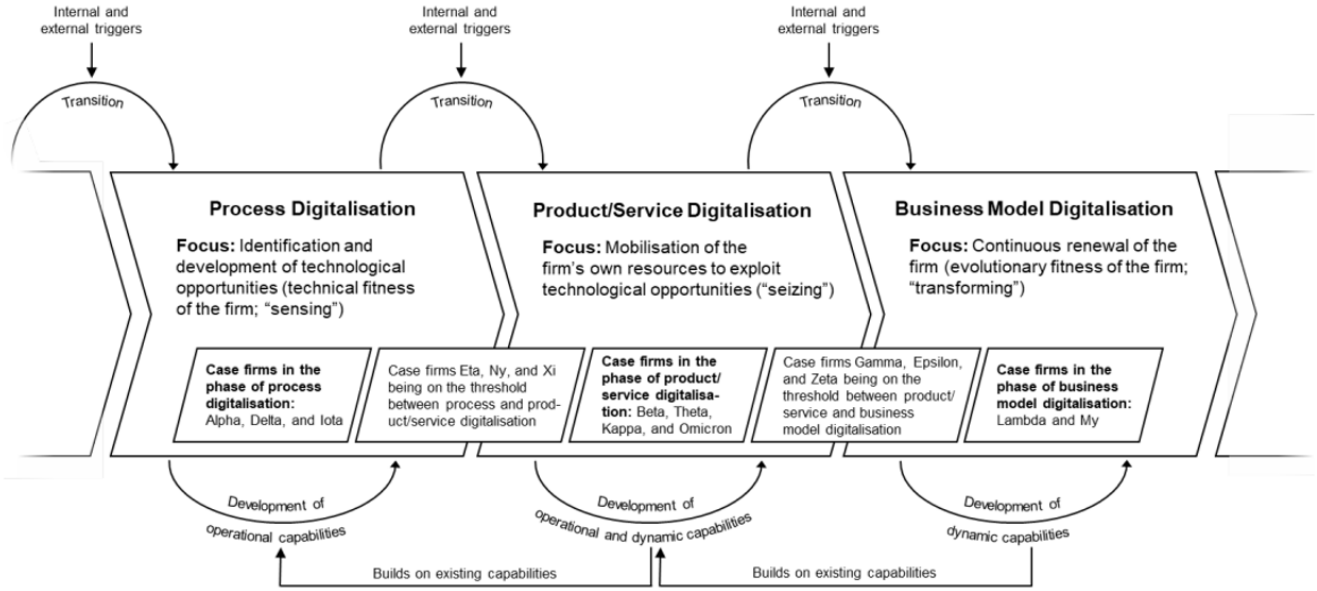
4.2. Digitalization Drivers in FBs

After providing a broad overview of the current state of digitalization in the interviewed FBs, the following section outlines the drivers of digitalization in the FBs to answer the research question. In addition, Figure 2 summarizes all drivers and barriers of digitalization in FBs.

4.2.1. Internal and External Connectivity as Driver

After two years of a pandemic situation, the way people connect has changed. For example, governmental travel restrictions or guidelines for limited meetings with a certain number of people have affected the way people communicate and have led people to digitize their communications. Furthermore, the connectivity between people within FBs has also massively changed, driving digitalization, both in terms of internal connectivity within FBs and external communication. INTV8 particularly highlighted the importance of connectivity for FBs with a high proportion of exports to international countries, as various restrictions have resulted in a lack of connections with customers and/ or suppliers. In addition, the interviewee stated that before the pandemic, the connection was easily given by a business trip to an international country, whereas now the meetings are held via digital communication platforms like TeamViewer or MS Teams. Moreover, INTV5 underscored digital success by providing virtual problem analysis via a camera transmission, which saves a lot of time and money.

Furthermore, since INTV3 and INTV7 described regionality and customer proximity as a major advantage of FBs over



Note. This chart was produced by Soluk and Kammerlander in 2020, illustrating the digital transformation process of FBs in a three-stage model. From "Digital Transformation in Family-Owned Mittelstand Firms: A Dynamic Capabilities Perspective", by J. Soluk and N. Kammerlander, 2020, European Journal of Information Systems, 30(4), p.736.

Figure 1: The digital transformation process in FBs by Soluk and Kammerlander.

their non-family competitors, the development of new digital connections to customers was driven even more strongly. Another big driver for digitalization was also the connection of four of the FBs (FB1, FB3, FB5, FB6) to larger corporations as Business-to-Business (B2B) customers, which almost "forced [us] to change over years ago so that everything runs electronically via IT systems", as stated by INTV8. Moreover, not only was external connectivity digitized, but internal connectivity became more digitized as well. Since it was already a great advantage of FBs that their internal communication was very efficient, as most employees are tied to one location and narrow work paths lead to better connectivity, digitalization made communication even faster and more efficient.

4.2.2. Improved Productivity through Digitalization

Another driver of digitalization, in addition to more efficient connectivity, is significantly improved productivity through digital technologies (Martínez-Caro, Cegarra-Navarro, & Alfonso-Ruiz, 2020), with ten of the eleven interviewees noting an increase in productivity following the digitalization of certain work processes, for example. INTV10 cited as an example an increase in efficiency through travel expense reporting via digital HR systems, digital employee time recording, or also online vacation administration on the intranet. Moreover, digital contract management is also more efficient due to its online and constant availability. In addition to such smaller investments, especially in the administrative departments, larger investments in for example Big Data within production can also massively increase productivity, as INTV6 stated:

"With the help of digitalization, I can use the analyzed data to see which non-value-adding processes I can eliminate or need to improve. Without the data collection, I would not be able to identify and improve certain weak points within the supply chain."

This described improved productivity within the production processes also ensures a competitive advantage in Germany as a production location, as otherwise, it would be necessary to outsource abroad, as many non-family-run businesses have already done.

An investment in Big Data cannot only help in the production area but is also used by FB1 to ensure greater transparency. The collected data through digital technologies feed the digital inventory management system to have a better overview of the throughput with an accurate daily overview of the products. As FB1's CEO explains, "the digital inventory management system is extremely important for managing our product range of over ten thousand products and is much more efficient than the replaced system with paper receipts and issue slips for the products." Such an increase in efficiency through digitalization underlines the importance of digitizing work processes and is one of the more important drivers for the digitalization of FBs.

4.2.3. Economic Opportunities

Due to their limited financial possibilities (De Massis et al., 2018), one of the bigger drivers of digitalization in FBs are the economic opportunities with the associated cost savings and efficiency gains through digital technologies. As

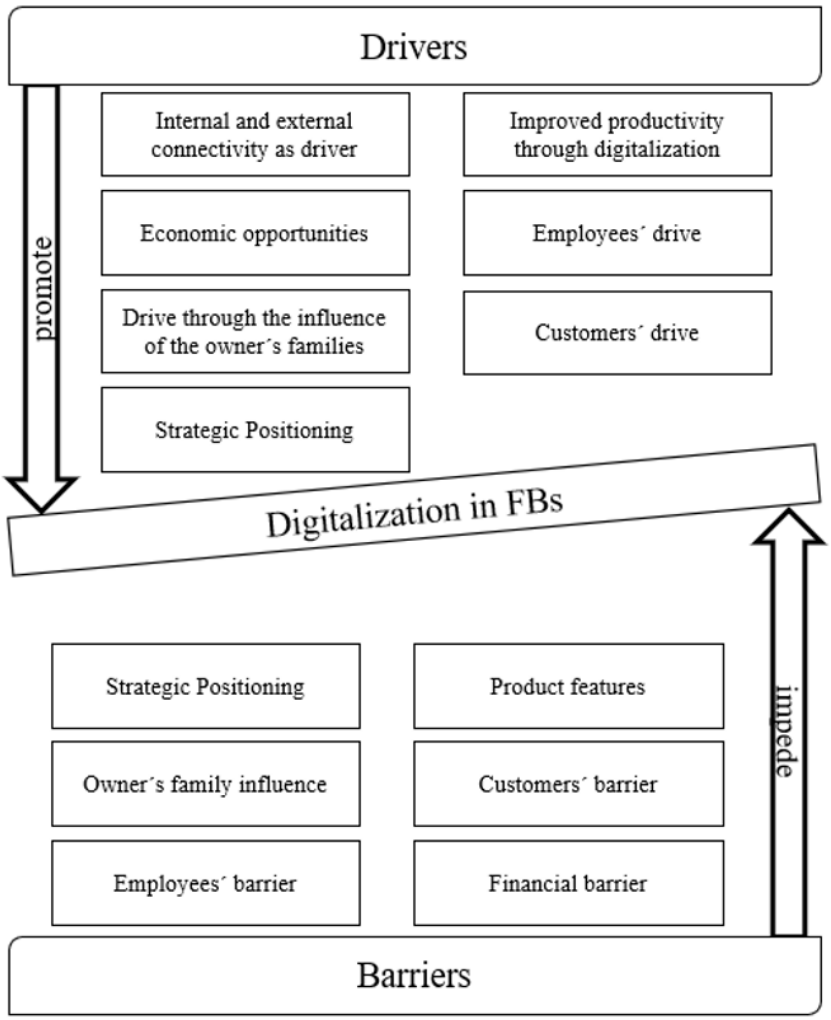


Figure 2: Drivers and barriers of digitalization in FBs.

INTV7 stated, "without digitalization, the entire work processes would not run efficiently in business terms", the big driver behind digitalization is the enormous economic potential in terms of higher productivity and cost efficiency. Moreover, as INTV5 added, a lack of further development and investments in new digital technologies leads to an investment backlog that is difficult to finance, especially for financially constrained FBs. In addition to looking at the long-term use of digital technologies, the short-term management decisions of FBs can also be supported and improved by internal transparency in controlling. For example, real-time data with accurate and transparent data sets, as already implemented in two of the FBs (FB4, FB5), support managers' decision-making processes with clear and structured data.

Furthermore, a major advantage of FBs and one of the drivers promoting the decision to invest in digital technologies is the much longer investment horizon than non-family-owned or publicly traded companies, as confirmed by all interviewees and summed up by INTV6 in the following words:

"We think and invest from generation to generation, while our non-family competitors act from quarter to quarter."

A long investment horizon, even for financially constrained FBs, is one of the main drivers in deciding for or against digitalization, since, for example, a major investment in digital technologies cannot be amortized within a few years, but theoretically only after decades.

4.2.4. Employees' Driver

In addition to promoting drivers through economic aspects, employees within FBs are also driving digitalization, as described by ten of the eleven interviewees. INTV9 primarily described the employees' demand for more digital opportunities within the FB, which is also met by the majority of the FBs through the established home office options with the integration of more digital connectivity.

Moreover, INTV3 also highlighted the drive by their in-house IT department with its developers to bring many business processes to a new digital level. While it is not only their employees who are driving digitalization in FBs, several interviewees (INTV2, 3, 7, 8) also mentioned their increased interest in hiring new employees to develop their internal ex-

pertise. INTV7 stated that the new commercial manager of an external company is one of the biggest drivers of digitalization within the FB. Furthermore, especially when looking for new employees in a tight labor market with too few qualified specialists, a certain attractiveness for new employees concerning the digital level is necessary, as INTV6 described.

4.2.5. Driver through the Influence of the Owner's Families

Concerning the influence of the owning families on the current level of digitalization within the FBs, the interviews revealed a major difference between the FBs. While some of the FBs have been massively influenced by the high digital affinity of individual family members, or in other FBs a successor has joined the FB and thus became an important driver in the topic of digitalization, in some FBs the influence of the owning family is very low or manageable. INTV4 stated, "the owning family takes a critical view of investments in digital technologies, but largely agrees with them", and INTV10 added, "the owner family does not close itself off to digitalization, but lives it."

Another major advantage of the family driver since the owning families influence the FBs is the possible fast decision-making by individual family members or a few shareholders, whereas in corporations the decisions have to be legitimized by several supervisory boards or financial investors who want to influence the decision. Therefore, INTV2 stated:

"Fast implementation and flexibility in decision-making is the most important thing when integrating fast-changing digital technologies within our FB. [...] This makes us unbeatably fast compared to many competitors."

4.2.6. Customers' Driver

The drive by customers to digitize, for example, digital ordering options, digital handling returns, and beyond, has reached FBs in today's digital age (Bélanger & Crossler, 2011). To remain competitive in the market with non-family-owned businesses, FBs need to provide added value to customers, as INTV2 explained that digital options ensure a better service through faster accessibility or shorter communication channels. In addition, FB1 was requested by customers to improve the processing of returns and handle them digitally to provide more transparency. Furthermore, according to INTV10, "the option of a digital e-commerce sales platform provides added value for customers." Moreover, several interviewees (INTV2, 4, 6) added that in addition to securing and expanding their sales channels, these digital ordering options are also more convenient, faster, and less time-consuming, which further promotes digitalization within these FBs. Added to that, digital marketing is particularly important for the target groups of young customers, and customers' demands and given trends must be served through the appropriate digital platforms, as explained by INTV6.

Furthermore, several of the interviewed FBs were forced by electronic data interchange (EDI) data transfer requirements by suppliers or B2B customers to integrate a digital management system to retain their customers. However, such a closer interface between FBs, customers, and suppliers through IT-supported processing ensures long-term customer retention and further promotes digitalization, as INTV9 noted.

As especially the dimension to the customers is very important for a FB, as confirmed by all interviewees, the owner families are present in public to reflect their FB. This closeness to customers further drives the digitalization of FBs, as special closeness to customers is required for the development of new digitized products for future generations and can be given through new digital technologies. INTV7 stated: "As an FB, we are significantly closer to the market and can act more quickly, for example, in the event of changes in customer requirements." In addition, the new digital dimensions to customers can further shape proximity to customers and convey the important family values and traditions of the FBs, as INTV8 underlined.

4.2.7. Strategic Positioning

As a further driver of digitalization in FBs, strategic positioning places high demands on the more traditional FBs. As INTV4 noted, "we are currently changing our FB's corporate image away from a traditional FB with its traditional products to a diversified business with online offerings and new business areas." This is further driving digitalization within FB2 and is driven by competition with international competitors and the requirements for a digital strategy to be able to compete with global corporations with high-quality standards. Furthermore, in a long-term view of strategic positioning, following INTV6, only the integration of digital technologies makes it possible to maintain competitiveness in high-wage locations such as Germany. In addition, a broader positioning in the overall business model due to new digital possibilities, in other words, greater complexity, requires further digitalization to be able to better organize and process the increased data volumes, as described by INTV7. Moreover, the strategic positioning of FBs is described by all interviewees as cross-departmental within the FBs, as the departments work across departments for the entire company and not just for their departments. Therefore, there is a high demand for connectivity through digital technologies, as already described in the first driver of the thesis, which further drives the digitalization process.

4.3. Digitalization Barriers in FBs

After analyzing the found drivers in the interviewed FBs, the following section provides an overview of all barriers to the digitalization process in these FBs.

4.3.1. Financial Barrier

While on the one hand, financial opportunities through the implementation of digital technologies can be seen as a strong driver of digitalization, the financial limitations of FBs are one of the biggest barriers. As most interviewees indicated, FBs' financial resources are limited, especially for

major investments in digital large-scale projects. INTV9 compared the FB to a non-family run competitor and noted, "our main competitor is non-family-run and much stronger and broader financially, and therefore pioneers in social media, e-commerce, etc., while we are still in many testing phases and think twice about whether to invest or not." Furthermore, some investments in digitalization come at a very high cost with no benefit, as they usually only improve soft values, such as better customer service via online platforms, but do not directly increase profits, as INTV4 noted.

In addition, most FBs are driven by a low willingness to take risks, as their entire business depends on the financial situation over generations, and thus there is a lower risk appetite due to the close ties to the company and fear of financial difficulties. According to the fact that FBs generally do not engage in costly experimentation, INTV6 stated the following:

"It must pay off according to the motto: what does it bring, what does it cost?" Furthermore, most interviewees stated their willingness to invest less at the moment and accumulate more liquidity in the current crises, which are associated with many uncertainties, as the possibility of the investments flopping, resulting in immense losses, could affect the financial situation for decades.

4.3.2. Employees' Barrier

Another barrier to digitalization in FBs is employees' resistance to change, which was also described by all interviewees. In particular, the quote "people don't like to change" occurred independently in four interviews (INTV2, 6, 10, 11) and underscores the importance of counteracting employees' fears and debunking them. Especially, the fear of staff reductions due to digitalization and the associated automation of processes is present in all FBs and brought to the point by INTV7:

"Employees are afraid they will lose their jobs if work can be done more efficiently at the push of a button, but after a short time they realize that they have much more time for other tasks."

It is therefore particularly important to take the employees along with them and teach them the new tools with appropriate tailored training courses, as INTV10 noted. However, there is an insistence by individual employees, for example, on old workflows or software, which impedes digitalization in FBs. Nevertheless, these cases are rare in FBs, as INTV8 stated because in FBs there is very close proximity to the employees, which is much more pronounced and important than in large corporations due to tradition and established family values. Due to this close relationship between employees and FBs, they have a strong value position as a family with faces and certain values in the background, which makes it easier to reduce such fears of digitalization than in corporations, as INTV6 described.

In addition to resistance to change or these fears, the lack of employee expertise can also be a barrier to the processes of digitalization in FBs. In FBs, it is usually common that many of the employees have been working in the same company for decades and most of the employees have even done their training in the same company, which leads to a lack of knowledge, especially in digital technologies. It further requires new external employees with specific expertise, but who are only available on the labor market in a very limited way, as INTV7 stated.

4.3.3. Owner's Family Influence

In the interviews with the family member CEOs and workers, as already described in the drivers' section, a major difference between the single FBs was apparent. While some family CEOs were strongly innovative and invested massively in new digital technologies so far, other family CEOs were not willing to make big changes because they have been this way for many generations or because they did not yet see any benefits in digitalization. INTV6 mentioned a lack of error culture within some FBs to see mistakes as an opportunity for each FB to learn from. In addition, a strong dependence of the level of digitalization on the education and age of the family CEOs or shareholder(s) was noted and analyzed self-critically by INTV8:

"I was personally a brake when it came to digitalization because that is not my thing. [...] That was a lesson for me and in retrospect, I can say that it is very important to integrate the younger generation into the business processes. [...] I know many FBs that have gone to the wall because the senior leader did not let go and kept going."

Furthermore, INTV7 compared FBs to non-family-owned businesses in the following terms regarding their level of digitalization:

"FBs are growing much more slowly and cautiously to avoid spending too much money. As a result, they lag behind their non-family-owned competitors in many areas of digitalization."

4.3.4. Customers' Barrier

Another barrier that emerged in the interviews was the desire of customers to keep FBs' business processes at a minimal level of digitalization, as INTV5 described. Since FBs traditionally operate in industries that are more traditional and their customers tend to use fewer digital technologies and push FBs to digitize less, customers can also be a barrier to the digitalization process. INTV10 experienced this customer behavior and noted the "customers' preference in classic industries to order everything analogously". What appears to be a small barrier to digitalization is a big problem in some FBs, as the relationship with customers willing to pay could be neglected and lost. Moreover, INTV9 stated that digitalization does not bring any increased customer value and thus only increases costs without any benefits. In addition to the willingness of customers to keep the level of digitalization as low as possible, many requirements imposed by customer data protection regulations, especially when processing customer data, also make digitalization more difficult, as INTV4 noted.

4.3.5. Strategic Positioning

The following question in the interview guideline focused on the strategic positioning of FBs especially in the long-term: How do you assess the value of your digital initiatives compared to other strategic projects in your FB? It was used to better understand the importance of digitalization in the FBs and thus to better analyze digitalization with its strategic value. In all FBs, the impression was that digitalization is only third or fourth in terms of importance (with one being the most important) in the strategy papers due to their limited resources of employees and financial constraints. INTV5 stated:

"For us, the strategic value of digitalization is in third place: It is being pulled along, but the decisive processes lie in product improvement and development, and internationalization, which all come before digitalization."

Two of the FBs (FB4, FB5) also relied on lean management principles, which were also described as a counterpart to digitalization, as many work processes were not yet efficient enough and the focus on lean management somewhat hindered the digitalization process, as the FBs' resources tend to be focused on other individual projects. In addition, INTV8 stated that "in terms of our strategic positioning [...], we have not yet suffered enough to digitize in some areas", which explains the lower priority given to digitalization in some FBs.

4.3.6. Product Features

In addition to these more complicated barriers to digitalization, product features that simply prevent the digitalization or add no value are a rather simple barrier, but also an almost insoluble one without developing a completely new product. Small analog products, as INTV7 explained, have at the first glance cheaper procurement costs than their digital counterparts. Furthermore, some micro products with low value simply cannot be digitized, as INTV8 noted. Moreover, as INTV5 described, the complexity of the product does not allow it to be digitized, or digitalization makes the product worse because it is more technically fragile or the more difficult repair is not guaranteed everywhere, as skilled workers are needed. In addition, INTV5 stated:

"The more digital the products are, the more difficult it becomes to sell the product via export to simple, technologically less advanced markets, such as South America or Africa. [...] Digitalization would thus prevent or significantly limit our high export rate as FB or an expansion into developing countries."

Moreover, a too high degree of specialization requires a high level of consultation and individual feedback, which makes it much more difficult to sell and accompany the sold products with service without added value through digitalization, as INTV9 noted.

4.4. Business Model Canvas

To answer the research question of the thesis regarding the development and transformation of the FBs' business models, the impact of the drivers and barriers are analyzed using the BMC, as suggested by Osterwalder and Pigneur (2010). The core elements of the BMC, such as the value proposition, key resources, channels, or cost structures, help to examine these drivers and barriers and their influence on the FBs' transformation of the business models in a more structured way. The following section provides a straightforward overview of the drivers and barriers in order of the key elements of BMC and how they promote or impede the FBs' business model digitalization. Figure 3 gives an overview of all the key elements that will be examined to analyze the impact of digital transformation on the FBs' business models and provides the related questions.

4.5. Business Model Digitalization in FBs

4.5.1. Value Proposition

The value proposition describes what added value a company offers its customers with the products and services it provides to meet the customers' needs (Muhtaroğlu, Demir, Obalı, & Girgin, 2013). Through digitalization in the interviewed FBs, it is now possible to offer customers new and value-added products or services, as three of the interviewees described (INTV2, 3, 9). This section provides an overview of the new value propositions that the interviewed FBs can offer their customers following the introduction of new digital technologies, as well as the value propositions that have remained unchanged.

While some of the interviewees stated that they convey a modern and innovative FB to customers through digitalization, which has a positive impact on the image of their products, other FBs' value propositions remained nearly unchanged by digitalization. INTV3 commented as follows on their positive drive through digitalization:

"We want to become more modern in our dealing with our customers and promise innovations through the digitalization of our brand, moving away from the old, traditional newspaper publisher to a versatile, modern company with a broad online offering and new areas of business."

Furthermore, whereas FB2 conveys a genuine culture of innovation to the customers and offers new digital products with new added value to the customers, also INTV9 stated the following new changed value proposition to the customers as a driver for digitalization:

"By digitizing many work processes and company procedures within our FB, we can save large amounts of energy and thus promise the customer a green offer, which our customers place great value on, especially these days. [...] As requested by the customers in advance, this was also a driver for digitalization in our FB."

Nevertheless, many of the interviewed FBs kept their value proposition largely unchanged by digitalization and focused instead on communicating the same values to customers as before digitizing, such as modesty, reliability, humanity, respect, and fairness, in combination with a great deal of tradition, as INTV2 noted. Moreover, INTV2 emphasized the importance of these values, which have already

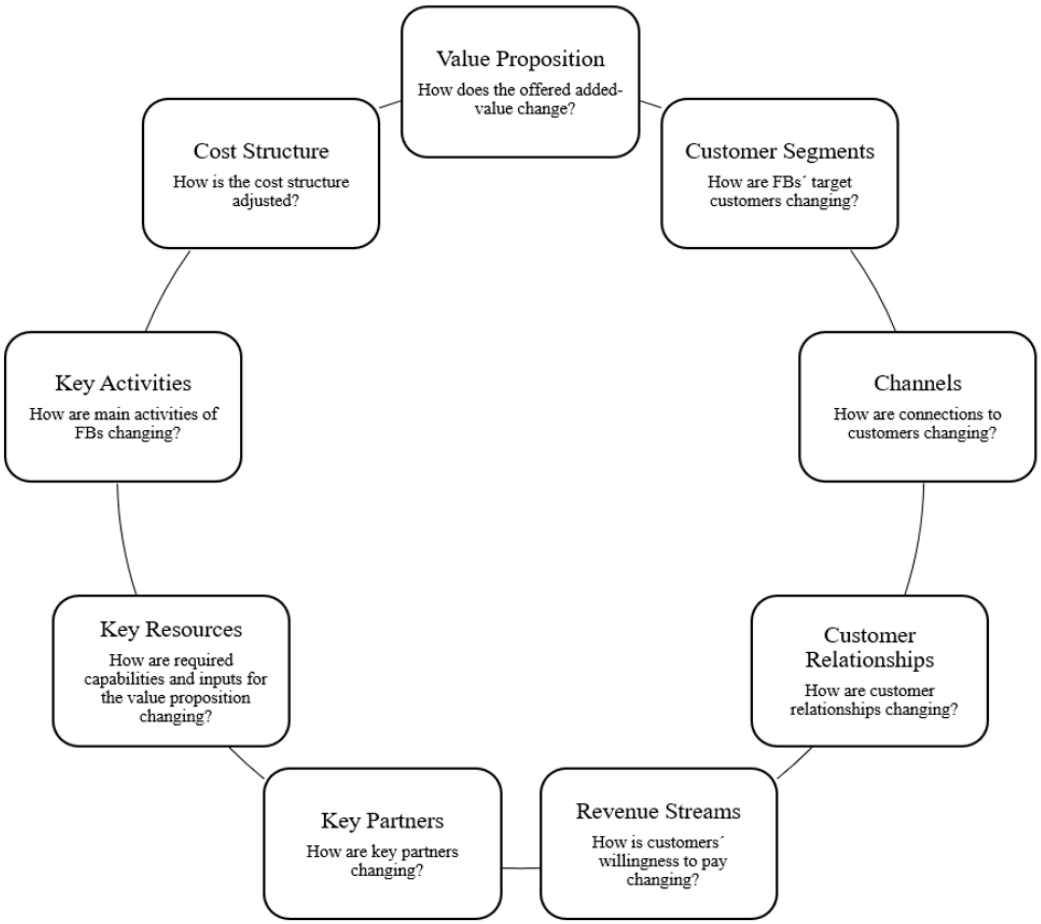


Figure 3: Impact of the drivers and barriers on the development and transformation.

characterized the FB and its activities for many decades and should remain unchanged even with the digitalization of some business processes.

Furthermore, regarding the question of what values FBs add to the market, INTV5 mentioned "the limit of digitalization [that] lies in the characteristics of the product." Therefore, as INTV5 described, the products of FB3 and the added value for the customers remain the same, as the product must remain a rather simple one, and especially abroad a digitized product is worse. After all, the customer rather wants a robust small, and with little technology-equipped product. Therefore, in summary, for some of the interviewed FBs, the characteristics of the products are hindering the change of the value proposition in the FBs' business models, but some FBs were already able to change or add certain values to their value proposition.

4.5.2. Customer Segments

The type of customers the FBs want to address with their products and services and their value propositions are defined as customer segments (Muhtaroğlu et al., 2013). Generally, none of the interviewed FBs have rapidly changed their customer segments by digitizing their products or services. However, the market and the demands of the market have become much more in the focus of the FBs due to digitalization, as INTV2 noted. In addition, a very common view in FBs is the great importance of broad positioning in the market to take the lowest possible risks and to finance the core of the FBs. This broad positioning in the market is also a driver for new segments that can be reached by integrating digital technologies, for example, via e-commerce platforms, as it was implemented in FB7's business model to reach new customer segments, especially outside Germany. In addition, as digitalization brings many new opportunities, especially in terms of globalization and reaching global markets (Autio, Mudambi, & Yoo, 2021), these new opportunities through the adoption of digital technologies have also changed the FBs' customer segments in terms of location, as four of the seven FBs (FB3, 4, 6, 7) can now also serve international customers.

However, the implementation of digital technologies does not affect every customer segment of FBs, as all of them have had their main customer segments for a long time. Moreover, some of the FBs are constrained by their regionality, while their non-family-owned competitors tend to be national or international and have a broader customer base, FBs are limited to their region by their capabilities and tradition, as INTV3 stated. In addition, on the one hand, FBs often have customers who have been loyal to them for decades, and it

is these customers who are very reluctant to the digitalization of the FBs' sales channels, as INTV5 noted. On the other hand, most FBs are active in traditional industries that involve the processing and finishing of raw materials or intermediate products and are classically driven by a customer's preference to order everything analog, thus preventing digitalization, as INTV5 further noted.

4.5.3. Channels

Channels explain how the FBs connect with their customers and how they deliver their products and services to them (Muhtaroğlu et al., 2013). The interviews revealed that the FBs use many new channels to contact and serve their customers, which is enabled by digital technologies and their new capabilities.

As INTV4 noted, "customers want more digital offerings these days", which forces them to digitize their channels to customers by depending on customer challenges. Moreover, INTV4 stated that their FB2 started taking the first steps in e-commerce already ten years ago. In addition, INTV10 noted that the development of their business model in the future will be based on more commerce through digital relationships with customers, such as selling through a website or more digital touchpoints with customers. Furthermore, the majority of the interviewed FBs identified one main objective as making it much easier to place orders through new digital trading platforms. Additionally, INTV6 explained why they do not yet have a website with ordering options: "We are currently in a test phase for our online store because implementing an online store is so labor- and cost-intensive that we have to be at least 95 percent sure that the store will be successful before we make the final decision [for or against], while our main non-family-owned competitor already has one."

Moreover, as the personal relationships with the customers are more pronounced and especially important for FBs and are one of the major drivers of their success, as INTV7 noted, these relationships must remain consistent, if not strengthened through more digital communication opportunities. Precisely because FBs are closely connected to their customers, FB7 is deepening their connection through new online events and product launches via digital channels to be as close as possible to their customers and what they want for existing and upcoming products.

However, digitalization has not only promoted pre-sales channels to customers but has also influenced after-sales channels. Due to the increased numbers of online trade and orders, INTV8 noted that they have massively strengthened their logistics and online product tracking capabilities. Moreover, they introduced a digital after-sales service to save customers from having to visit their site or FB's workshop through the new digital communication channels, saving time and money above all. In addition, INTV5 stated:

"Our repair service for customers is offered through online technical issue sessions, where our employees receive real-time videos of the issues via cameras on the customers' heads, allowing them to fix minor issues without having to fly to South America, for example."

Furthermore, in addition to technical support, as already described in the pre-sales section, the proximity of FBs to their customers is of great importance, as also highlighted by INTV3, and can be fostered by a stronger connection with customers through digital technologies even after the product has been sold. For example, product improvement suggestions are less time-consuming through a short online digital form or social media than through a call.

Nevertheless, there are also barriers that affect the digital transformation of the FBs' channels. As INTV3 stated, "we make less money through digital channels than with the traditional newspaper business", as the product feature of a newspaper has a greater value on the market when sold through traditional channels, such as a newsstand. In addition, INTV6 stated that due to the small size of most products, with an overall average of two Euros per product, a very high number of products need to be sold. However, current online sales through external service providers are only about 20 percent, which tends to limit investments in expanding the online sales channel, as INTV6 pointed out and further stated that customers prefer to buy their small products locally. In addition, the small size of products makes it difficult to sell through digital channels and the associated logistics, and product complaints would also be difficult to implement through digital channels and their logistics. Moreover, as INTV5 noted, many after-sales services such as analytic services or predictive maintenance offered by their non-family-owned competitors are not feasible because they lack IT expertise in these areas and would be forced to rely more heavily on external service providers, which would limit profits in offering these new services as part of the digitized business model.

4.5.4. Customer Relationships

Of particular importance are the customer relationships that FBs have established and maintained with their customers over a long period (Muhtaroğlu et al., 2013). By adopting new digital technologies, the FBs can offer a broader service to their customers, which also requires a high level of digitalization. INTV7 described the current transformation in their relationships with customers as follows: "Much of the customer and service experience is undergoing incremental change, and no disruptive changes are expected soon." However, given the FBs' traditional customer-centric orientation, new digital technologies offer the opportunity to further deepen and improve customer relationships, as INTV8 noted. Furthermore, INTV4 highlighted the drive provided by digital communication channels, saying, "through digitalization, a better service can be offered at a higher speed [due to improved connectivity]".

In addition, since the customers trust FBs more than a corporation due to years of consistency, most FBs have very close relationships with their customers, as INTV8 noted. Therefore, many digitalization of processes take place in consultation with customers to drive such digitalization always together in a more efficient way, as INTV9 pointed out. They also have a significantly lower complaint rate than their non-

family-owned competitors due to their closer customer contact and better relationships with customers, as INTV8 mentioned. Moreover, INTV6 sees the greatest potential for the next five years in Big Data, to further deepen their knowledge about their customers and better analyze their customers' buying behavior and thus product wishes.

While on the one hand the relationship with certain customer groups can be deepened by digitalization, on the other hand, the relationship with some supposedly older customer bases could suffer from greater digitalization. In addition, the time spent on-site with the customers, which according to INTV4 is a strong feature within the FBs' business models in terms of customer relationships, could become less due to more digital contact channels. INTV10 highlighted:

"For us, the close also personal customer relationship and not only digital relationship with the customers is still very important. [...] Because human contact is particularly important for FBs and their business models and also a clear advantage as a FB."

Such close contact with the customers is also crucial for the development of new products, as it provides an accurate view of customer needs and is one of the most important indicators of success within FBs, as it was emphasized by all interviewees. The degree of digitalization of customer relationships must therefore be tailored and weighed up entirely according to the FBs' customer groups.

4.5.5. Revenue Streams

The revenue streams state what values the customers are willing to pay for and illustrate how the customers are currently paying (Muhtaroğlu et al., 2013). In terms of generating money, only one of the interviewed FBs (FB2) has so far generated a new business opportunity by implementing an online offering for the customers. This is mainly due to the long-term planning perspectives of FBs from generation to generation, which makes it difficult to generate new business opportunities to make money in a short period. In addition, the other six FBs indicated that they are also not currently planning to change their product range towards digitized products within their revenue stream. Nevertheless, completely new products could emerge in the future because of digitalization, either through further developments using digital technologies or through completely new product developments. INTV6 also highlighted this potential in the future to change the FB's revenue stream:

"That's where I see the greatest potential, especially with the help of digitalization: [...] How can we remove non-value-added activities from processes and work much more in the direction of the customer to discover new ways of making money?"

As described earlier, FB2 has already introduced new structures within its business model to earn money through new revenue streams and new payment options. INTV3 explained: Through new online product lines with an online newspaper, we have generated online sales of our newspaper on the one hand and advertising revenue on the other hand. However, an online product would significantly need more customers to earn the same money as its non-digitized counterparts.

Furthermore, in addition to generating new revenue streams through new products, improved or new services could also be offered through new digital technologies. INTV11, for example, was already thinking about a premium service pass that could be offered for the sold products and that would guarantee fast service or predictive maintenance solutions, which in turn could be provided by digital technologies. However, a premium service was not implemented after a short test phase because the customers were not willing to pay more than before for an improved service. Nevertheless, the possibility of charging for services provided in addition to the existing product, such as predictive maintenance or a cloud solution tailored to the product, could be a driver for digitalization within revenue streams.

The main reasons why only one of the interviewed FBs has so far partially developed new revenue streams through a digital offering are probably the caution and low risk-taking that are firmly embedded in the FBs' business models. INTV11 noted the following, which applies to all interviewed FBs:

"FBs often wait for the necessary pressure to digitize, especially in the area of new business opportunities. [...] FBs usually wait rather cautiously and then follow the competition when new business fields are successfully implemented, as so-called fast followers."

Moreover, due to the limited capabilities of FBs, the additionally developed revenue streams only improved soft values, for example, through increased customer loyalty, but not any metric in the final calculation, as INTV5 stated. In addition, INTV7 noted that many customers are not willing to pay more for more services offered online via digital technologies and that the development of new digitized products for new revenue streams is still an ongoing process.

4.5.6. Key Partners

Key partners are defined as close relationships with other companies, governments, or other partners that either perform certain activities or supply important resources (Muhtaroğlu et al., 2013). These key relationships are motivated by reducing uncertainties or increasing efficiency, for example, by outsourcing certain work processes. Such key partners of FBs have usually been partners for a very long time and have very close connections to each other. These key partnerships, therefore, become even closer through the integration of digital user interfaces or data connections and are a strong driver for digitalization to increase the aforementioned efficiency, as INTV6 stated. Moreover, INTV8 noted that established test phases have been set up with suppliers and external support to identify any barriers and they already started implementing digital connections through digital technologies in the most stable way to further strengthen their key partnerships. Connecting parts of the ERP systems within key partnerships helps to increase transparency and throughput in the warehouses of key partners through digital technologies, thus improving ordering

and delivery conditions within their partnerships, as INTV11 described. In addition, new technologies and associated external service providers are leading to an increase in new key partnerships, as the FBs' own IT departments are unable to handle large projects themselves, as INTV2 realized.

However, more key partners classically mean more opportunities for conflicts. Added to that, since FBs are usually built on very close and especially personal relationships, the increasing online presence with key partners could lead to these partnerships becoming more fragile because humanity is lost to a certain degree, as INTV10 noted. INTV10 particularly emphasized the importance, for example, of drinking coffee together after business meetings, which would be significantly reduced by increasing digital communication via online meetings.

4.5.7. Key Resources

Key resources describe what capabilities and inputs FBs need for their value proposition, such as financial, physical, or even human capabilities (Muhtaroğlu et al., 2013). The main driver of digital transformation for the FBs' business models is the major shortage of skilled workers, which enables and drives the FBs to invest heavily in further digitalization and automation to increase efficiency and reduce the number of employees, as INTV7 underscored:

"Through modern software and other digital technologies, we can save many employees by increasing efficiency through automation to respond to the shortage of skilled workers in the near future."

Furthermore, INTV9 highlighted the attractiveness for employees of an agile culture of change and technological drive, in addition to the classical advantages of employment in a FB in terms of low termination rates and long-term employment, usually lifelong employment. Moreover, this attractiveness for employees is becoming more important as FBs are often surrounded by their self-trained employees with dual students or trainees within the FBs, so there is very close contact with the FBs, but also dwindling digital expertise that in some cases would have to come from outside.

While many of the key resources of the FBs remain the same, such as most product features, design, or brand, the core processes along the value chain, such as production or in-house logistics, are being transformed in some of the FBs (FB1, FB4, FB5, FB6) through the implementation of digital technologies. INTV6 explained their integration of Insights as a Service (IaaS) along their entire value chain from production to purchasing and logistics to sales through data from digital technologies that help to measure and define which processes need to be improved or eliminated:

"Without digital technologies, we would not be able to collect the data we need to measure which processes along our value chain need to be improved or completely rethought."

In addition to IaaS, FB1 has also integrated a digitized inventory as one of the main components of its value creation processes as a logistics service provider, and FB4, FB5, and FB6 have further implemented data-driven solutions such as predictive maintenance for their large aggregates to reduce their downtimes due to lack of or untargeted maintenance.

One of the main barriers to key resources that affect the development and digital transformation of FBs' business models are the tenured employees, who have grown with the company for a very long time, and have a hard time with change, as all FBs have realized. These employees make it difficult for FBs to transform their business models due to their resistance to change. However, INTV7 stated:

"The majority of employees are open-minded, but it is quite normal that 10-20 percent of employees are rather closed-minded shortly before retirement and resist digitalization. [...] Therefore, employees need to be trained and educated so that they can embrace new systems and not become inhibitors or afraid of digitalization."

Nevertheless, if employee training is unsuccessful, another major barrier for FBs to the digital transformation of their business model is the increasing shortage of skilled workers and, in particular, digital expertise. As INTV3 described it, "FBs find it extremely difficult to transform because they do not bring the right people into their businesses and they cannot find qualified people because they mostly stay within their industry or network and do not go beyond that." In addition, their flexibility, which is given by short decision-making paths and fast follow-up strategies, would suffer from increasing automation within their value chains. Moreover, there are still far too many technological innovations and changes, so that firm planning, especially with regard to the financial return on investments, is not possible, as INTV5 noted.

Another barrier to digitizing the FBs' business models are the characteristics of the required resources, as INTV8 of a grocer stated:

"I often compare a cauliflower to an airplane: I can tell you exactly how much the airplane weighs, but the cauliflower is always individual and weighs differently, has a different number of florets, a different proportion of leaves. Just as different as people are so that digitalization and automation of work processes based on product characteristics are not possible."

In addition, INTV8 noted, that 'first in first out' does also not work because the maturity of a food product is always different, which makes certain digitalization approaches simply impossible for now.

4.5.8. Key Activities

The activities that a FB performs to produce, offer, and deliver to its customers and the way it uses them to generate profits are summarized as key activities (Muhtaroğlu et al., 2013). Since each of the interviewed FBs has already digitized at least some work processes within the administration, production, warehousing, or logistics, many key activities in everyday work are already being driven toward more digitalization by an increase in efficiency. One simple example of this is the increase in efficiency through pick-by-voice as a digitized work process, as INTV1 noted.

Furthermore, digital machines with the necessary interfaces do data collection automatically, as INTV7 noted. These data sets are used to get a better overview of the inventory, which can then be given at the push of a button by a digital recording of throughput, goods receipt, and goods issue. INTV9 highlighted the massive increase in efficiency by moving from manual entry to fully automatic inventory correction with digital technologies. INTV4 further noted the acquisition and integration of appropriate systems and inputs such as dashboards, etc., but that FB2 is not yet using these data sets for databased compilations to bring them closer to the customers. Another improved key activity through the integration of digital technologies are the short communication channels and the ability to act quickly within FBs. Increased connectivity with digital communication platforms has further supported cross-departmental and cross-team work processes and increased their efficiency, as all interviewees noted. Moreover, since many FBs are export-oriented (Federal Ministry for Economic Affairs and Energy, 2020) and the interviewed FBs export many of their products, the significantly increased complexity associated with internationalization within key activities can be better managed through digital connectivity via communication channels and fully digitized ERP systems, as INTV5 mentioned.

However, arguably the biggest barrier to digitalization of the FBs' key activities, is the problem that the long growth phase in recent decades, with a long time in the hands of one or a few decision-makers, leads to impediments to digitalization depending on the shareholder(s), as INTV9 noted. Moreover, such processes that have grown over years are not sufficiently questioned, according to INTV7, "why do we do certain things and how can we make them more efficient?" In addition, the limited capabilities of FBs and their small number of product lines compared to large non-family-owned competitors do not allow for further digitalization, as they are too small in some respects to automate cost-effectively, as INTV2 mentioned.

While the size of FBs is a barrier, the state of technology is also still too incomplete in some cases, and INTV5 described their more wait-and-see attitude as follows:

"Currently, technological development is like buying a new cell phone. In the end, you can use it to make phone calls and write messages, but not much else changes in my view. [...] Therefore, we are currently still waiting for the one technological invention that will give us a good advantage in improving our key activities."

This view on the current digital developments of a single shareholder influences the FB's strategic decisions in terms of digitalization of key activities and INTV8 highlighted this influence as a barrier to digitizing the business model with the following words:

"Personally, as a shareholder of my FB, I was a brakeman in terms of digitalization, because that is not my thing at all."

4.5.9. Cost Structure

The cost structure summarizes all costs associated with the FBs' business models to deliver their value propositions to customers, as well as any other costs for other business activities such as infrastructure or administration costs (Muhtaroğlu et al., 2013).

These cost points are, as interviewees agreed, an important and concrete benefit, primarily financial or to improve competitiveness, achieved through the implementation of digital technologies. INTV7 highlighted the importance: "Cost-efficient working was the decisive factor in digitizing most of our work processes within our business model." Furthermore, INTV6 cited many examples of implemented technologies and the associated increase in efficiency: The digitalization mainly took place in the three business areas of logistics, accounting, and HR. While in logistics some work processes were supplemented by pick-by-light, pick-by-voice, or automatic shipment size calculators, all of which increased the productivity within logistics, in accounting many processes such as payment transactions, dunning, asset accounting, and much more were also digitized and experienced a strong increase in efficiency. Moreover, in the HR department, processes such as payroll accounting, applicant management, or time recording were digitized and led to an increase in efficiency too. To these drivers of digitalization through increased efficiency, INTV5 added that more digital technologies can save further immense amounts of time and money, for example through digital meetings or virtual problem analyses through camera transmission to the customer to save a lot of money and travel time.

Furthermore, and especially important in these times of rapidly changing prices in the marketplace, INTV6 stated that they can use their digital, data-driven technologies to monitor price and margin developments, as well as the costs of their raw materials, on a daily basis to counteract any eventualities. This capability can mean massive cost savings through a shorter response time for market-adjusted prices. In addition, INTV11 stated:

"Data is the mega topic of the future for us and can bring us immense business benefits, but it also requires major investments to be able to collect and process the data in a structured way."

This quote brings us to the main barrier to digitalization in the cost structures of the FBs' business models. Since digitalization entails gigantic costs, from licenses to personnel or from hardware to software, the FBs are very constrained with their big steps in terms of digitizing certain areas of their business models due to their limited financial resources and lower risk appetite. In addition, as INTV10 noted, "the process of digitalization is an ongoing process that is never finished and must continue, which in turn brings new and further unknown costs." Moreover, the FBs are growing much more slowly and deliberately than non-family-owned businesses to avoid spending too much money, as INTV11 described. Added to that, INTV5 explained their situation as follows:

"I am basically open to digitalization, but the bottom line is that it is not profitable for our FB at the moment, and it is actually more work in parts. [...] We still need that certain point where we can say, now it is worth it."

Ultimately, the impact on the cost structure through digitalization also depends on the different individual situations of the interviewed FBs and their current financial situation, so it is difficult to make a general statement about all FBs as they differ.

5. Discussion and Conclusion

5.1. Theoretical Contribution

First, further digitalization drivers and barriers in FBs in the Heilbronn-Franconia area and some outliers within a radius of 80 kilometers around Heilbronn were investigated, which is known for its globally successful FBs from many manufacturing industries (Suarsana & Glückler, 2016). These drivers and barriers are a contribution to previous research in the field of digitalization in FBs. The three most important identified drivers of digitalization are the economic opportunities due to increased efficiency and transparency through digital technologies, the customers drive due to the increased technical requirements of the customer markets, and the connectivity drive due to the massively improved connectivity between internal departments and to customers through the digitalization of certain channels. In addition, the three most important barriers that impede the digitalization process are, firstly, the limited financial capabilities, which restrict the immense investments required for digitalization and are also limited by the associated low financial risk appetite of FBs. Secondly, the employees' barrier due to their fear of staff reductions through the digitalization and the associated automation of work processes, which leads to employees' resistance to change. Thirdly, the product characteristics simply impede digitalization, as complexity makes it impossible to digitize or the digitalization of the product would reduce the value of the product due to error-prone technologies and more difficult repair in case of damage.

Second, the impact of these drivers and barriers on the development and transformation of the FBs' business models was examined. The findings suggest that these drivers and barriers impact the BMC in all key elements through new opportunities due to digital technologies, such as new business channels to the customers or improved key partnerships, but the key elements are also hindered by findings such as customer group requirements, existing cost structures, or limited capabilities.

Among the interviewed FBs, there are major differences in the status of digitalization and the different views on digitalization and its advantages and disadvantages. Furthermore, the interviewees have different levels of knowledge on the topic of digitalization, with some dealing with the topic significantly more intensively, while others are just beginning to deal with the topic of digitalization. In addition, there seems to be a correlation between the level of digitalization and the generation of the interviewee. It seems that the younger the interviewee was, the greater the knowledge of digitalization, and this correlation was also supported by some comments of the interviewees on their predecessors and their view on the digitalization of work processes, product parts, or even FBs' business models. In addition, there is also a notable correlation between FB's industry with its specific customer segments and its level of digitalization. While some of the interviewees indicated that their customers are interested in more digitalization of products and services, some other customer segments of other FBs had a rather negative attitude towards digitalization.

While previous research has highlighted the increasing influence of digitalization on the decision-making process in organizations (Karimi & Walter, 2015), the findings in the FBs affirm the increased interest in digitalization and the associated new technologies and changes within their business processes and models. However, due to the importance of product knowledge and further research and development work in the FBs, digitalization is not mentioned as the highest priority in the interviewed FBs, but rather in third or fourth place in the strategy papers. Furthermore, the continued drive for digitalization by new generations of digital technologies described by Oswald et al. (2022) is consistent with the findings of this thesis. In addition, the importance of digitalization will continue to increase due to new technical possibilities, which was also underscored by the findings that the FBs are planning further implementations or even building up financial reserves for upcoming major investments in digitalization in the near future.

Moreover, the interview results are consistent with the findings of Bharadwaj et al. (2013) and the impact of digitalization on the overall long-term success of organizations. For FBs, the successful integration of digital technologies to increase efficiency in all business processes is also an important driver and will help to ensure long-term success and, most importantly for FBs, keep their production location at their headquarters to preserve their regionality and traditions. In addition, the findings support the claim of Yoo et al. (2010) that digitalization offers many new business opportunities, which has already been recognized by some of the interviewed FBs, while other FBs are still waiting for their initial driver to digitize their business model and value creation, for example, provided by newly developed digital technologies.

A further contribution to the findings of Kammerlander et al. (2020) that the new digital technologies offer immense potential, especially in the industrial sector, is revealed by the interviewed FBs. They have shown that a massive increase in efficiency can be reached through the successful integration of digital technologies into specific work processes and, above all, that an increase in transparency through big data structures helps to exploit the full potential of digitalization in FBs. While previous research has focused on the direct drivers of digitalization, these findings reveal an indirect increase in productivity through digitalization due to improved transparency in the value chain to eliminate or improve certain weaknesses within the processes. Furthermore, the findings affirmed Kammerlander et al. (2020) claim that the introduction of digital technologies is associated with many challenges and requires external support due to the lack of knowledge about digital technologies. Most of the

interviewed FBs either used external support from a service provider or, indirectly contradicting their claim, some FBs employed new staff from external companies and used their knowledge and successfully integrated it into their business processes.

The claim that entirely new capabilities would need to be built in IT or logistics to deal with the newly implemented technologies (Nambisan et al., 2017) was also consistent with the findings in all cases, as most FBs upgraded their capabilities across departments, especially in the IT department, to better deal with the new technologies. However, due to the increase in efficiency from the digitalization of certain work processes, many employees became redundant in their current positions and were retrained in certain areas to avoid hiring new workers and layoffs, which underscores the importance of long-term employment relationships in FBs. Furthermore, the findings are in line with De Massis et al. (2018) and their hypothesis that FBs are particularly affected by challenges posed by digital transformation due to their limited financial capabilities. In particular, the high financial risk due to large investments in digitalization and the need to acquire relevant knowledge either through new employees or through external service providers influences the business decisions of FBs. However, it is not only the limited financial capabilities that hinder digitalization but many other barriers that affect the digital transformation of FBs and their business models, as this thesis shows.

Additionally, the findings are partially at odds with Newbert and Craig (2017) claims that FBs' decisions differ from those in non-family businesses, as some interviewees indicated that there are no major differences between the business decisions of FBs and their non-family-owned businesses counterparts. However, this depends on the degree of influence of the owner families of the FBs and their level of integration into the FB. While some owning families completely lead the decision-making processes and have a massive impact on the development of the FB, other owning families only act to a limited extent within their FB and tend to stay in the background of operations and decisions. On top of that, the findings of this thesis are consistent with Kammerlander et al. (2020) assertion that FBs as such differ greatly in their diverse backgrounds, knowledge, and the influence of the owning families on the businesses, which may provide room for further research on the diversity of FBs and their influence on the success of digitalization. In addition, Duran et al. (2016) claim that family influence is an important determinant of innovation in general, is contrary to the findings of this thesis. Among the interviewed FBs, the degree of family influence varied from FB to FB and was not an indicator of whether a FB was innovative or not. Rather, it depended on the decision makers and their attitudes toward digital technologies, rather than on individual family members and their influence on decisions. Furthermore, the previous literature was extended by adapting the BMC to the digital transformation process of the business models of FBs to not only consider digitalization as such in FBs.

Added to that, according to the findings of George et al. (2021), the success of businesses that have established digital technologies and continue to respond innovatively to social and organizational change is in line with the findings of this thesis but does not automatically indicate for economic failure due to non-digitalization of business processes and models. Moreover, even interviewed FBs with less digitized work processes can compete with their fully digitized competitors in the market, depending mainly on their older customer segments and their preferences for less digitized channels. However, a change due to demographic change will also drive these FBs to more digitalization in order not to suffer from their dwindling customer groups, which future research could take into account.

Furthermore, based on the findings of Spieth et al. (2014) that FBs would need to adapt their business models to successfully implement digital technologies, the findings of this thesis rather suggest that an adaptation of the entire business model is not necessary. Several of the interviewed FBs have only partially digitized some work processes and left their business model almost unchanged. Moreover, the digitalization of business processes is to a small extent an automatic change within the business model due to the associated work processes that are optimized by their digitalization.

5.2. Practical Implications for FBs

While previous research has focused on the main drivers such as cash opportunities, digital strategy, and early success stories, as well as on the main barriers such as paternalism, inconsistent understanding of digital transformation, and employee resistance to change (Soluk & Kammerlander, 2020), the results of this thesis demonstrate that there are many more drivers and barriers that need to be considered in such complex FBs. Furthermore, the findings of this thesis build on the existing findings of Soluk et al. (2021) that FBs can successfully transform their business models into digital business models, but also additionally highlight the importance of the decision makers' knowledge of digitalization to ensure successful development and transformation of the FBs and their business models. Here, the results have shown that there is a correlation between the generation of the interviewee and the level of digitalization.

In addition, the drivers and barriers found in this thesis can be used to identify the current state of digitalization within the FBs and to implement further steps according to the results of the thesis. Moreover, the analyzed drivers provide FBs' managers with strong incentives to take further measures to digitize work processes or parts of the business model and may reveal completely unknown new investment opportunities with new revenue possibilities. In addition, given their limited financial and human resources, the results provide insights into the importance of each driver and help identify the specific order of implementation of new digital technologies in FBs that best suits the businesses and their strengths and weaknesses. The analyzed drivers and barriers help to avoid unnecessary issues or complications in the digitalization process, contributing to the specific needs of their businesses.

Additionally, the results can reveal unknown barriers that have already occurred in other FBs and are most likely to occur in certain business processes as well to address them as early as possible to save financial resources or avoid conflicts within the FBs through early detection. Furthermore, the knowledge gained about other FBs can help to support problems beyond the knowledge and network of managers through early detection. Further, the results of this thesis contribute to a better understanding of the consideration of external help or knowledge for specific problems, as some of the drivers are not solvable due to their limited capabilities and need external support. Moreover, acquiring external knowledge by expanding their network through educational institutions or centers of excellence helps FBs in terms of their limited financial resources and capabilities. Such expanded knowledge then also helps to develop a concrete plan or digitalization strategy to avoid certain problems such as employees' fear or lack of structures.

5.3. Limitations and Future Research

The thesis has some limitations that provide further room for future research. Due to the case-based semi-structured interviews, statistical generalizability is not possible. However, with the given definitions in the interview guideline to increase external generalizability, some degree of generalizability is still achieved and makes it reasonable to apply the results and findings to other FBs. The number of interviewees and their characteristics further limit generalizability and encourage further research in the economically important area of FBs to deepen the given insights and even find further drivers and barriers of digitalization and their impact on the development and transformation of FBs' business models. Also, the influence of family member CEOs and their generational dependency on the integration of new digital technologies limits the generalizability due to the number of interviewees. Nevertheless, this can be another research point for future studies to investigate the specific relationship between the generation of CEOs and the associated knowledge of digital technologies and the strategic positioning of FBs in the topic of digitalization. Furthermore, as digitalization is an ongoing process, this thesis is only a snapshot of the current state of the FBs in their digitalization process, which is sure to change in the coming years. This provides further room for research to measure the success of the implemented digital technologies and the overall digitalization of FBs and, in particular, the development and transformation of their business models.

In addition, the correlation between the generation of the CEOs in the FBs and their attitude towards digitalization in terms of development and digital transformation offers room for further research and needs to be investigated in more detail. The current pandemic situation as a driver for digitalization in FBs can also be further taken into account by future studies. Additionally, further research should broaden the view on FBs outside of Europe to take further different traditions, decision-making processes, and degrees of digitalization into account.

5.4. Conclusion

The digitalization in FBs is both a great opportunity and simultaneously a major challenge for the resource-constrained FBs. Therefore, the right actions in the decision-making processes are even more important for their long-term economic success. This thesis supports this process by contributing to previous research by increasing the knowledge about the drivers and barriers to digital transformation and the related processes in FBs. In addition, this thesis bridges previous research on business models and digital transformation in FBs to provide deeper insights into the process of digitalization of business models in the field of FBs. Moreover, the thesis analyzes the changes within the business models using the BMC and summarizes the impact of the drivers and barriers' of digitalization on the overall value proposition of FBs to their customers.

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Acceptance conditions of algorithmic decision support in management

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Abstract

This thesis explores the acceptance of decision-aiding technologies in management, which is a challenging component in their use. To address the lack of research on algorithmic decision support at the managerial level, the thesis conducted a vignette study with two scenarios, varying the degree of anthropomorphizing features in the system interface. Results from the study, which included 281 participants randomly assigned to one of the scenarios, showed that the presence of anthropomorphized features did not significantly affect acceptance. However, results showed that trust in the system was a crucial factor for acceptance and that trust was influenced by users' understanding of the system. Participants blindly trusted the system when it was anthropomorphized, but the study emphasized that system design should not focus on the benefits of blind trust. Instead, comprehensibility of the system results is more effective in creating acceptance. This thesis provided practical implications for managers on system design and proposed a structural model to fill a research gap on acceptance at the managerial level. Overall, the findings may assist companies in developing decision support systems that are more acceptable to users.

Keywords: Decision support systems; Algorithmic management; Artificial intelligence; Anthropomorphizing; Technology acceptance.

1. Introduction and area of problem

Recent advances in technology enable aid for business in the context of problem-solving (J. R. Evans & Lindner, 2012). In practice, the usage of systems aiding decisions is low. Therefore it is necessary to research on acceptance conditions. This introduction outlines the practical and theoretical necessity of deriving acceptance conditions for research. Furthermore, the structure of the thesis is outlined.

1.1. Objective and research question

The scientific field of business analytics and business intelligence has gained high importance in strategic management. In this context, it is important to differentiate between these terms. Business analytics is defined as a process where data is converted to actions through an analysis of this data in the context of organizational problem solving or decision-making (J. R. Evans & Lindner, 2012). Business intelligence is defined as the use of various technologies like information technology to help managers to gain insights about their business and to improve decision-making (Gluchowski, 2016). Since analytic procedures are based on algorithms the term business analytics can be used as a synonym for algorithmic decision support.

Despite the rise of opportunities for algorithmic decision support, arising challenges should not be neglected. Challenges are legal issues like ownership and privacy of data and technical obstacles like analysis of complex data and scaling of algorithms (Mishra & Silakari, 2012).

One of the most challenging components due to the use of algorithmic decision support in business is the acceptance of these systems by users. From a user's perspective, one major problem is that precise algorithms generate the perception of authoritative correctness therefore human beings can feel inferior toward algorithms. Especially the introduction of deep learning algorithms in artificial intelligence (Linardatos, Papastefanopoulos, & Kotsiantis, 2020) and the scaling of algorithms (Mishra & Silakari, 2012) lead to higher accuracy and precision which in turn makes the human being feel inferior to algorithms. In this regard, it is necessary to do further research on the acceptance condition of algorithmic decision support.

Therefore, this paper conducts an analysis on the following research question: Which conditions lead to an accep-

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tance of algorithmic decision support in management?

1.2. Theoretical and practical research gap

To answer the research question, it is necessary to make an analysis of the state of the art in research and elucidate the research gap. Various studies do research on the topic of acceptance of artificial intelligence-based technologies. Hastenteufel and Ganster (2021) apply this topic to the digital transformation in banking. Therefore, they use the technology acceptance model by Davis, Bagozzi, and Warshaw (1989). Hastenteufel and Ganster (2021) identify the trustworthiness, perceived usability and social influence as acceptance conditions for algorithmic decision support. Gersch et al. (2021) do research about the challenges particular in trust in collaborative service delivery with artificial intelligence in the field of radiology. Therefore they conduct interviews with various stakeholders in radiology. They identify trust as an indicator to cope with uncertainties. Furthermore, they identify that cognitive trust is built in the first contact with the user. With repeated experience, the user develops affective trust. Understandability and comprehensibility are important for users. Further challenges are the change of own position in the workplace due to the introduction of support through artificial intelligence and arising of new duties and prerequisites in the design of the socio-technical system. Therefore, explainable artificial intelligence should take into account the perspective of different stakeholders. Rathje, Laschet, and Kenning (2021) do research about trust in banking. Therefore, they develop their own research model based on the models by Mayer, Davis, and Schoorman (1995), Gefen, Karahanna, and Straub (2003) and Davis (1989). They conducted a survey with 119 participants where the affinity to technology is high. Rathje et al. (2021) identify that trust has a relationship to the intention to use the technology. Pütz, Düppre, Roth, and Weiss (2021) do research on the topic of acceptance of voice and chatbots. They use the technology acceptance model (TAM) of Davis (1989) and the extended version of Venkatesh and Davis (2000) and Venkatesh and Bala (2008) to analyze the acceptance of this technology. The approach used by Pütz et al. (2021) is literature-based. They identify a relation between perceived usability and perceived user-friendliness. Further results are a relation between perceived user-friendliness and intention to use the technology.

Scheuer (2020) develops an acceptance model for the use of artificial intelligence. The model developed by Scheuer is called the KIAM model. The KIAM model is an extension of the TAM model and is considered the Artificial Intelligence Acceptance Model. Whereas KI is referred to as the german term for AI. The AI acceptance model (KIAM) consists of a holistic acceptance model that addresses the characteristics of the theoretical properties of an AI compared to a classical computer system. Scheuer (2020) assumes that an AI is accessible via a technology (e.g., a smartphone application) and enriching it with Narrow AI services (e.g., a chatbot integration, Speech-To-Text, or Text-To-Speech) through which a user can interact with the AI in natural language. Based on this, two essential components emerge first, the classical technology in the form of a software application, and second, the dialog component for interacting with the AI in the background. For the classical technology and the investigation of its acceptance, Scheuer uses the existing TAM model by Venkatesh and Bala (2008) TAM 3. However, for the dialog component and the resulting interaction between the AI and the user, Scheuer (2020) differentiates to what extent the user accepts the AI as a personality or even as a complete person. For this, he considers that psychological models for measuring sympathy and affection apply as personality acceptance takes precedence over pure technology acceptance. In this regard, Scheuer highlights that if the filter of the perception of the system as a personality is taken into account an AI is recognized as a personality. This relationship with technology can be described as interpersonal acceptance. According to inter-parental acceptance-rejection theory (IPART) (Rohner & Khaleque, 2002), interpersonal acceptance is generated by warmth and affection in the relationship and is based on sympathy. Sympathy, in turn, is dependent on reciprocity in human behavior of communication and sameness of character traits. Reciprocity of behavior is subsequently influenced by a perceived and radiated attractiveness of and to the other person and positive external perception. Interpersonal acceptance in decision support is a new component for analyzing acceptance conditions. Therefore this thesis considers interpersonal acceptance for deriving acceptance conditions. Due to a lack of research findings of algorithmic decision support on managerial-level, this thesis aims to identify acceptance conditions, in order to contribute to research and practice. This section aimed to emphasize the research gap and underline what has been already used in the context of academic literature. Summing up, the section shows that there is a need for investigating the conditions of accepting algorithmic decision support systems from a managerial perspective.

1.3. Outline of the thesis

This thesis aims to answer the following research question: which conditions lead to an acceptance of algorithmic decision support in management? In order to answer the research questions and derive the conditions that lead to an acceptance of algorithmic decision support in management, it is necessary to provide a better understanding of the theoretical foundation regarding algorithmic decision support in management and explain how this takes place in practice. This will be presented in section two where the relevance of algorithmic decision support is outlined. Hereby, the advantages of the integration of business analytics into business are examined. Necessary technological foundations are given in order to understand the underlying technology behind algorithmic decision support and understand the rapid development in performance of computing architecture.

Furthermore, acceptance conditions are derived from the literature. At first theories for an increase usage of technology are examined. In addition, the term acceptance plays an important role in the context of the research question, as

the conditions that lead to an acceptance of algorithmic decision support in management are investigated. To further elaborate on the role of acceptance from a theoretical point of view, different acceptance models that exist in the literature are presented. Findings from literature from of non-managerial-levels are used to derive hypotheses for acceptance conditions.

Afterward, a structural equation model will be derived based on the thoughts of the TAM for conducting a quantitative study (vignette study) to provide empirical evidence to answer the research question. The target group for the empirical study will be managers and students in future management positions as the research question focuses on the acceptance of algorithmic decision support in management. The items are derived from Scheuer (2020) who introduced the KIAM model which contains the TAM of Venkatesh and Bala (2008). The items are used in a vignette study (Wason, Polonsky, & Hyman, 2002). The results are analyzed empirically and descriptive statistics are provided.

Before estimating the structural equation model, the quality indicators for the measurement models and structural models are examined.

In the next section, the survey data is analyzed by estimating a structural equation model. The results of the analysis are discussed in a further section and contextualized to findings in literature. This section puts emphasis on the interpretation of the results where the quantitative results are transferred into qualitative measures and reflected in the theoretical foundations. In addition to this, the findings will be applied and compared to the results of the state of the art in literature. Afterward, the theoretical and practical implications are presented along with the limitations of the study. The conclusion summarizes the findings of the thesis.

2. Understanding acceptance of algorithmic decision support

In order to answer the research question, it is necessary to outline theoretical foundations. The following section will emphasize the importance of algorithmic decision support for strategic management. At first, the relevance of algorithmic decision support is derived on a general level. Further, algorithmic decision support is applied to the business context where advantages of the application of this technology are outlined. Afterward, the underlying technological components or related technologies are addressed for a sufficient technological foundation.

2.1. Relevance of algorithmic decision support

In order to understand the relevance of algorithmic decision support, it is important to understand what decisions are and when they occur. According to Mallach (1994), decisions are part of the problem-solving process and are defined as a reasoned choice between available alternatives. The literature identifies two types of decision-making processes. The intuitive decision-making approach and the rational decision-making approach (Alvarez, Barney, & Young, 2010). These approaches are based on the two types of cognitive processes of Stanovich and West (2000) and are defined as System 1 (based on intuition) and System 2 (based on reasoning). An intuitive decision-making approach is defined as a decision based on biases and heuristics (Alvarez et al., 2010). Individuals tend to use various kinds of heuristics in judgmental decisions (Tversky & Kahneman, 1974).

Managers tend more toward the intuitive decision-making approach than the rational decision-making approach (Anderson, 2015). Anderson (2015) identified that only 29% of senior executives of 1135 surveyed base their decision on data and analysis, where 30 % of them use their intuition or experience and 28 % of them use advice or experience of others as a source of decision. The majority of the surveyed managers use availability heuristics to make decisions which implies that most managers tend to use the intuitive decision-making approach. The use of heuristics and biases may lead to efficient decision-making or to decreased decision quality. Various studies show that the occurrence of biases lowers the quality of decisions (Camerer & Lovallo, 1999; Carr & Blettner, 2010; Everett & Fairchild, 2015; Forbes, 2005; Kahneman & Tversky, 1996; Koellinger, Minniti, & Schade, 2007; La Hayward, Forster, Sarasvathy, & Fredrickson, 2010). According to Carr and Blettner (2010) especially the quality of *hot decisions*[1] is strongly related to the success or survival of companies. This literature shows those wrong decisions by an intuitive decision-making approach can lead to the failure of the company. On the other hand, the advantage of intuitive decision-making is that it may be faster than rational decision-making. Intuitive decision making is based on *System 1* which is faster than *System 2* (Kahneman, 2003). The rational decision-making approach is based on *System 2*.

In the literature, there is no mutual agreement on an exact description of the process of the rational decision-making approach. Bazerman and Moore (2012) specify the rational decision-making approach as a rational model of decision-making assuming that people follow a certain process. The rational decision-making process by them is segmented into six phases: (1) *perfectly define the problem* (2) *identify all criteria* (3) *accurately weigh all of the criteria according to preferences* (4) *know all relevant alternatives* (5) *accurately assess each alternative based on each criterion* (6) *accurately calculate and choose an alternative with the highest perceived value* (Bazerman & Moore, 2012).

The main problem by the rational decision-making approach is that human-beings do not have complete information (Biswas, 2015).

The Prospect Theory addresses the problem of bounded rationality and gives the advice to use biases and heuristics when rational decision-making is not applicable (Kahneman, Slovic, Slovic, & Tversky, 1982). Despite incomplete information, a manager may use the rational decision-making approach for problem-solving process. It is tautologic to imply

[1] Hot decisions are defined as decisions who are critical for companies' success Janis and Mann (1977)

that decisions based on incomplete information lead to a decreased decision quality because the use of incomplete information is referred to as the availability heuristic. The effects of heuristics and biases on decision quality are mentioned above.

To overcome this vicious cycle the literature suggests a different kind of decision aids. Decision support systems (DSS) are a particular technological form of a decision aid. First DSS help decision-makers by giving them more information and extending their decision-relevant knowledge (Mallach, 1994). Referring to previous thoughts extended information would increase decision quality. Huber (1990) identifies that managers using computer-assisted decision aiding would make better decisions. Mcafee, Brynjolfsson, Davenport, Patil, and Barton (2012) consider data-driven decisions better than intuitive decisions because they are based on evidence. Despite the dynamic development of technology computer-aided decision support is not new. In fact, it is more than 50 years old. The First DSS application was built in 1970 (Watson & Wixom, 2007). The usage of DSS has various advantages.

Carlson (1977) identifies that DSS can be used in all decision-making phases. DSS can help to make the rational decision-making process better by partially reducing previous incomplete information. Nevertheless, the past 50 years led to an increased computing power by the factor of approximately 67.41 Million[2] according to Moore's law (Moore, 1965). A better example to understand the increased computing power is given in the following. Assuming no change in algorithms, operations that needed approximately 2.13 years of calculation to give decision aid in 1970 can now be processed within one second. Considering the rise of new and better algorithms which differ in performance since they are evaluated by runtime (Güting & Dieker, 1992; Mcafee et al., 2012) the performance of algorithmic decision support is increased. In fact, new algorithmic technologies like artificial intelligence, big data analytics, neural network, etc., leverage the performance of decision support systems. This increase in the performance of decision support systems may lead theoretically to an extensive improvement of a rational decision-making process by reducing time and incomplete information in theory. At the practical level, necessary data for information processing should be available since information is processed out of data by analytics. The analysis of data to support decision-making is considered business analytics (Shanks & Bekmamedova, 2012). Besides supporting decisions, business analytics has a wide range of impacts on business. Therefore it is necessary to understand the impact of algorithmic decision support on business and the underlying technologies of algorithmic decision support.

[2]Meaning the computing power is doubled every second year due to constant costs of transistors. The necessary mathematical operation is 2^{26}. 52 years were passed. These years are divided by two results in the power of 26.

2.1.1. Advantage of business analytics in management

In order to understand the impact of business analytics on management, it is necessary to understand the role and tasks of management.

Management is defined as leadership in the efficient, informed, purposeful and planned conduct of complex organized activity (Andrews, 1980). The activity is characterized by high complexity and the desirability to increase the intuitive competence of the executing manager. Andrews (1980) suggests the need for a unitary concept for reducing the complexity of the manager's job and identifies strategy as a possible solution to reduce complexity. Therefore it is important to distinguish between operational and strategic activities. According to Porter (1996), operational activities are about performing similar activities. They differ only if they are performed in a more efficient way than rivals. Porter (1996) defines strategy as the creation of a unique and valuable position, involving various sets of actions. Therefore Andrews (1980) delivers the approach of a schematic development of an economic strategy. According to Andrews (1980), it is necessary to identify external opportunities and risks and get insights into the corporate capabilities and resources in terms of strengths and weaknesses and consider all combinations of internal and external analysis to evaluate and determine the best match for opportunity and resources. In the end, a choice is derived which is called an economic strategy. This schematic development of an economic strategy is relevant in theory and practice because the SWOT-Analysis is based on this scheme (Kotler, Berger, & Bickhoff, 2010). Andrews's (1980) approach shows that strategy is all about the evaluation and selection of choices – similar to the definition of making decisions. Porter (1996) confirms that strategy is the deliberate disregard of other alternatives by purposefully limiting what a company should do. Strategic management can be considered as the reasoned choice or decision between the combination of strategies from the internal and external analysis. As mentioned before there are two decision-making approaches.

The highest valuated companies in the world can be considered as successful in competition due to the financial indicator. The top five companies with the highest valuation in May 2022 are Apple, Saudi Aramco, Microsoft, Alphabet and Amazon (Companiesmarketcap, 2022). Except for Saudi Aramco, the highest valuated companies could establish their market position due to the use of algorithmic support, explicitly through the use of artificial intelligence (Rainsberger, 2021). Rainsberger (2021) shows four dimensions where algorithmic aid (artificial intelligence) revolutionizes business activities. The four dimensions are strategy, performance, effectiveness and competence. In the following, the wide range of impacts on business analytics is outlined. Especially strategic management is affected by business analytics.

The assumption that an alternative future can be derived from certain past events (Luhmann, 1990) is essential for algorithmic aid. This assumption is essential, since analytics is based on historical data (descriptive analytics), esti-

mates future outcomes (predictive analytics) and determines actions for optimizing business outcomes (prescriptive analytics) (Apté, Dietrich, & Fleming, 2012). Descriptive analytics enable organizations to calibrate opportunities by providing insights into what happened previously in their internal and external environment (van Rijmenam, Erekhinskaya, Schweitzer, & Williams, 2019). Anticipating a possible future leads to a competitive advantage (Koch, 2015). Côrte-Real, Oliveira, and Ruivo (2017) specify that algorithmic aid allows effective internal and external knowledge management enhancing organizational agility. Côrte-Real et al. (2017) address the scheme of economic strategy by Andrews (1980) for sensing opportunities and threats and seizing possible chances.

The implementation of algorithmic aid in the internal and external analysis of a company can gain insights into the internal processes and external events (Benaben et al., 2019) with the possibility to analyze this data and make predictions of future internal processes and external events. Considering all combinations of internal and external analysis a more precise evaluation and determination for the best match of opportunity and resources is possible. The literature suggests that algorithmic aid (predictive analytics) leads to better decision-making by improving business value and competitive performance (LaValle, Lesser, Shockley, Hopkins, & Kruschwitz, 2011; Shanks & Bekmamedova, 2012). A possible explanation for this relation is that predictive analytics helps companies to remain competitive by anticipating changing environments and adapting to these changes (Hajkowicz et al., 2016).

The distinction between strategic and operational activities was outlined. We showed that business analytics can enhance strategic activities. Other dimensions of Rainsberger (2021) address operational activities. In the following, a detailed description of enhanced operational activities is derived.

The second dimension of Rainsberger (2021) is performance. Operational activities can be enhanced by business analytics since we showed that algorithmic aid (Big Data Analytics) improves business performance (Mcafee et al., 2012). Furthermore, Chen, Preston, and Swink (2015) and Apté et al. (2012) show that algorithmic aid enhances operational efficiency. An example of operational efficiency is improved workforce planning and reduced need for new hires and a reduction in overtime (D. Barton & Court, 2012). Further benefits are decreased cost for IT-Infrastructure and efficient data delivery resulting in saving time (Watson & Wixom, 2007). An example of the reduction of costs is preventing and monitoring fraud in organizations. Analytics enable fraud detection at reasonable costs (Mishra & Silakari, 2012). All in all algorithmic aid helps to make effective decisions faster (Reid, McClean, Petley, Jones, & Ruck, 2015) even enabling to automate operational workflows (Iansiti & Lakhani, 2020) resulting in greater performance.

The third dimension of Rainsberger (2021) is competence. Gartz (2004) shows that business intelligence can enhance the representation and evaluation of companies' knowledge using knowledge-based systems. Therefore algorithmic aid can help to preserve knowledge within the company and make information flow more efficient (Watson & Wixom, 2007).

The fourth dimension of Rainsberger (2021) is effectiveness. The literature suggests explicit effectiveness of the use of algorithmic aid in sales and marketing (Halper, 2014; Mishra & Silakari, 2012; Rainsberger, 2021). The effectiveness is shown by the term pervasive business intelligence. Pervasive business intelligence is providing users with information for better job performance (Watson & Wixom, 2007). The advantage of pervasive business intelligence is that data is delivered to the certain user who needs the data to take an effective decision (Rainsberger, 2021). Furthermore, algorithmic aid can provide insights into customer habits & patterns by analyzing customer data (Hamilton & Koch, 2015). Therefore the use of algorithms enables personalized contextual interaction with customers (Brahm, Cheris, & Sherer, 2016). Customization to customers' needs is a very effective form of gaining competitive advantage at operational level since data-based customization to customers' needs brings value (Davenport, 2013). On the other hand customer prioritization by analyzing customer profitability through digital devices can increase effectiveness of business (Davenport, 2013). The effectiveness of a business can be measured by financial indicators. J. R. Evans and Lindner (2012) suggest that algorithmic aid can increase profitability, revenue and shareholder return. Furthermore, companies' goals can be reached faster with the use of analytics (Rainsberger, 2021).

2.1.2. Technological foundations for algorithmic decision support

The main goal of algorithmic decision support is to gain value-creating information (Mikalef, Pappas, Krogstie, & Pavlou, 2020). The information is derived from data (Azvine, Cui, Nauck, & Majeed, 2006; Benaben et al., 2019). The abstraction levels of data, information, decision and knowledge are shown in Figure 1.

According to Benaben et al. (2019) data is a formalized observation of the reality. Information is defined as the result of the interpretation of data through algorithmic methods (Benaben et al., 2019). The process of applying data analysis and discovery algorithms over the data is described as Data Mining (Fayyad, Piatetsky-Shapiro, & Smyth, 1996). Benaben et al. (2019) define the exploitation of information generated by data mining as a decision. The definition of Benaben is not contradictory to the definition of Mallach (1994) mentioned earlier in this paper due to the fact that the information provides the ability for reasoning in choice-settings. The last distinction by Benaben et al. (2019) is knowledge.

Knowledge is a capitalized static information about extracted abstract concepts or previous experience (Benaben et al., 2019). As described earlier the interpretation of data is executed by algorithms. Therefore, it is necessary to define algorithms. The literature has a broad definition of algorithms. Moschovakis (2001) outlines the necessity to define algorithms precisely. According to Moaschavakis, a rigorous

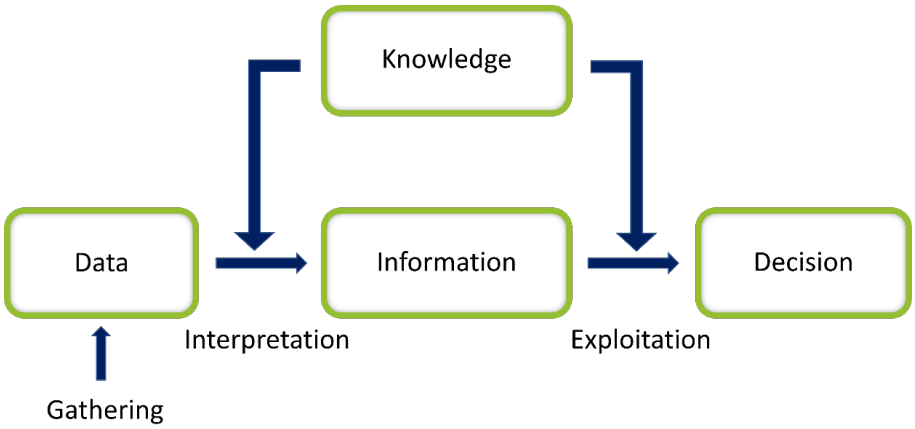

Figure 1: K-DID framework presenting the abstraction levels of data, information, decision and knowledge (Source: Benaben et al. (2019))

definition can lead to a wrong identification of abstract machines or mathematical models of computers.

According to Güting and Dieker (1992), an algorithm is defined as a specific process of tasks with a clear order of tasks run by mechanical or technical devices to receive an expected output for a task. Furthermore, they characterize that every task has to be described clearly and is executable with finite effort in finite time leading to a termination of an algorithm. Therefore algorithms can metaphorically be seen as a recipe for a problem-solving process. The recipes for the problem-solving process can vary in tasks. In the end the best performance of a recipe matters.

The implementation of a certain data type on algorithmic-level is characterized by data structures (Güting & Dieker, 1992). Algorithms differ in performance if they are used in other data structures than intended. Short runtimes are performance measures for algorithms. The selection of algorithms is based on a runtime analysis (Güting & Dieker, 1992; Knebl, 2019). The runtime analysis does not contain computing power of the underlying hardware run on algorithms. In the evaluation of algorithms, it is necessary to distinguish between runtime and computing time since the computing time involves the performance of hardware and algorithm combined. In practice, computing time is a desirable performance measure for algorithms. Computing time can be reduced by aiming for a low runtime of an algorithm or using performant hardware. Therefore decision support can perfectly aid in the decision-making process since the quality of algorithms is evaluated by time.

Recent advances in hardware show a leveraging effect on computing power. Besides Moore's law, other advances in hardware can be seen in Butters or Kryder's law. Butter's law indicates that the amount of data transmitted by fiberglass doubles every 9^{th} month (Rainsberger, 2021). Furthermore, Kryder's law states that storage capacity doubles every 13^{th} month proportional to one square-centimeters of a hard drive (Rainsberger, 2021). These technological advances have exponential growth by definition leading to radical advances of exploitation in the business context. Despite the rapid development of technology, the conception of computing hardware exhibits weakness in performance due to architectural issues. Computing architecture nowadays is divided into Central Processing Unit (CPU) and Random Access Memory (RAM) defined as Von-Neumann-architecture (Leimeister, 2019). The CPU interprets and executes commands in sequential order and the RAM saves necessary data for the necessary point of time for processing (Leimeister, 2019). Shi (2021) and Rosenberg (2017) show several problems in Von-Neumann architectures. Shi (2021) states that Moore's law will reach its physical limit in the coming 10 - 15 years. Furthermore, the sequential processing of commands leads to an inefficiency in comparison to the actual brain. The human brain has advances against the computer in coping with novelty, complexity and ambiguity (Furber, 2016). The calculating speed and precision of a computer is higher than that of human brains but the level of intelligence of computers is low (Furber, 2016; Shi, 2021). In fact, various research fields of computer science are inspired by the human brain. Therefore neuromorphic computer architecture is a solution toward the challenges faced by Von-Neumann architecture. Neuromorphic computing is inspired by the research findings of the structure and operation of the brain (Furber, 2016). Neuromorphic computing aims to extract the formidable complexity of the biological brain and apply this knowledge to practical engineering systems (Furber, 2016). An example of neuromorphic computer architecture is the product of the german startup from Bochum called GEMESYS Technologies. This startup develops a neuromorphic chip that substitutes Von-Neumann architectures (GEMESYS Technologies, 2022). Recent breakthroughs in neuromorphic computing research show that computing architecture can become intelligent. Kagan et al. (2021) introduce a new system architecture called DishBrain. The DishBrain integrates neurons into digital systems to leverage their

innate intelligence. Kagan et al. create a synthetic biological intelligence by harnessing the computational power of living neurons. Therefore the DishBrain can exhibit natural intelligence and create a new computing architectures by potentially substituting Von-Neumann architectures (Kagan et al., 2021). Future developments in computing architecture are to use the human brain as a processing unit by creating an interface between the human brain and the computing system developing an interface to human brain (Kreutzer & Sirrenberg, 2019). These interfaces are called Brain Machine Interfaces (Kreutzer & Sirrenberg, 2019).

Since software is a leverage for enhancing computing performance (Rosenberg, 2017) it is necessary to put emphasis on recent advances in algorithmic developments.

AI is an expression of form of algorithms. The term AI has a wide range of definitions, and the selection of a specific definition results in path dependency for research (Wang, 2019). Considering the path dependency interpreted by Wang, a more general definition of AI is used. According to Rich (1985), AI is the science of enabling computers to do things that humans are currently better at. According to Kreutzer and Sirrenberg (2019), AI is the ability of a machine to perform cognitive tasks. This includes reasoning skills, learning, and finding solutions to problems independently. The idea of an AI is first introduced by Turing. Turing (1950) investigates the ability of machines to think. Therefore he argues that a successful imitation game by a computer can lead to the suggestion that machine can think. In the imitation game, the computer is programmed for doing realistic conversations. The imitation game is successful if a human being can differentiate whether the subject in the conversation is a computer or another human. According to Turing (1950), the perception of the interrogator plays a role in the evaluation of the question of whether machines can think or not. Therefore, if a machine is perceived as a human, Turing considers that this machine can think. The test for considering a system as intelligent according to Turing's definition of intelligence is defined as the Turing test.

Dellermann, Ebel, Söllner, and Leimeister (2019) define intelligence as the ability to achieve complex goals, reason, learn and adaptively perform effective activities within an environment. Moreover, they extend the concept of intelligence by dividing it into human intelligence and machine intelligence to gain complementary capabilities and augment each other (Dellermann et al., 2019). As mentioned before, computer architectures are in terms of performance in intelligence lower than human brains. Therefore computer architectures are inspired by the human. Dellermann et al. (2019) introduce the term of hybrid intelligence in terms to combine the advances of human brain and computer systems. The same applies to algorithms. The research field of computational intelligence aims to develop algorithms devised to imitate human information processing and reasoning mechanisms for processing complex and uncertain data sources (Iqbal, Doctor, More, Mahmud, & Yousuf, 2020). Further technologies inspired by humans are neural networks (Iqbal et al., 2020; Kreutzer & Sirrenberg, 2019).

A neural network is a computer system containing hardware and software inspired by human brain (Kreutzer & Sirrenberg, 2019). A neural network has multiple CPUs in order to approximate simultaneous information processing. In Figure 2 the structure of the neural network is shown. The first layer is the Input Layer where data is stored as input for further processing by the following Hidden Layer. Following layers are defined as Hidden Layer. A Hidden Layer can take the outputs of previous Hidden Layers and do further processing generating a new output which is processed by the following Hidden Layer. The last layer is defined as the Output Layer. The Output layer generates a new output of the previously generated outputs by the previous Hidden Layer. Each processing algorithm of a neural network can vary from the other. In Hidden Layers machine learning algorithms are also used (Kreutzer & Sirrenberg, 2019).

Machine learning (ML) on general level is defined as a set of methods that can automatically detect patterns in data and use uncovered patterns to predict future data or to support other kinds of decision-making under uncertainty (Murphy, 2012). Murphy (2012) states that ML provides automation in data analysis. Therefore he suggests three types of learning algorithms supervised learning, unsupervised learning and reinforcement learning (Murphy, 2012). Supervised learning is when results the machine should process are given a priori. The machine is trained to process the right results (Rainsberger, 2021). When results are not given a priori a ML algorithm is defined as unsupervised learning. Here the machine identifies automatically patterns in data and creates results (Rainsberger, 2021). Reinforcement learning is inspired by human learning the machine gets rewards for right results and punishments for wrong results (Buxmann & Schmidt, 2021; Murphy, 2012; Rainsberger, 2021). Punishments and rewards are normally associated with the teaching process (Turing, 1950). Reinforcement learning is inspired by the findings of Turing (1950) who suggests instead of programming a simulation of an adult mind programming a simulation of a child's brain can lead to a simulation of an adult brain in future. If ML is applied in neural networks the term Deep Learning is used in literature (Kreutzer & Sirrenberg, 2019).

As mentioned before data is necessary for data mining. Besides the technological advances in hardware and algorithms, data itself is developing in a broad way. It is necessary to define the term Big Data due to the fact that Big Data is essential for the previously mentioned technologies. Mashingaidze and Backhouse (2017) show various definitions of Big Data in literature and practice. Considering the broad range of definitions for Big Data, Mashingaidze and Backhouse (2017) synthesize all definitions into a new one. According to them, Big Data is data that is high in volume gathered from a variety of sources or data formats and is generated at high velocity. Conventional technologies are insufficient for the management of Big Data due to the high level of complexity of Big Data. Therefore new advanced technologies and techniques for storage and analysis of data are required (Mashingaidze & Backhouse, 2017). Data Ware-

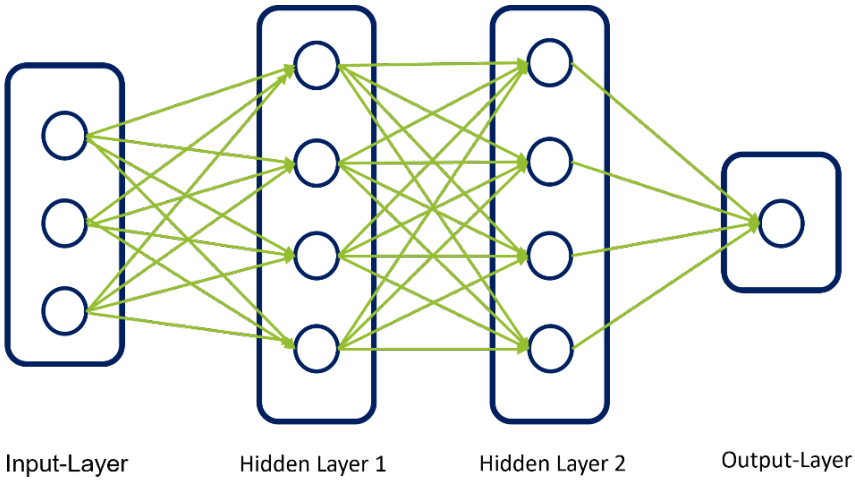

Figure 2: Structure of a neural network (Source: Own illustration according to Kreutzer and Sirrenberg (2019))

houses are the necessary technology for coping with the high level of complexity of Big Data (Leimeister, 2019). According to Leimeister (2019), Data Warehouses are a specialized technology for the storage of data and information. Furthermore, they are the underlying technology for business intelligence. Their function is to gather data and ensure data quality considering uniformity, consistency and freedom from error of data (Leimeister, 2019). They provide data for other systems using interfaces (Leimeister, 2019).The mentioned technologies can be used to assist humans in their work. The collaboration of technology and humans is called human-machine interface (Blutner et al., 2009). Human-machine interfaces are used to execute hybrid intelligence. Sheridan and Verplank (1978) develop ten automation levels for assisting human. In Figure 3 the ten automation levels are shown the terms used in the illustration are developed by Blutner et al. (2009).

The first level of automation is the manual control where the human executes tasks without the aid of the computer. In the second level (Action Support) the computer suggests choices for task execution. The Batch processing reduces the number of choices and takes a preselection of choices. The selection of the choices is done by the human. In the next level (Shared Control), the computer reduces the degree of choices and processes a result for one alternative which is suggested to the human. The human has the possibility to select the processed choice. The next level is Decision Support where the confirmation of the human is necessary for the computer-aided execution of the processed result. In the Blended Decision Making level, the human only has the right for interventions. The computer does the tasks automatically. The next level is Rigid system where the task execution is automated through computer aid. Human role here is to monitor task execution. At the Automated Decision Making level, the monitoring by human is only provided by request. The level of control by the computer is extended in the next level where the computer executes the tasks automatically. Monitoring possibility is only provided after a decision. Furthermore, the last level of automation is full automation where the computer has full control over the task and the human is ignored (Blutner et al., 2009; Sheridan & Verplank, 1978). Systems, where various technologies and concepts are combined to aid in management, are defined as business intelligence systems (Nedelcu, 2013). Therefore, a decision support system can be seen as an assistant system for management tasks. The use of various technologies to aid managers in decision-making is defined as business intelligence (Baars & Kemper, 2021; Gluchowski, 2016). In fact, the term business intelligence has no uniform definition. Furthermore, it is important to distinguish between business analytics and business intelligence. Mashingaidze and Backhouse (2017) show various definitions of business intelligence (BI) and business analytics (BA) in literature and practice. BI is defined as a set of integrated strategies, applications, technologies, architectures, processes and methodologies in order to gather, store, retrieve and analyze data to support decision-making (Mashingaidze & Backhouse, 2017). According to Mashingaidze and Backhouse (2017), BA is defined as a set of skills, applications, technologies, architectures, processes and methodologies used to collect, store and retrieve data for the purpose of data mining in order to support decision-making, inform business strategy and drive performance. The data mining techniques can be descriptive, predictive and prescriptive from scientific disciplines such as mathematics and statistics. Since this paper outlined the technological foundations and benefits of algorithmic decision support it is necessary for summarization to illustrate the components of decision support system. The figure 4 shows the framework of Delen and Demirkan (2013). Business processes create transaction data which are gathered in data warehouses. These data warehouses include various data sources for data mining. Interfaces with other systems process new data, information or knowledge. The processed findings are used for consultation of decision makers or to identify opportunities and risks (environmental monitoring).

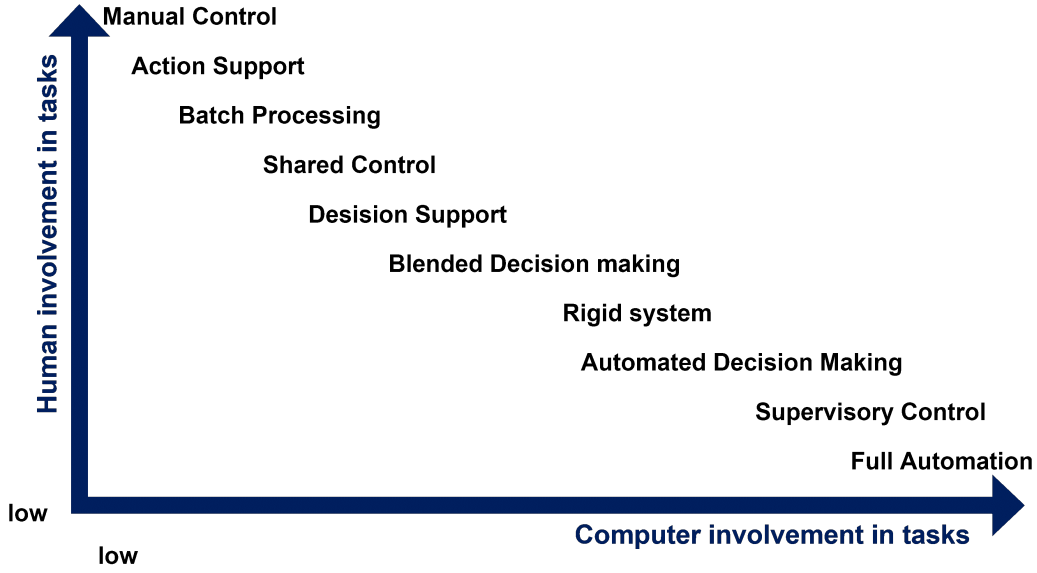

Figure 3: Illustration of ten automation levels for assisting humans (Source: Own illustration according to Sheridan and Verplank (1978) and Blutner et al. (2009))

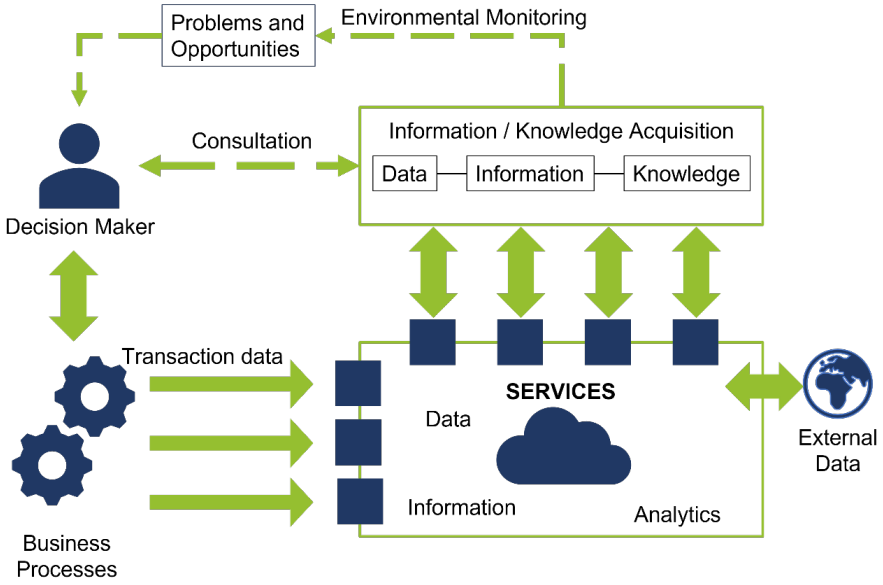

Figure 4: A conceptual framework for service-oriented decision support systems (Source: Delen and Demirkan (2013))

2.2. Deriving the need for acceptance conditions: technology acceptance models

Since this paper showed a wide range of benefits of algorithmic decision support on business activities, one can suggest to easily implement algorithmic aid to outperform the competition. In fact, the benefits of algorithmic aid are not from the application themselves. Moreover, the integration of algorithmic aid into business where business processes are transformed and redesigned deliver these kinds of benefits (Apté et al., 2012). Further literature shows that the application of algorithmic aid can even lead in a failure to realize expected performance gains (Mikalef, Boura, Lekakos, & Krogstie, 2019). Mikalef et al. (2019) outline that organizational aspects and managerial skills are more important in an uncertain environment than application of technology itself. Laudon, Laudon, and Schoder (2016) outline factors that determine the success or failure of an information system. They state that four factors influence the result of the implementation in terms of design, cost, usage and data. The factors of Laudon are the involvement of users and consideration of their influence which is also supported by (Korsgaard, Schweiger, & Sapienza, 1995). The next factor of Laudon et al. (2016) is the support from the management. Due to the fact that this paper focuses on decision support systems used

by managers, managers and users are the same people. However, the need of support from management is a crucial factor for decision support systems (Mcafee et al., 2012; Rainsberger, 2021). A further factor of Laudon et al. (2016) is the degree of complexity and the risk of the implementation process. The next factor of Laudon et al. (2016) is the management of the implementation process. Laudon et al. (2016) refer here to the change management process.

In general, the technological change management process is related to challenges (Orlikowski, 1992). In specific, Larson and Chang (2016) show that the adoption of BI applications and services is challenging for organizations. According to Savolainen (2016), the commitment to a change process can be predicted by acceptance. Scheuer (2020) shows that the aim of acceptance research is the explaining of behavior of users in terms of rejection or affirmation due to the use of material or non-material (artificial) technologies. Therefore he defines acceptance as the willingness of someone to voluntarily accept, acknowledge, approve or agree with a subject. In fact, a decision suggested by system inhibits quality if the decision fulfills the goals and is accepted by users (Sharma, Mithas, & Kankanhalli, 2014).

Scheuer (2020) shows various kinds of acceptance models in the literature. Acceptance research varies in the point of technology usage. Various research fields focus on acceptance: information system research, marketing research, behavioral consumer research, psychology and philosophy (Königstorfer, 2008). The information system research is characterized by the technology acceptance model. The technology acceptance model (TAM) was first introduced by Davis (1989) and states that the attitude toward using a technology is influenced by the perceived usefulness or perceived ease of use. Furthermore, TAM by Davis (1989) was extended by social influence mechanisms and cognitive instrumental processes who influence decision making or an attitude towards using a technology (Venkatesh & Davis, 2000). This extension is defined as TAM 2 (Venkatesh & Davis, 2000). Moreover, a further extension of TAM 2 was introduced and defined as TAM 3 (Venkatesh & Bala, 2008). TAM 2 by Venkatesh and Davis (2000) is extended by determinants of perceived ease of use by Venkatesh (2000). The determinants of perceived ease of use are defined in the following. *Perceived Enjoyment* is defined as the perception of joy resulting from system use (Venkatesh, 2000). The second determinant of perceived ease of use is *Computer Self-Efficacy* which is defined as the subjective perception to have the necessary capabilities to perform a specific task using a computer. A further determinant by Venkatesh (2000) is the *Computer Playfulness* defined as the degree of cognitive spontaneity while interacting with the computer (Venkatesh & Bala, 2008). *Perception of External Control* is defined as the perception of support for the computer from organizational and technological resources. A further determinant is *Computer Anxiety* which stands for the perception of fear while using the computer. The last determinant of Venkatesh (2000) is the *Objective Usability* which is defined as a comparison of the system in terms of task completion.

Scheuer (2020) develops an acceptance model for the use of artificial intelligence. The model developed by Scheuer is called KIAM model (Scheuer, 2020). The KIAM model is an extension of the TAM model and is considered as the Artificial Intelligence Acceptance Model. Whereas KI is referred to the german term for AI. The AI acceptance model (KIAM) consists of a holistic acceptance model that addresses the characteristics of the theoretical properties of an AI compared to a classical computer system. Scheuer assumes that an AI is accessible via a technology (e.g., a smartphone application) and enriching it with Narrow AI services (e.g., a chatbot integration, Speech-To-Text, or Text-To-Speech) through which a user can interact with the AI in natural language. Based on this, two essential components emerge first, the classical technology in the form of a software application, and second, the dialog component for interacting with the AI in the background. For the classical technology and the investigation of its acceptance, Scheuer (2020) uses the existing TAM model by Venkatesh and Bala (2008) TAM 3. However, for the dialog component and the resulting interaction between the AI and the user, Scheuer (2020) differentiates to what extent the user accepts the AI as a personality and sees the system as a complete person or as a technology. Furthermore, he shows that the perception of the system as technology or as person determines suitability of acceptance models.

For this, he considers that psychological models for measuring sympathy and affection apply as personality acceptance takes precedence over pure technology acceptance if the system is seen as a person. In this regard, Scheuer (2020) highlights that if the filter of the perception of the system as a personality is considered and an AI is recognized as a personality. This relationship with the technology can be described by interpersonal acceptance models.

On the other hand, if a system is perceived as a technology TAM is suitable (Scheuer, 2020). He shows that the perception of a system as a technology has an influence on acceptance.

Since Scheuer (2020) shows that the perception of a system as a technology or a person determines how acceptance is created it is necessary to consider the perception of the system for acceptance conditions. Therefore it is necessary to derive further acceptance conditions for decision support systems.

Since decision support systems may influence the decision of the user it is important to understand the concept of persuasive technologies in order to derive acceptance conditions. A persuasive computer is an interactive technology that changes the attitude or behavior of the user (Fogg, 1998). The intention for technology usage is key here. If a person is using the interactive technology with the intent to extend or change his or her attitude or behavior the type of intent is defined as autogenous by Fogg (1998). The intent is defined as exogenous if the access to the interactive technology is given by others (Fogg, 1998). Furthermore, the intent of creation or production of interactive technology is defined as endogenous by Fogg. Additionally, Fogg (1998) differentiates three types of computer functions. Fogg (1998)

sees the computer as a tool for reducing barriers, increasing self-efficacy, decision support and change of mental models. Moreover, the computer is seen as a medium for providing experience by insights and visualization, promoting understanding of causal relationships and motivating through experience. At least Fogg (1998) sees the computer as a social actor who creates relationships by establishing social norms, invoking social rules and dynamics and providing social support or sanction. Fogg (1998) demonstrates that it is important to see decision support systems as persuasive technologies with various kinds of functions for usage.

The structuration approach from DeSanctis and Poole (1994) focuses on the social structures for human activity provided by technology. Further, they differentiate between two social structures. Firstly the features of the technology called the structural and secondly the general experience towards the feature of the technology, defined as spirit. The adaptive structuration approach of DeSanctis and Poole (1994) can be seen as a structuration approach that highlights the user-centricity in terms of user experience (UX) and user interface (UI). The spirit of the social structure can be referred to UX due the definition by Hassenzahl and Tractinsky (2006). They define UX as a consequence of a user's internal state while interacting with the technology. UI is defined as including all aspects of system design that affect a user's participation in handling the system (Smith & Aucella, 1983). If the features of the system are not comprehensible a mismatch between system and user is given leading to a decreased effectiveness of the information system (Barbosa & Hirko, 1980).

UX and UI optimization may be a fundamental part of acceptance research for information technologies since Gong (2008) shows that an anthropomorphized interface leads to higher social responses from users. Scheuer (2020) identified that anthropomorphizing a system interface has a positive influence on the perception of the system as technology and as a person. **Therefore the hypothesis should be tested that an anthropomorphizing of a system leads to an acceptance of the system (H1)**.

In the following, the necessity of user-centricity due to the process of implementation of algorithmic decision support is outlined. Makarius, Mukherjee, Fox, and Fox (2020) research how to successfully integrate AI into an organization. They outline that comprehension of employees is crucial for a successful integration of AI. Furthermore, Makarius et al. (2020) formulate research necessity in the field of trust of decision-makers in the output of decision support systems, fostering team identification between AI systems and users. Scheuer (2020) identified a positive influence of trust on acceptance. Trust may be an acceptance condition for decision-support systems. **Therefore the hypothesis should be tested that trust leads to acceptance (H2)**.

Rainsberger (2021) identifies major challenges in the adoption of AI systems. According to Rainsberger insufficient knowledge about the benefits of the technology, lacking trust towards the technology and insufficient resources for technology implementation hinder AI adoption in an organization. He summarizes that these fallacies arise due to ignorance of the decision-makers. The TAM by Venkatesh and Bala (2008) considers the result demonstrability as the transparency of the information system in result processing. Since Scheuer identifies that trust is influenced by the transparency of the system **the hypothesis higher transparency/comprehensibility of a system leads to more trust is tested (H3)**.

Gartz (2004) also sees challenges in implementation of technologies for decision support due to missing awareness or lack of interest and motivation of management. It is necessary for senior leaders to recognize the importance of decision support (Grossman & Siegel, 2014; Mcafee et al., 2012). One major challenge here is the change in the decision-making culture. In important decisions companies often rely on "HIPPO" (highest paid person's opinion) (Mcafee et al., 2012). If a decision support system is introduced which is by definition a persuasive technology does the senior leader or decision maker allow themselves to be overruled by data (Mcafee et al., 2012)? Orlikowski and Robey (1991) assumes that more information in the decision-making process leads to a higher power of the decision maker**.** Does more information lead to a shift in the decision-making process from the HIPPO as an expert to HIPPO as an interrogator (Mcafee et al., 2012) leading to a decreased power? Does the senior leader accept a decision support system that may lead to a shift in their role in form of decreased power? **Therefore the hypothesis more transparency leads to higher perceived participation of the user in the decision-making process (H4) is tested**.

Participation in decision-making leads to a higher perception of fairness (Korsgaard et al., 1995). Newman, Fast, and Harmon (2020) show that participation possibilities in the decision-making process increase trust. Do participation possibilities in the decision-making process lead to an increased perception of trust if the output is not comprehensible due to the black box of algorithmic aid? In order to answer these questions, **the hypothesis the higher the perceived participation of the system-user in the decision-making process the higher the perceived trust towards the system (H5) is tested**.

The TAM model considers the perceived usefulness as an indicator for acceptance. Therefore it is necessary to consider the perceived intelligence of the system as an acceptance condition. Furthermore, Scheuer (2020) tests the effect of perceived intelligence and trust. Despite no evidence from Scheuer for a relationship between trust and the perceived intelligence, trust may be a mediator for the relationship between perceived intelligence and acceptance. **Therefore, the hypothesis the higher the perceived intelligence of the system is the higher the trust (H6) should be tested**.

As mentioned earlier Scheuer (2020) identifies that the perception of a system as a technology or as a person creates acceptance. The following hypotheses should be tested. **The higher the perception of the system as technology is, the higher acceptance (H7)**. **Furthermore the higher the perception of the system as a person, the higher acceptance**

(H8).

2.3. State of the art in literature: acceptance conditions of algorithmic decision support

In order to answer the research question, it is necessary to make an analysis of the state of the art in research. Various studies do research on the topic of acceptance of artificial intelligence-based technologies which is one of the technologies for algorithmic decision support.

Hastenteufel and Ganster (2021) apply this topic to the digital transformation in banking. They analyze the acceptance of Robo Advisors using a modified TAM model. Therefore they use the technology acceptance model by Davis et al. (1989) as a foundation. Hastenteufel and Ganster (2021) identify trustworthiness, perceived usability and social influence as acceptance conditions for algorithmic decision support. Similarly to Hastenteufel and Ganster (2021), Rathje et al. (2021) do research about trust in banking. Therefore they develop their own research model based on the models by Mayer et al. (1995), Gefen et al. (2003) and Davis (1989). They conducted a survey with 119 participants where the affinity to technology is high. Rathje et al. (2021) identify that trust has a relationship with the intention to use the technology. Despite relevant findings for this thesis, these papers analyze the acceptance on consumer-level.

Gersch et al. (2021) do research about the challenges particular in trust in a collaborative service delivery with artificial intelligence in the field of radiology. Therefore they conduct interviews with various stakeholders in the radiology. They identify trust as an indicator to cope with uncertainties. Furthermore, Gersch et al. (2021) identify that cognitive trust is built in the first contact with the user. With repeated experience, the user develops affective trust. Understandability and comprehensibility are important for users. Further challenges are the change of own position in the workplace due to the introduction of support through artificial intelligence and arising of new duties and prerequisites in the design of the socio-technical system (Gersch et al., 2021). Therefore they suggest that explainable artificial intelligence should consider the perspective of different stakeholders. Since the objective of research in this paper is applied to the health industry these results are partially applicable for this thesis.

Pütz et al. (2021) do research on the topic of acceptance of voice and chatbots. They use the technology acceptance model of Davis (1989) and the extended version of Venkatesh and Davis (2000) and Venkatesh and Bala (2008) to analyze the acceptance of this technology. The approach used by Pütz et al. (2021) is literature-based. They identify a relation between perceived usability and perceived user-friendliness. Further results are a relation between perceived user-friendliness and intention to use the technology. Since the research of Pütz et al. (2021) focuses on the acceptance of voice and chatbots these results are applicable to the research question of this thesis if these kinds of technology is considered.

Lee's (2018) study shows how people perceive decisions made by algorithms compared with decisions made by humans. He made an online experiment by using four managerial decisions that required human or mechanical skills. By manipulating the decision maker in terms of algorithm and human he measured the perceived fairness, trust and emotional response. In mechanical tasks, decisions made by algorithms and humans were perceived as equally in fairness, trustworthiness and evoked similar emotions. Decision made by humans for mechanical tasks differ in terms of trustworthiness due to the attribution to managers' authority. Decisions made by algorithms were perceived as fair and trustworthy due to attribution perceived efficiency and objectivity. In human tasks, decisions made by humans evoke positive emotions which can be attributed to social recognition. Further Lee (2018) identifies that human task made by algorithms are perceived as less fair and trustworthy. Furthermore, decision made by algorithms in human task evoke negative emotions due to the perception of a dehumanizing experience of being tracked and evaluated by machines. The perceived lack of intuition and subjective decision capabilities caused lower perception of fairness and trustworthiness. Newman et al. (2020) analyze the perceived fairness of decision-making by algorithms in human resource management. They assume that algorithms increase procedural fairness. Further they assume that decisions made by algorithms are less accurate than identical decisions made by humans. Newman et al. (2020) prove that individuals perceive decisions made by algorithms as less fair than comparable decisions made by humans. Further they outline that algorithms are perceived as reductionistic leading to a decreased perception of fairness. Newman et al. (2020) show that organizational commitment is affected in a negative way by decisions made by algorithms where the perception of fairness has a mediating effect. However, the negative effect of decisions made by algorithms is mitigated in decisions made by hybrid intelligence where the human has more involvement. Furthermore, high transparency in algorithmic decisions has a negative effect on perceived fairness and leads to decontextualization. On the other hand transparency in human decision leads to an increase in the perception of fairness and cause less decontextualization.

Lee (2018) shows that the perception of algorithms lies in the decision context and characteristics of the decision. Newman et al. (2020) show that the perception of fairness is human-centered. Despite the strong consideration of Lee (2018) on acceptance or Newman et al. (2020) on perceived fairness at worker-level, these results are applicable for this thesis. Newman et al. (2020) findings about the role of transparency will be considered for this thesis.

Panagiotarou, Stamatiou, Pierrakeas, and Kameas (2020) confirm Lee's (2018) results since they reveal that task characteristics matter in order to understand people's experiences with algorithmic technologies. Furthermore, they find to prove that participants with different levels of technical skills have statistical differences in perceived usefulness of the technology, perceived ease of use, intention to use

the technology and actual use of the technology. Sagnier, Loup-Escande, Lourdeaux, Thouvenin, and Valléry (2020) analyzes the acceptance of Virtual Reality (VR). They identified an indirect effect of personal innovativeness on the intention to use due to the fact that people with high personal innovativeness have an interest in new technologies and are more likely to perceive a higher usefulness which leads to an intention to use Virtual Reality. Besides task characteristics, the literature suggests that the characteristics of the person who is going to use the technology matter. The results from (Panagiotarou et al., 2020; Sagnier et al., 2020) can be considered for further analysis.

Uysal, Alavi, and Bezençon (2022) analyze potential harmful and beneficial effects while using artificial intelligent assistants (AIA) such as Alexa. They identify that anthropomorphism of artificial intelligent agents increase consumer satisfaction through increased trust but also threatens user identity by undermining their comfort by a high degree of anthropomorphism of the technology. Further, the perception of threat to user-identity increases if the consumer relationship is closer and the relationship is longer (Uysal et al., 2021). The perception of threat to human identity can be mitigated when consumers are aware of data security solutions and adopt them in relationship with AIA. The hypothesis by Uysal et al. (2022) that higher anthropomorphism reduces consumer satisfaction and consumer well-being was not supported. Further findings of Uysal et al. (2022) indicate that higher threat to human identity reduces consumer comfort through decreasing consumer's AI empowerment. This effect is attenuated when consumers with a long relationship to AIA are aware of data issues of their usage (Uysal et al., 2022). Scheuer's (2020) findings imply a new acceptance model based on the dual-process theory (J. S. B. T. Evans & Stanovich, 2013; Kahneman & Schmidt, 2012). He distinguishes between acceptance based on System 1 (IPART) and System 2 (TAM). Scheuer (2020) identifies that the acceptance for AI systems is dependent on the acceptance of the specific technology medium, acceptance of AI as a technology and the interpersonal acceptance. If the degree of anthropomorphism is high the AI is considered as a personality. The use of AI systems which are considered as a personality is emotion-driven. Therefore Scheuer (2020) states that TAMs are not suitable to measure acceptance of an AI system if an AI system is considered as personality. Interpersonal acceptance models should be considered to describe acceptance of AI systems. On the other hand, TAMs are suitable if the user perceives the AI system as a technology (Scheuer, 2020). Furthermore, Scheuer identifies that users seek to use an AI system where the degree of machine learning is controllable and transparent. Since Panagiotarou et al. (2020) and Sagnier et al. (2020) showed the relevance of task characteristics, Uysal et al. (2022) and Scheuer (2020) put emphasis on the relevance of system features by anthropomorphizing the interface. The findings of Uysal et al. (2022) and Scheuer (2020) have a high applicability for this thesis. The specialty of Scheuer's research approach is that he refers to the Turing's idea of intelligence. Considering the computer developed to the point where it is perceived as a human being by the user (Turing, 1950). Since no literature except Scheuer (2020) focuses on interpersonal acceptance Scheuer's findings contribute to this thesis.

Bader and Kaiser (2019) research on the assessment of the role of artificial intelligence in workplace decisions. Bader and Kaiser (2019) outline the spatial and temporal detachment of decision-making. They explore how users deal with algorithmic decision-making and how user interfaces influence the involvement of decision-making. Bader and Kaiser (2019) argue due to sociomateriality the detachment to decision-making gets reduced. They outline that AI has a dual role in workplace decisions. On the one hand, AI creates human attachment due to emotion driven affective entanglement. On the other hand, AI facilitates detachment due to deferred decisions and manipulation in data. The dual role of AI results in high and low involvement in interactions with the interface. The involvement of interfaces in research will be necessary for this paper.

Merendino et al. (2018) explore whether Big Data has changed strategic decision-making processes on board-level. They identify a lack in cognitive capabilities in order to cope with Big Data. Furthermore, they outline a friction in group cohesion on board-level which has consequences on the decision-making process. Merendino et al. (2018) show that boards seek new ways of working in order to avoid information silos and relying on capabilities of third parties such as consultants in order to handle Big Data. Merendino et al. (2018) findings are applicable to this thesis due to the focus on managers. However, Merendino et al. (2018) results address decision making of managers in a group.

Abhari, Vomero, and Davidson (2020) analyze the psychological motivation behind the use of BI tools. Therefore they use the Needs-Affordances-Features framework by Karahanna, Xin Xu, Xu, and Zhang (2018). At first, they identify that the need for autonomy and competence in business environment motivates the use of BI tools where psychological affordance features of autonomy, collaboration and communication are addressed. Further, they outline that the need for relatedness, having a place and self-realization motivates the use of BI that afford the psychological features of collaboration and communication. Since Abhari et al. (2020) researches the adoption of BI on a voluntary user-level the findings of them are applicable for this thesis.

Meske, Bunde, Schneider, and Gersch (2022) show that explainability is a prerequisite for fair AI. Therefore Meske et al. define explainable AI (XAI) by distinguishing it from interpretable AI. If humans can directly make sense of a machine's decision without additional explanation interpretable AI is given (Guidotti et al., 2018). Giving additional information for an explanation as a proxy to comprehend the arguing process is defined as XAI (Adadi & Berrada, 2018).

The TAM by Venkatesh and Bala (2008) considers perceived comprehensibility of the system as an acceptance condition. An explanation as proxy tries to create acceptance by having a higher result demonstrability. XAI tries to overcome the boundary between artificial and material by approaching

the cognitive System 2 of the human. By definition, it reduces simultaneously the amount of information approaching the cognitive system System 1 of the human by using availability heuristics. System 1 may lead to misinterpretation which can be reduced through a personalized XAI according to Meske et al. (2020). As the literature showed high lack in comprehensibility of the decision support systems, it may be challenging to create an acceptance through XAI.

The state of the art in literature shows that the research on acceptance in algorithmic decision support is new as the oldest literature is from 2018. Furthermore, few studies such as Merendino et al. (2018) analyze the acceptance of algorithmic decision support on managerial-level. However, they do not consider the acceptance of a single manager since they focus on board-level decision-making. Other studies show various results in the acceptance of algorithmic decision support. These studies do not focus on managerial-level. The study of Uysal et al. (2022) shows that anthropomorphism can lead to an increased consumer satisfaction and increase in trust. Since trust has a relationship to the intention to use the technology Rathje et al. (2021), it is necessary to consider anthropomorphizing of decision support systems for an analysis of acceptance. Therefore anthropomorphizing an interface can be seen as the structuration approach by DeSanctis and Poole (1994).

No literature except Scheuer (2020) and Uysal et al. (2022) focuses on the acceptance of anthropomorphized systems. Furthermore Scheuer (2020) showed that anthropomorphizing AI systems leads to an use that is emotion-driven. Since Bader and Kaiser (2019) show a dual role of AI in the workplace, it is necessary to analyze empirically whether anthropomorphizing the AI system may mitigate the detachment from AI system. The answer to this question may lead to conditions for an acceptance of algorithmic support on managerial level.

3. Analyzing acceptance conditions: methodological approach

This thesis aims to answer the following research question: which conditions lead to an acceptance of algorithmic decision support in management? To answer the research question two approaches are chosen. A vignette study is conducted along with a quantitative survey. The results are empirically analyzed and afterwards, a structural equation model is derived to illustrate the conditions that may lead to the acceptance of algorithmic decision support. In this regard, it is first important to explain why in the context of the research question it was important to select the innovative approach of a vignette study along with a quantitative survey. According to this, in the following section the rationale behind the methodological approach of this thesis will be presented.

3.1. Theoretical foundation of a vignette study

One of the most frequent tools to investigate the beliefs, attitudes and judgments of respondents is the combination of quantitative research and vignette study. Vignette studies are particularly helpful when research is designed to assess judgment from respondents about specific scenarios. In academic literature quantitative surveys along with vignette analysis were innovational breakthroughs as they allowed a new way of assessing public opinion in form of a survey while keeping the element of integrating contextual perception of specific situations. In the past, quantitative vignette studies have been used in different disciplines such as psychology by Barrera and Buskens (2007), Dülmer (2001) or Walster (1966) and marketing by Wason et al. (2002) or sociology by Alves and Rossi (1978), Beck and Opp (2001) or Jasso and Webster Jr (1999). Atzmüller and Steiner (2010) define a vignette as a "carefully constructed description of a person, object, or a situation representing a systematic combination of characteristics." (Atzmüller & Steiner, 2010). According to Dubinsky, Jolson, Kotabe, and Lim (1991), vignettes help identify management decisions. They especially outline that "Vignettes can be particularly illuminating with respect to managerial implications; an appropriately constructed and relevant [vignette] can help management discern where specific action is necessary" (Dubinsky et al., 1991). Another benefit of vignette studies is that the design of vignettes allows to simultaneously present several explanatory as well as context-dependent factors through which more realistic scenarios are possible (Atzmüller & Steiner, 2010). Moreover, vignettes can be presented in different forms such as text, dialog, cartoons, pictures, audios, or videos. Depending on the research setting and research question a vignette can inhibit an experimental design feature.

Several researchers argue that vignette surveys are superior to normal question-based surveys. In this regard, Wason and Cox (1996) support this statement by outlining that vignette surveys provide greater realism. Robertson (1993) underlines that vignette studies offer a greater range of situational and contextual factors. Similarly, Barnett, Bass, and Brown (1994) state that vignette studies "approximate real-life decision-making situations". Alexander and Becker (1978) further explain that vignette studies supply standardized stimuli to all respondents which makes a replication of the study easier and enhances the measurement reliability. On the other hand, Cavanagh and Fritzsche (1985) argue that vignette studies also improve construct validity (Wason et al., 2002). Furthermore, they outline that vignette studies increase the involvement of the respondents and decrease the potential of errors through not paying attention to questions or answering the same throughout the survey.

Researchers claim that in the context of vignette studies the target group plays an essential role and an appropriate population should be selected. Stevenson and Bodkin (1998) argue that with regard to the decision-making process vignette studies can be targeted toward students as the students are tomorrow's business professionals. Regarding the design of vignette studies, researchers suggest that vignettes should be designed adequately and not much detailed. Hyman and Steiner (1996) argue that vignettes should not be so detailed that they overburden respondents.

Grant and Wall (2009) highlight that especially in the context of management research it is important to understand causal relationships which in turn requires the use of experimental or quasi-experimental designs. Through vignette studies, exactly this aspect is addressed as this research design improves our knowledge about causal relationships (Aguinis & Bradley, 2014). The vignette survey methodology tackles participants with carefully constructed and realistic scenarios to assess dependent variables including intentions, attitudes, and behaviors. An example of providing insights on the causal relationships through vignette surveys is illustrated by McKelvie, Haynie, and Gustavsson (2011) where they addressed the impact of uncertainty in the decision-making process of entrepreneurs. In particular, they provided an evidence on which type of uncertainty had an effect on whether entrepreneurs choose to exploit or not to exploit opportunities (Aguinis & Bradley, 2014; McKelvie et al., 2011). Aguinis and Bradley (2014) conducted a review on 30 management journals from 1994 to 2003 and provided evidence that vignette surveys are a way to address the problem of internal and external validity.

In this regard, vignette surveys have been used in several contexts and formats. Cook (1979) investigate whether Americans support programs for social groups in need of aid or not. For this, they used text vignettes. On the other hand, Atzmüller, Kromer, and Elisabeth (2014) took a closer look at peer violence among adolescents. For their approach, they used short video vignettes. Also, audio vignettes have been used for example by Atzmüller et al. (2014) to investigate radio news on crimes. Several scholars claim that vignette surveys are flexible and have a wide range as they allow participants to come out of their comfort zone and perceiving different experimental settings in form of videos, audios, text etc. Moreover, vignette surveys allow participants to move away from socially desirable answers or politically correct answers which in turn reduces biases (Steiner, Atzmüller, & Su, 2016).

Based on the aforementioned aspects a vignette survey seems to be an appropriate tool to first, identify management decisions (Dubinsky et al., 1991). Secondly, to include different experimental settings in a survey such as videos, audios, text, etc. (Steiner et al., 2016). Thirdly, to construct realistic scenarios and consider context-dependent aspects (Atzmüller & Steiner, 2010). Because of this, the approach of a vignette survey was selected to answer the research question. In the next section it will be explained why structural equation modeling is relevant in the context of the research question and why is it used for the empirical approach in this thesis. In particular, why is structural equation modeling used to illustrate the results of the survey.

3.2. Structural equation modeling

With the method of structural equation modeling (SEM) it is possible to simultaneously model complex relationships among multiple dependent and independent variables (Hair Jr. et al., 2021). Moreover, there are two options in SEM which are common factor-based-SEM (CB-SEM) and partial least squares SEM (PLS-SEM). In this regard, the option of common factor-based SEM is mostly used in the context of accepting or rejecting hypotheses, which serves as an indicator to confirm or reject theories. In a practical manner, this approach of common factor-based-SEM investigates how closely a proposed theoretical model is able to reproduce a covariance matrix for the considered dataset. On the other hand, we have the PLS-SEM. For this thesis, a PLS-SEM was used. In the following, it will be explained why PLS-SEM is more appropriate than a common factor-based SEM for this thesis. PLS-SEM should be conducted if the objective of research is an exploratory research for theory development (Hair Jr. et al., 2021). The objective of research of this thesis is to identify acceptance conditions. Therefore, the approach of PLS-SEM fits to the objective of research of this thesis.

According to Jöreskog and Wold (1982), PLS-SEM is a "causal predictive" approach and aims at explaining the variance of the dependent variable. Basically, a partial least square (PLS) path consists of two essential elements.

One element is the inner model whereas the other one is the outer model. The inner model is referred as a structural model which links together constructs. The outer model, on the other hand, is referred as the measurement model. These measurement model shows the relationships between the constructs and the indicator variables as rectangles. The figure 5 demonstrates the inner and outer model. Another benefit of PLS-SEM is that there is a high efficiency in parameter estimation, and it is flexible in terms of its modeling properties. According to Hair Jr., Matthews, Matthews, and Sarstedt (2017), PLS-SEM is a prediction-oriented approach and is mostly used in exploratory research. PLS-SEM maximizes the amount of explained variance of endogenous constructs in a path model and provides a better understanding of the underlying causes and predictions (Shmueli et al., 2019).

In addition to this through PLS-SEM, it is also possible to include control variable to account for the target construct's variation. Furthermore, PLS-SEM allows the assessment of not only reflective but also formative measurement models along with single-item constructs, with no identification problems. Regarding the single items, it can be said that they have the advantage of being not complicated in terms of the scales and result in higher response rates where the questions are easily understood and answered (Fuchs & Diamantopoulos, 2009; Sarstedt & Wilczynski, 2009). Hair Jr. et al. (2021) further point out that a global single item is sufficient and captures the essence of the construct, especially in the context of executing a redundancy analysis.

As explained in the aforementioned section, the path model for PLS-SEM will be presented. This thesis aims to answer the following research question: which conditions lead to an acceptance of algorithmic decision support in management? In the theoretical foundation, acceptance conditions for algorithmic decision support were derived and formulated as hypotheses. The state-of-the-art shows that the degree of anthropomorphizing an AI system may lead to an acceptance. Therefore, a new model (figure 6) is derived

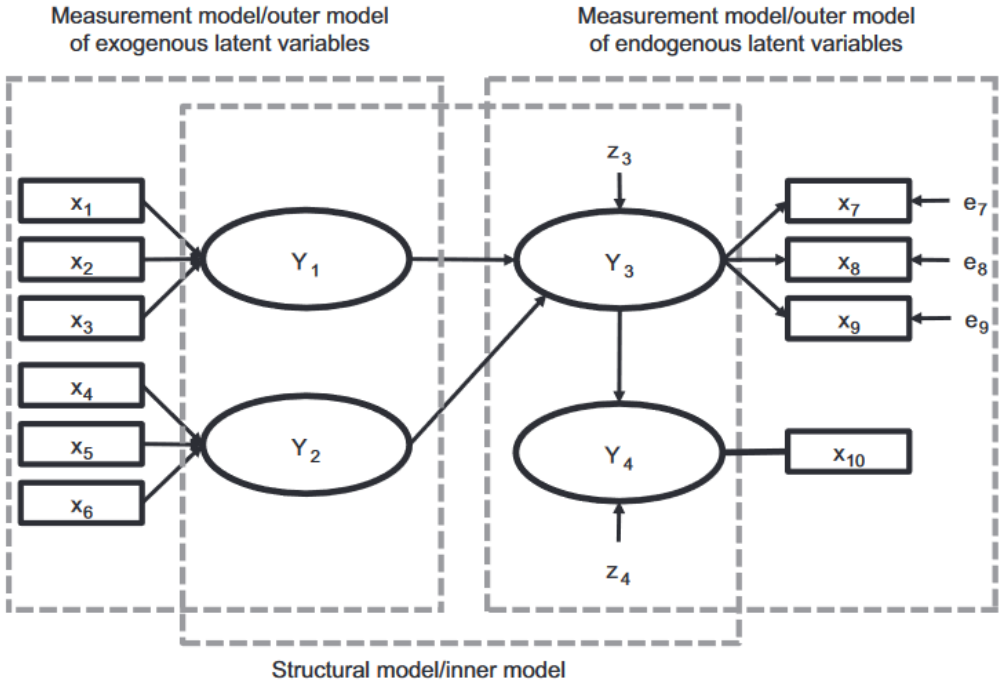

Figure 5: A simple path model (Source: Hair Jr. et al. (2021))

from the previously formulated hypotheses.

Due to hypotheses tests the path model is tested for validity using PLS-SEM. The hypotheses tests are executed in a two-step process according to Hair Jr. et al. (2021). Hair Jr. et al. (2021) suggest to first confirm reliability and validity of the measurement model and then testing the structural equation model for validity.

In order to create a measurement model, a survey is conducted where the degree of anthropomorphizing of the system-interface is manipulated. The items from the survey are used for creating a reflective measurement model.

The variables in the path model are measured as latent constructs in a reflective measurement model. The definition of constructs is described in table 1. In table 2 the hypotheses are summarized.

In an experimental setting, these hypotheses are tested for validity. These interactions with a system is simulated by a vignette study.

3.3. Design and parameters of the survey

A vignette study is conducted in german language where the scenario is described. In this scenario the survey participant is in the situation of a manager in a dynamic market environment where he has to make a hot decision according to Janis and Mann (1977). Furthermore, a decision support system aids in the decision-making. The decision support system is introduced in the scenario with high prediction capabilities. Moreover, the decision support system is implemented as an interface. The survey participants simulate an interaction with a decision support system. Due to the interaction, the survey participants are involved in the problem-finding process. Furthermore, the system suggests a solution to the problem without further explanation. The survey participants have to make the choice to accept the suggestion or to reject the suggestion and make their own decision. The structure of the survey is shown in figure 7.

There are two interfaces with a different degrees of anthropomorphizing features. The interface with low anthropomorphizing features is created by embedding HTML and javascript code into the survey tool. The interface is named Lisa, shown in figure 8.

Furthermore, the interface implemented as an interactive video with high anthropomorphizing features is named Maria, shown in figure 9.

The degree of anthropomorphizing features is relatively high due to the use of professional tools. In order to create the interface Maria, an AI actor is created with the tool Colossyan (Colossyan, 2022) and saved as a video. Furthermore, the tool Tolstoy (Tolstoy, 2022) is used to make the interface more interactive. Therefore the videos created by Colossyan (2022) are ordered through the use of various conditions leading to a high degree of anthropomorphizing features. The degree of anthropomorphizing could have been maximized through voice inputs. Despite the substitution of voice input for the interaction of the user via textual or button components, voice outputs could be implemented in the interface. Furthermore, the AI actress uses gestures while speaking.

The participants are randomly distributed to one interface. After the interaction with the interface, the participant has to make a decision, where he can approve the suggested decision by the system or reject the suggestion and choose an

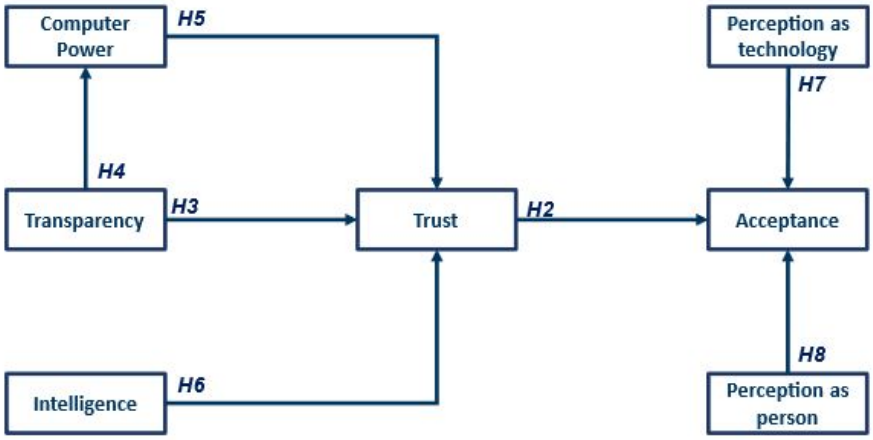

Figure 6: Path model for hypotheses testing (Source: Own illustration)

Table 1: Construct definition

Constructs	Description
Perception as technology is abbreviated as "TEC"	The extent to which the system-user perceives the anthropomorphized system as technology. A low value (1) for *perception as technology* indicates that the system is not perceived as a technology.
Perception as person is abbreviated as "PER"	The extent to which the system-user perceives the anthropomorphized system as a person. A low value (1) for *perception as person* indicates that the system is not perceived as a person.
Trust is abbreviated as "TRU"	The extent to which the user has trust towards the system. A low value (1) for *trust* indicates that the user does not trust the system.
Transparency is abbreviated as "TRAN"	The perceived comprehensibility of the system results. A low value (1) for *transparency* indicates that the results processed by the system were not perceived as transparent in terms of comprehensibility of the decision-making.
Computer Power is abbreviated as "CPOW"	The perceived control of the system within the decision-making process by the user. A low value (1) for *computer power* indicates that the system-user perceives his participation in decision-making process as high. A high value (5) indicates that the system-user perceives the participation of the system in decision-making process as high.
Intelligence is abbreviated as "INT"	The perceived intelligence of the system. A low value (1) for *intelligence* indicates that the user perceives the system as not intelligent.
Acceptance is abbreviated as "AIACC"	The willingness to voluntarily approve the system. A low value (1) for *Acceptance* indicates that the user is not willing to use the presented system in the future.
Decision is abbreviated as "ACC"	The final decision after receiving aid from the system. A low value (0) indicates that the user has rejected the suggested decision from the system. A high value (1) indicates that the user has accepted the suggested decision from the system.

Table 2: Formulation of hypothesis

Construct	No.	Hypothesis
Acceptance (ACC; AIACC)	H1	An anthropomorphizing of a system leads to an acceptance of the system.
Acceptance (ACC; AIACC)	H2	A higher trust in a system leads to higher acceptance.
Trust (TRU)	H3	A higher transparency/comprehensibility of a system has a positive effect on the trust towards the system.
Computer Power (CPOW)	H4	A higher comprehensibility of a system has a positive effect on the perceived participation of the user in the decision-making process.
Trust (TRU)	H5	The higher the perceived participation of the system-user in the decision-making process is, the higher the perceived trust towards the system.
Trust (TRU)	H6	The higher the perceived intelligence of the system is, the higher the trust.
Acceptance (ACC; AIACC)	H7	The higher the perception of the system as technology is, the higher the acceptance.
Acceptance (ACC; AIACC)	H8	The higher the perception of the system as person is, the higher the acceptance.

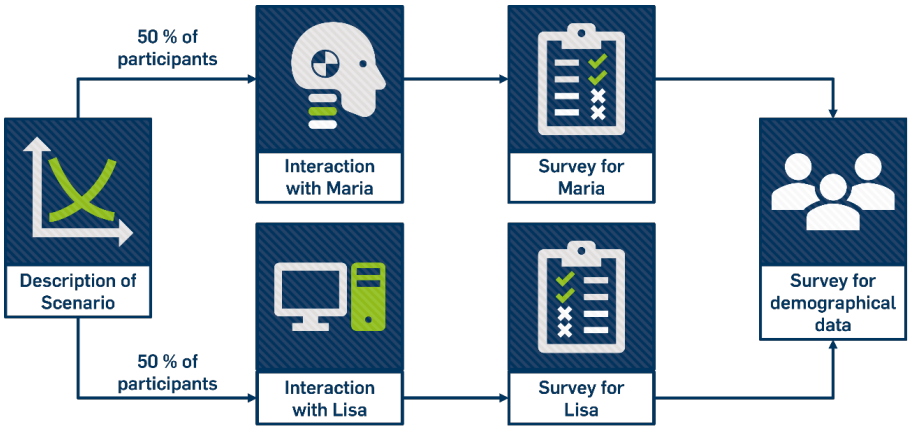

Figure 7: Structure of the survey (Source: Own illustration)

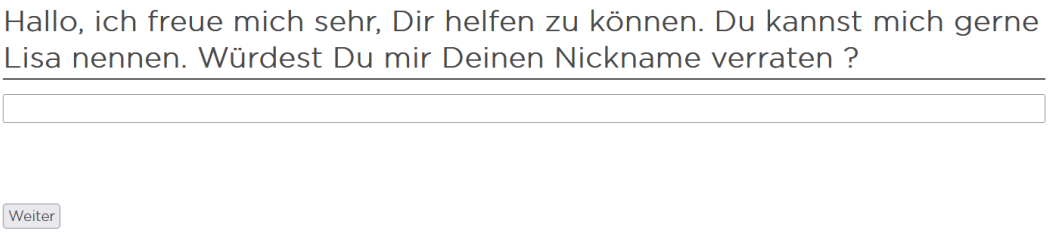

Figure 8: System interface of Lisa (Source: Own illustration)

alternative decision. Furthermore, the participants are surveyed for their experience while interacting with the system. In the end demographical data were surveyed.

The survey was created with the survey tool Unipark. This tool saves cookies on the devices of the participants and prevents multiple participations in the survey from the same user. The survey was online from 25.07.2022 to 07.08.2022 and distributed via various channels. Despite no specific target group, the target group was varied across the distribution channels. The survey was shared on social networks

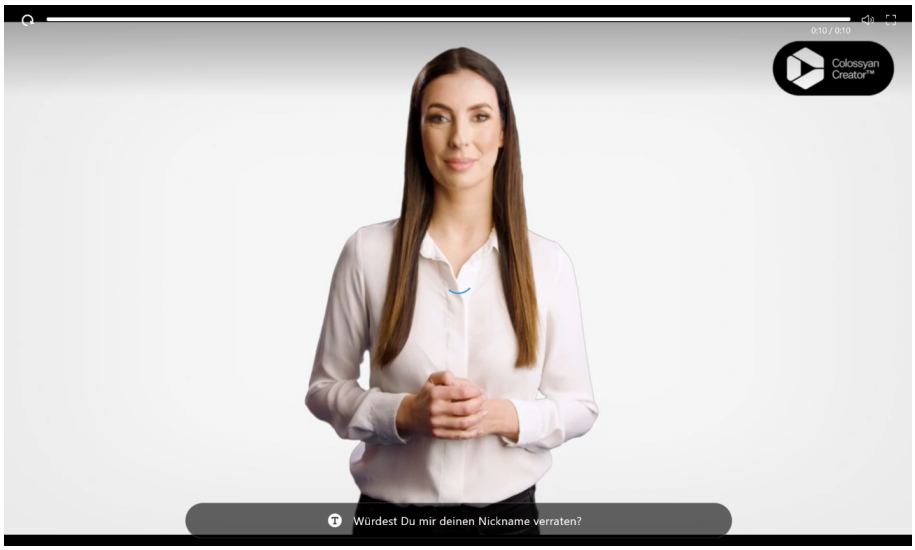

Figure 9: System interface of Maria (Source: Own illustration)

like Linkedin, Instagram and Whatsapp. The target group on Linkedin was specified as managers or people in leadership positions. The Linkedin post where the survey was shared had impressions of 6824 (07.08.2022) meaning the call for participation has reached 6824 people. Furthermore, students and researchers were targeted due to the distribution of flyers. 1000 Flyers were printed. People in the university were asked to participate in the survey while giving them the flyer. Furthermore, a flyer could be used multiple times meaning that minimum of 1000 students or researchers could be approached by flyers. The survey was shared multiple times on multiple Whatsapp and Instagram accounts with daily views of approximately 200 people. Leading to a distribution of approximately 3000 people as a non-specifiable target group. The sharing activities lead to a distribution of the survey to 11000 people who could be accounted multiple times.

746 people clicked on the survey and 253 people canceled their survey participation or did not give their consent to the survey leading to 493 people who started the survey. 212 people canceled their survey participation after starting the survey leading to 281 people who have fully participated in the survey. Due to the cancel activities, an equal distribution of the interfaces among the participants could not be guaranteed.

3.4. Assessment of measurement model

The latent constructs were measured by the previous described survey. The operationalization of constructs was derived from the study of the KIAM-Model by Scheuer (2020). Since Scheuer considers various items from TAM by Venkatesh and Bala (2008) in his research, the items from TAM are used for this study. The operationalization of the items is executed in german language since the target group of the study are german speaking students and employees. All operationalized items for the interface Lisa are shown in table 3. Items for the interface Maria are mostly identical to the interface Lisa. The items for Maria only differ from Lisa when the item consists the name of the interface. Similar to the study of Scheuer (2020) the measurement of items is executed on a 5-point-likert scale. Scheuer argues that the use of this scale minimizes time for the survey participants and delivers a higher precision than on a 7-point-likert scale due to more intuitive responses on perception.

On the 5-point-likert scale the rejection of the statement is coded as one and is increased by one each for a lower rejection or higher affirmation of the statement where the maximum affirmation of the statement is coded with a five.

The construct of acceptance was measured with a further construct defined as “ACC” where the variable is named as “acc” and is measured on a binary scale. The binary scale is used to assess the acceptance due the interaction with the system. A zero in this binary variable reflects rejection of the suggested decision. Moreover, one reflects an affirmation of the suggested decision.

The construct of acceptance could have been measured as a higher order construct, where the constructs “AIACC” and “ACC” are reflective measures for the higher order construct. This study composites the constructs “AIACC” and “ACC” as no single constructs because the estimation of the SEM is conducted partially for each acceptance construct leading to a higher accountability of acceptance conditions. A composition of both constructs to one higher order construct may distort the results due to the different scaling of both constructs. Therefore two SEM are estimated where the construct “ACC” is used to validate the results from the estimation with the construct “AIACC”.

As shown previously Scheuer (2020) states that the perception of a system as a technology or a person determines how acceptance is created. Therefore it is necessary to separate the measurement of both systems into individual measurement models. A separation of measurement models in-

Table 3: Operationalization of items

Construct	Item	Question	Reference
INT	int_1	*"Das System wirkt intelligent"*	*"Das System wirkt intelligent"* (Scheuer, 2020)
TEC	tec_1	*"Ich habe das System als Technologie wahrgenommen"*	*"Ich habe das System als Technologie wahrgenommen"* (Scheuer, 2020)
TEC	tec_3	*"Ich habe Lisa als Technologie wahrgenommen"*	*"Ich habe das System als Technologie wahrgenommen"* (Scheuer, 2020)
PER	per_1	*"Ich habe das System als Persönlichkeit wahrgenommen"*	*"Ich habe das System als Persönlichkeit wahrgenommen" (Scheuer, 2020)*
PER	per_2	*"Ich habe Lisa als Persönlichkeit wahrgenommen"*	*"Ich habe das System als Persönlichkeit wahrgenommen" (Scheuer, 2020)*
PER	per_3	*"Ich habe in Lisa Menschlichkeit wahrgenommen"*	-
CPOW	part_1	*„Ich habe keine Kontrolle über die Nutzung des Systems"*	*"Ich habe Kontrolle über meine Nutzung des Systems"*–TAM *(Scheuer, 2020)*
TRAN	tran_1	*"Die Entscheidung des Systems ist transparent"*	-
TRAN	tran_2	*"Ich kann die Entscheidung des Systems nachvollziehen"*	-
TRAN	tran_3	*"Für mich ist hinreichend transparent, wie das System funktioniert"*	*"Für mich ist hinreichend transparent, wie das System funktioniert"(Scheuer, 2020)*
TRU	tru_1	*Ich vertraue dem System*	*"Ich vertraue dem System" (Scheuer, 2020)*
TRU	tru_2	*Das System wirkt vertrauensvoll*	-
TRU	tru_3	*„Ich vertraue auf die Ergebnisse des Systems"*	"Ich vertraue auf die Ergebnisse des Systems" (Scheuer, 2020)
AIACC	aiacc_1	*„Die zuvor vorgestellte künstlichen Intelligenz würde ich aktiv verwenden, wenn ich Zugriff auf dieses System habe und die Rahmenbedingungen gegeben sind"*	*"Eine künstliche Intelligenz wie dieses System würde ich aktiv verwenden, wenn ich Zugriff auf diese habe und die Rahmenbedingungen gegeben sind" (Scheuer, 2020)*
AIACC	aiacc_2	*„Angenommen ich hätte Zugriff auf das System, würde ich es nutzen wollen"*	*"Angenommen ich hätte Zugriff auf das System, würde ich es nutzen wollen"-TAM (Scheuer, 2020)*
AIACC	aiacc_3	*„Ich würde das System freiwillig nutzen, wenn die Rahmenbedingungen gegeben wären"*	*"Ich würde das System, wenn die Rahmenbedingungen gegeben wären, freiwillig nutzen"-TAM (Scheuer, 2020)*
ACC	acc	*Decision of the user*	-

creases the accountability of estimation for the certain interface. A separation of measurement leads to major challenges in the minimum sample size required.

For path coefficients of minimum 0.11 a minimum sample size of 113 is required to have significant path coefficients on a 10 % significance level. Furthermore, a sample size of minimum 155 is required to have significant path coefficients on a 5 % significance level (Hair Jr. et al., 2021).

Since the measurement model of Maria has a sample size of 127 and the measurement model of Lisa has a sample size of 154 the requirements for significant path coefficients on a 10 % significance level are fulfilled. The minimum sample size required for path coefficient with a minimum value of 0.21 is 112 with a significance level of 1% (Hair Jr. et al., 2021). Both measurement models exceed the minimum sample size required for significant path coefficients with a minimum value of 0.21.

In the following, the sample of the survey is described.

4. Analysis and findings of the survey

In the next section, the descriptive statistics of both measurement models are shown for describing the underlying sample. Furthermore, the data from the survey is analyzed according to Hair Jr. et al. (2021). At first, the quality indicators for both measurement models are assessed. Moreover, the quality indicators of the structural models are evaluated. At the end of the section, the results from the analysis are discussed.

4.1. Descriptive statistics: first findings

The sample size is 281, where eight people did not respond to sociodemographic questions. Furthermore, the average age of the participants is 25,66 years where the youngest participant being 18 years old and the oldest participant being 66 years. The distribution of ages is shown in the appendix. In addition to this 57.14 % of the participants were male and 41.03% were female. 1.47% of survey respondents were not specifiable and 0.37% of survey participants classified their gender as diverse.

More than 50% of the survey participants were students. The second largest group of the survey is classified as Managers. Further job descriptions of the survey participants are shown in figure 10.

Furthermore, 23.13% of survey participants stated that they have already gathered management or leadership experience with a duration of more than two years. Standard Industrial Classification (SIC) was used to determine the branch classifications of the companies of survey participants. The majority of branches were not specifiable. 62 survey respondents classified their branch in “Services”. The branch of “Agriculture, Forestry, Fishing” and “Mining” was not present in the sample. Furthermore, the survey participants were asked to classify their organization. 32.6% of survey participants responded that the classification is not specifiable. 17.95% of survey participants stated that they are working in public institutions. Further classifications of job institutions are shown in figure 11.

Since Panagiotarou et al. (2020) show the relevance of personal innovativeness on acceptance, it is necessary to have insights into the affinity to technologies or personal innovativeness of survey participants. At first, 91.21% of survey participants evaluated that they have the necessary capabilities for handling Office-software. Furthermore, 68,5% of survey participants responded that they have no experience in programming. 15.02% of participants stated that they have recently gathered experience in programming (less than years). 16.48% of participants reported that they have more than years of experience in programming. Since programming capabilities afford a high level of technical affinity 31.5% of survey participants can be classified as the minimum share of survey participant with a high level of technical affinity. People who spend time for gaming have the need to inform their self about the latest hardware. Therefore the survey measured the technical affinity by asking survey participants whether they like to spend their free time gaming. 40.66% of survey participants have answered with „Yes“ to this question. Besides the gaming experience, it is important to measure the experience with VR-technology for the assessment of personal innovativeness. Since Sagnier et al. (2020) argue that the use of new technologies like VR is related to personal innovativeness, the survey participants were questioned whether they have used VR-technology before. 51.28 % of survey participants have answered with „Yes“ to this question. Overall there is a high affinity to technology and personal innovativeness among the survey participants. The experience in handling Office-software may not be a measure for technical affinity because these are relevant job capabilities and are often expected as general knowledge in practice. The high share of participants who have Office-capabilities shows a representativeness of the sample since these capabilities are expected as general knowledge. Furthermore, 31.5% to 51.28% of survey participants can be classified as participants with a higher level of technical affinity leading to an overall high technical affinity of the sample.

4.1.1. Descriptive statistics: measurement model of Lisa

The summary of descriptive statistics of the measurement model Lisa are shown in table 4.

The maximum variance for a five-point likert scale on mathematical foundation is 2.00 [3]. Therefore the measurement model of Lisa shows a moderate to high variance within the variables. The acceptance variables show a low to moderate variance. As anticipated the Interface Lisa is perceived more as a technology (mean = 3.9870) than a person (mean = 2,4156).

Furthermore, the correlation matrix of constructs (table 5) shows that “CPOW” is negatively correlated to other constructs which is expected. The correlation of the perception of the system as technology is negatively correlated with the perception of the system as person. These negative correlations imply a validity of the measurement.

4.1.2. Descriptive statistics: measurement model of Maria

The descriptive statistics measurement model of Maria are shown in table 6. As shown previously the maximum variance for a five-point likert scale is 2.00. Therefore the measurement model of Maria shows a moderate to high variance within the variables. Similar to measurement model of Lisa, acceptance variables show a low to moderate variance.

Furthermore, the interface Maria is perceived more as a technology (mean = 4.1417) than a person (mean = 2,5669). Since Maria is an anthropomorphized interface the perception of the system as technology should be lower

[3] High dispersion on five-point likert scale means that every number should be distributed equally among the scale. Therefore a quantity of one number at each point of scale can be considered for further calculations due to the reduction of complexity. The average among the scale is equal to the median. The average is three. This average is considered for the variance calculation. The sum of squares of the difference between the observation and the mean is equal to 10. 10 is divided by the number of observations, leading to a variance of 2.

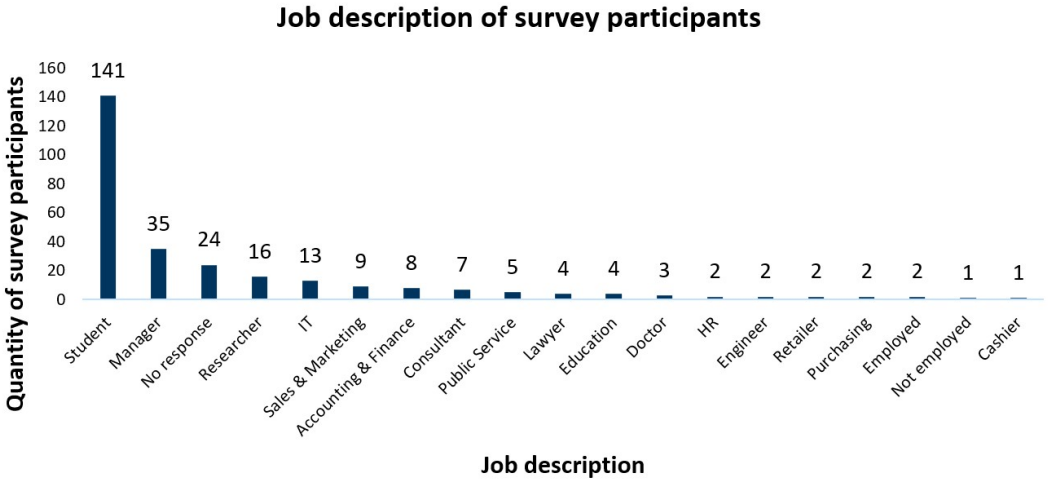

Figure 10: Job description of survey participants (Source: Own illustration)

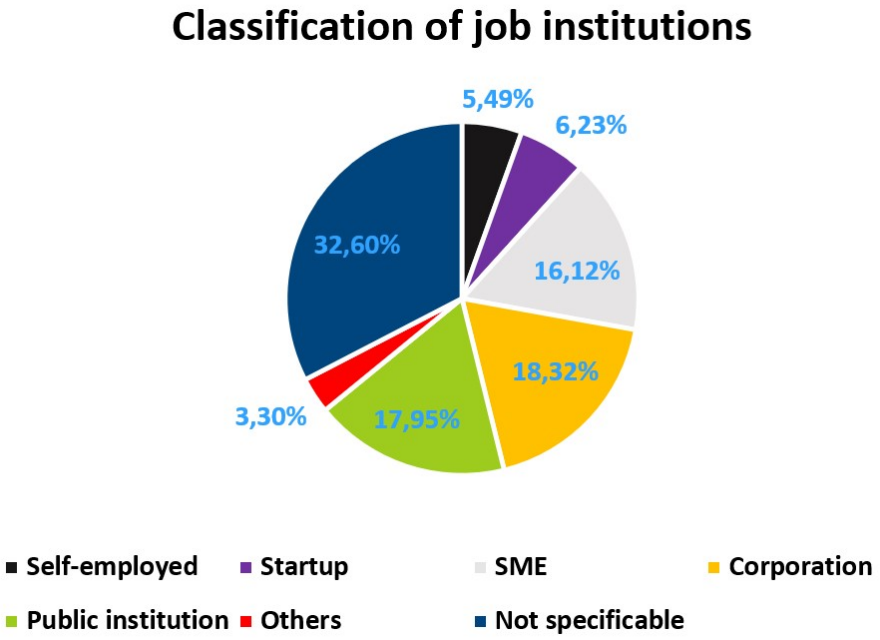

Figure 11: Classification of job institutions (Source: Own illustration)

than the perception of the system as technology. In fact, the system Lisa has a lower mean value for the perception as technology than the system Maria, which may indicate that the anthropomorphized system has failed the Turing test (Turing, 1950). Furthermore, the mean value for acceptance parameters of the system Lisa are slightly higher than the system Maria. The correlation matrix in table 7 shows that "CPOW" is no more negatively correlated to all other constructs which was not expected. Similar to the measurement model of Lisa the correlation of the perception of the system as technology with the perception of the system as person is negative which indicates a validity of the measurement.

4.2. Quality indicators for measurement and structural model

Hair Jr. et al. (2021) show that the first step in the assessment of measurement models is the examination of indicator reliability. Hair Jr., Risher, Sarstedt, and Ringle (2019) recommend indicator loadings, above 0.708 as reliable indicators. Indicators under this threshold should be considered for a removal. Indicator loading below 0.4 should always be eliminated from the measurement model (Hair Jr. et al., 2021).

Therefore, a factor analysis was conducted in R using the package "seminr" by (Hair Jr. et al., 2021). The results of the factor analysis are shown in the appendix. The measurement model was adjusted by deleting indicators with low values for indicator loadings. The final stage of the factor

Table 4: Descriptive summary of the measurement model of Lisa

Descriptive statistics

	n	min	q25	mean	median	q75	max	sd	var
l_per_1	154	1	2	2.4091	2	3	5	1.1411	1.3021
l_per_2	154	1	1	2.3312	2	3	5	1.1719	1.3733
l_per_3	154	1	2	2.4156	2	3	5	1.0646	1.1334
l_int_1	154	1	3	3.3766	4	4	5	1.1265	1.2690
l_tran_1	154	1	1	2.0974	2	3	5	1.1130	1.2388
l_tran_2	154	1	2	2.6299	3	4	5	1.1713	1.3719
l_tran_3	154	1	1	2.2338	2	3	5	1.2250	1.5006
l_part_1	154	1	2	2.9481	3	4	5	1.1013	1.2130
l_tru_1	154	1	2	2.9870	3	4	5	1.0846	1.1763
l_tru_2	154	1	2	3.1039	3	4	5	1.0427	1.0872
l_tru_3	154	1	2	3.1494	3	4	5	1.0833	1.1736
l_tec_1	154	1	4	3.9870	4	5	5	0.9768	0.9541
l_tec_3	154	1	3	3.8571	4	5	5	1.0125	1.0252
l_aiacc_1	154	1	3	3.5974	4	4	5	0.9533	0.9088
l_aiacc_2	154	1	3	3.5649	4	4	5	0.9283	0.8618
l_aiacc_3	154	1	3	3.5779	4	4	5	0.9754	0.9514
l_acc	154	0	1	0.7987	1	1	1	0.4023	0.1618

Table 5: Correlation matrix of Lisa

Correlations of constructs of Lisa

	TEC	PER	TRAN	INT	CPOW	TRU	AIACC
TEC	1	-0.312	0.109	0.064	-0.095	0.056	0.177
PER	-0.312	1	0.347	0.469	-0.169	0.381	0.258
TRAN	0.109	0.347	1	0.557	-0.274	0.536	0.268
INT	0.064	0.469	0.557	1	-0.353	0.581	0.414
CPOW	-0.095	-0.169	-0.274	-0.353	1	-0.492	-0.385
TRU	0.056	0.381	0.536	0.581	-0.492	1	0.514
AIACC	0.177	0.258	0.268	0.414	-0.385	0.514	1

analysis is shown in table 8. Indicator loadings from the initial measurement model are shown in the appendix. Due to low loadings the item “tran_4” and “part_2” had to be removed from the measurement model. Further measurement errors in construct validity were identified. Therefore “tec_2”, “int_2”,”int_3”,”part_4”, ”part_5” were eliminated in the measurement model.

After removing the previously stated indicators the measurement models were tested for final indicator loadings. The item “part_3” had an indicator loading of 0.589 for the measurement model of Maria. Therefore Hair Jr. et al. (2021) suggest to examine internal consistency. The necessary threshold for internal consistency could not be reached by both measurement models. Deleting an indicator should be considered when a removal leads to an increase in reliability (Hair Jr. et al., 2021). Therefore the item “part_3” was removed from the measurement model.

The second step for evaluating reflective measurement models according to Hair Jr. et al. (2021) is the examination of internal consistency reliability. Hair Jr. et al. state that the use of Cronbach’s alpha is a very conservative reliability measure. Further, they assume that composite reliability (rhoC) may be a too liberal measure. Therefore they suggest to use the reliability measure of rhoA. The reliability summary is shown in table 9.

The results from the reliability summary show high reliability of the measurement model. Since the rhoA-value for the construct of “TEC” in the measurement model of Maria is higher than 1, which may imply measurement errors. The correlation of items (Appendix 12) for measurement model of Maria show no anomalies since these items are correlated 0.716. The composite reliability shows reliability values exceeding the threshold of 0.7 to 0.9 suggested by Hair Jr. et al. (2021).

They state value above 0.9, especially above 0.95 imply a redundancy of indicators. As stated by Hair Jr. et al. (2021) the composite reliability measure may be too liberal measure for internal consistency. The results on the measure of Cronbach’s alpha, which is a conservative measure for reliability, show that the constructs “TEC”, “ PER” and “TRAN” can be

Table 6: Descriptive summary of measurement model of Maria

Descriptive statistics

	n	min	q25	mean	median	q75	max	sd	var
m_per_1	127	1	2	2.4961	2	3	5	1.0902	1.1885
m_per_2	127	1	2	2.5118	2	3	5	1.1117	1.2360
m_per_3	127	1	2	2.5669	3	3	5	1.1026	1.2157
m_int_1	127	1	3	3.4720	4	4	5	0.9048	0.8187
m_tran_1	127	1	1	2.3150	2	3	5	1.1866	1.4079
m_tran_2	127	1	2	2.8413	3	4	5	1.1298	1.2764
m_tran_3	127	1	1	2.2598	2	3	5	1.1071	1.2256
m_part_1	127	1	2	2.8898	3	4	5	1.0633	1.1306
m_tru_1	127	1	2.5	2.9921	3	4	5	0.9128	0.8333
m_tru_2	127	1	3	3.1969	3	4	5	0.9001	0.8101
m_tru_3	127	1	3	3.0709	3	4	5	0.9101	0.8283
m_tec_1	127	1	4	4.1417	4	5	5	0.8704	0.7575
m_tec_3	127	2	3.5	4	4	5	5	0.8909	0.7937
m_aiacc_1	127	1	3	3.3780	4	4	5	0.9994	0.9989
m_aiacc_2	127	1	3	3.4016	4	4	5	1.0333	1.0676
m_aiacc_3	127	1	3	3.4488	4	4	5	1.0213	1.0430
m_acc	127	0	1	0.7953	1	1	1	0.4051	0.1641

Table 7: Correlation matrix of Maria

Correlations of constructs of Maria

	TEC	PER	TRAN	INT	CPOW	TRU	AIACC
TEC	1	-0.386	-0.154	-0.049	0.028	-0.077	-0.128
PER	-0.386	1	0.311	0.373	-0.060	0.349	0.418
TRAN	-0.154	0.311	1	0.424	-0.185	0.428	0.276
INT	-0.049	0.373	0.424	1	-0.102	0.591	0.531
CPOW	0.028	-0.060	-0.185	-0.102	1	0.045	-0.057
TRU	-0.077	0.349	0.428	0.591	0.045	1	0.657
AIACC	-0.128	0.418	0.276	0.531	-0.057	0.657	1

considered as "good" in terms of reliability. Furthermore, the constructs of "TRU" and "AIACC" slightly exceed the threshold of 0.9. The constructs of "INT" and "CPOW" have a alpha-value of 1.0 because they are single item constructs.

The third step for the assessment of reflective measurement model according to Hair Jr. et al. (2021) is convergent validity. Therefore they suggest to examine the measure of average variance extracted (AVE). Furthermore, they state that the AVE should exceed the value of 0.5. The results from the examination of convergent validity are shown in table 9. All constructs exceed the threshold suggested by Hair Jr. et al. (2021).

In order to evaluate reflective measurement models, the fourth step of Hair Jr. et al. (2021) is the assessment of discriminant validity. They suggest to avoid the Fornell-Larcker Criterion by Fornell and Larcker (1981) due to an inability of the criterion to identify discriminant validities issues. Therefore Hair Jr. et al. recommend to examine the heterotrait-monotrait ratio of correlations (HTMT) (Henseler, Ringle, & Sarstedt, 2015). The results of the examination of the discriminant validity are shown in table 10.

Hair Jr. et al. (2021) suggest that the values for HTMT should be significantly lower than the threshold of 0.85. The values for HTMT shown in table 10 are below the suggested threshold. Furthermore, a significance test is conducted where the structural equation model is bootstrapped by 10000 samples for generating standard errors and confidence intervals. The significance test shows that the upper bound of the 95% confidence interval is significantly lower than the suggested threshold of 0.85 (Hair Jr. et al., 2021). The results of the bootstrapped values for HTMT are shown in the appendix. All bootstrapped paths are significantly lower than the suggested threshold leading to discriminant validity.

4.3. Analyzing acceptance conditions and robustness checks of study

Since the previous tests show that the measurement models fulfill reliability and validity measures, the structural model can be evaluated for testing the hypotheses. Before

Table 8: Loadings summary for Lisa and Maria

Loadings summary of Lisa

	TEC	PER	TRAN	INT	CPOW	TRU	AIACC
l_per_1	0	0.929	0	0	0	0	0
l_per_2	0	0.908	0	0	0	0	0
l_per_3	0	0.870	0	0	0	0	0
l_int_1	0	0	0	1	0	0	0
l_tran_1	0	0	0.890	0	0	0	0
l_tran_2	0	0	0.881	0	0	0	0
l_tran_3	0	0	0.880	0	0	0	0
l_part_1	0	0	0	0	1	0	0
l_tru_1	0	0	0	0	0	0.946	0
l_tru_2	0	0	0	0	0	0.883	0
l_tru_3	0	0	0	0	0	0.929	0
l_tec_1	0.946	0	0	0	0	0	0
l_tec_3	0.954	0	0	0	0	0	0
l_aiacc_1	0	0	0	0	0	0	0.919
l_aiacc_2	0	0	0	0	0	0	0.908
l_aiacc_3	0	0	0	0	0	0	0.916

Loadings summary of Maria

	TEC	PER	TRAN	INT	CPOW	TRU	AIACC
m_per_1	0	0.895	0	0	0	0	0
m_per_2	0	0.872	0	0	0	0	0
m_per_3	0	0.865	0	0	0	0	0
m_int_1	0	0	0	1	0	0	0
m_tran_1	0	0	0.902	0	0	0	0
m_tran_2	0	0	0.879	0	0	0	0
m_tran_3	0	0	0.918	0	0	0	0
m_part_1	0	0	0	0	1	0	0
m_tru_1	0	0	0	0	0	0.923	0
m_tru_2	0	0	0	0	0	0.888	0
m_tru_3	0	0	0	0	0	0.909	0
m_tec_1	0.851	0	0	0	0	0	0
m_tec_3	0.976	0	0	0	0	0	0
m_aiacc_1	0	0	0	0	0	0	0.934
m_aiacc_2	0	0	0	0	0	0	0.929
m_aiacc_3	0	0	0	0	0	0	0.954

Table 9: Internal consistency reliability and convergent validity

Summary of internal consistency reliability and convergent validity

Lisa	alpha	rhoC	AVE	rhoA	**Maria**	alpha	rhoC	AVE	rhoA
TEC	0.892	0.949	0.902	0.896	TEC	0.835	0.912	0.838	1.349
PER	0.890	0.930	0.815	0.967	PER	0.850	0.909	0.770	0.854
TRAN	0.863	0.914	0.781	0.892	TRAN	0.883	0.927	0.810	0.888
INT	1	1	1	1	INT	1	1	1	1
CPOW	1	1	1	1	CPOW	1	1	1	1
TRU	0.908	0.943	0.846	0.911	TRU	0.892	0.933	0.822	0.897
AIACC	0.902	0.938	0.835	0.902	AIACC	0.933	0.957	0.882	0.935

assessing the structural model, the hypothesis that an anthropomorphizing of a system leads to an acceptance of the system (H1) is tested for validity. Therefore the mean of the constructs of acceptance in the measurement model of Maria

Table 10: Summary of dicriminant validity

HTMT table of Lisa

	TEC	PER	TRAN	INT	CPOW	TRU	AIACC
TEC							
PER	0.365						
TRAN	0.125	0.392					
INT	0.069	0.490	0.592				
CPOW	0.101	0.176	0.278	0.353			
TRU	0.065	0.419	0.593	0.611	0.516		
AIACC	0.198	0.272	0.289	0.435	0.405	0.566	

HTMT table of Maria

	TEC	PER	TRAN	INT	CPOW	TRU	AIACC
TEC							
PER	0.464						
TRAN	0.183	0.366					
INT	0.043	0.403	0.446				
CPOW	0.025	0.067	0.191	0.102			
TRU	0.100	0.394	0.476	0.619	0.047		
AIACC	0.127	0.468	0.297	0.549	0.059	0.717	

has to be significantly higher than the mean of the constructs of acceptance in the measurement model of Lisa. Therefore a T-test is conducted in R (R Core Team, 2013), shown in table 11.

The T-test shows that the mean of the anthropomorphized system is not significantly higher than the mean of the textual interface. Therefore the hypothesis that an anthropomorphizing of a system leads to an acceptance of the system (H1) is not supported.

In fact, the mean-value of the textual interface for the construct of AIACC is higher than the mean-value of the anthropomorphized system. This difference in AIACC is not significant. Furthermore, the means of the constructs of ACC have equal means for both observation groups. Moreover, the mean-values for other constructs do not differ significantly, leading to the assumption that an anthropomorphizing of the system has no significant effect on acceptance measures. To confirm this assumption the structural models are assessed in order to understand how acceptance is created. Furthermore, equal findings in both structural models support the assumption that there is no significant effect of anthropomorphizing the system on acceptance.

In order to evaluate the structural model Hair Jr. et al. (2021) suggest to first examine potential collinearity issues in the constructs. Therefore the structural model is tested for variance inflation factors. According to Becker, Ringle, Sarstedt, and Völckner (2015) variance inflation factors above the threshold of 3.0 assume issues with collinearity. The results shown in table 12 indicate no issues for potential collinearity.

In the second step Hair Jr. et al. (2021) suggest to examine the significance of the structural model. Before evaluating the significance of the structural model it is important to outline the approach in order to estimate the model.

As mentioned earlier the dataset is divided into two measurement models. Furthermore, the construct of AIACC is considered as the main indicator for measuring acceptance. For confirming the results from PLS-SEM estimation, the construct of ACC is considered in a second structural model. The models only differ in the path coefficients from the predictors of acceptance to acceptance across both structural models. For reducing illustrative complexity the construct of ACC is added to the illustration of the SEM-estimation in figure 12 and figure 13. It is important to outline that both acceptance constructs were not estimated in a single SE. All in all two structural models with two measurement models were estimated by using R, specifically the “seminr”-package by (Hair Jr. et al., 2021), leading to four estimations of PLS-SEM.

In order to examine the significance of the path coefficients, it is necessary to perform bootstrapping standard errors for calculating confidence intervals (Hair Jr. et al., 2021). The summary of the bootstrapped paths is shown in the appendix. Figure 12 and figure 13 show the path coefficients after bootstrapping. Further green paths indicate positive path coefficients whereas red paths indicate negative path coefficients. The significance of paths is marked by stars. A p-value smaller than 0.01 is marked with three stars, p-value greater than 0.01 and smaller than 0,05 is marked with two stars and a p-value greater than 0.05 and smaller than 0.1 is marked with one star. The significance of paths aids to support the previously formulated hypothesis.

The path coefficients from Trust to Acceptance show a positive influence of trust on acceptance. This path is significant for both acceptance measures and by both measurement models. The SEM for Lisa shows a path coefficient of $\beta = 0.502$ ($p < 0.001$; 5% CI = 0.372; 95% CI = 0.625) for the construct Decision (ACC) and 0.445 ($p < 0.001$; 5%

Table 11: T-test summary for antropomorphizing interfaces

System	PER	INT	CPOW	TRAN	TRU	TEC	AIACC	ACC
Lisa	2.3852	3.3762	2.9480	2.3203	3.0800	3.3766	3.5800	0.7952
Maria	2.5249	3.4720	2.8897	2.4682	3.0866	3.4645	3.4094	0.7952
p-value	0.2407	0.4352	0.6531	0.2343	0.9518	0.4997	0.1223	1.0000

Table 12: VIF-values for structural model evaluation

Structural model of Lisa						
AIACC			**TRU**			**CPOW**
TEC	PER	TRU	TRAN	INT	CPOW	TRAN
1.153	1.344	1.217	1.464	1.546	1.154	.
Structural model of Maria						
AIACC			**TRU**			**CPOW**
TEC	PER	TRU	TRAN	INT	CPOW	TRAN
1.180	1.336	1.144	1.250	1.220	1.036	.

CI = 0.308; 95% CI = 0.571) for the construct Acceptance (AIACC).

Furthermore, the SEM for Maria shows a path coefficient of $\beta = 0.223$ (p = 0.008; 5% CI = 0.068; 95% CI = 0.371) for the construct Decision and 0.582 (p < 0.001; 5% CI = 0.372; 95% CI = 0.625) for the construct Acceptance (AIACC).

The path coefficients from Transparency to Trust show a positive influence of transparency on trust. This path is significant for both measurement models. The SEM for Lisa shows a path coefficient of $\beta = 0.277$ (p < 0.001; 5% CI = 0.155; 95% CI = 0.399). Furthermore, the SEM for Maria shows a path coefficient of $\beta = 0.237$ (p = 0.005; 5% CI = 0.084; 95% CI = 0.388).

The path coefficient from Transparency to Computer Power shows a negative influence of transparency on trust. This path is significant for both measurement models. The SEM for Lisa shows a path coefficient of β = - 0.277 (p < 0.001; 5% CI = - 0.396; 95% CI = - 0.149). Furthermore, the SEM for Maria shows a path coefficient of β = - 0.186 (p = 0.027; 5% CI = - 0.336; 95% CI = -0.028).

The path coefficient from Computer Power to Trust show different significant result of the trust towards the system. This path is significant for both measurement models. The SEM for Lisa shows a path coefficient of β = - 0.301 (p < 0.001; 5% CI = - 0.395; 95% CI = - 0.205). Furthermore, the SEM for Maria shows a path coefficient of $\beta = 0.142$ (p = 0.038; 5% CI = 0.011; 95% CI = 0.272).

The path coefficient from Intelligence to Trust shows a positive influence of Intelligence on Trust. This path is significant for both measurement models. The SEM for Lisa shows a path coefficient of $\beta = 0.321$ (p < 0.001; 5% CI = 0.172; 95% CI = 0.460). Furthermore, the SEM for Maria shows a path coefficient of $\beta = 0.504$ (p < 0.001; 5% CI = 0.374; 95% CI = 0.633).

The path coefficients from Perception as technology to Acceptance show a positive influence of trust on acceptance. The result on path significance differs for both measurement models. The SEM for Lisa shows a path coefficient of β = 0.096 (p = 0.160; 5% CI = - 0.004 ; 95% CI = 0.225) for the construct Decision (ACC) and 0.205 (p < 0.001; 5% CI = 0.073; 95% CI = 0.336) for the construct Acceptance (AIACC). Furthermore, the SEM for Maria shows a path coefficient of β = - 0.084 (p = 0.17; 5% CI = - 0.220; 95% CI = 0.057) for the construct Decision and 0.003 (p = 0.5; 5% CI = - 0.145; 95% CI = 0.175) for the construct Acceptance (AIACC).

The path coefficients from Perception as person to acceptance show a positive influence of trust on acceptance. This path is significant for both measurement models. Further, the path to the acceptance measure Decision (ACC) is not significant. The SEM for Lisa shows a path coefficient of β = - 0.069 (p = 0.160; 5% CI = - 0.239; 95% CI = 0.225) for the construct Decision (ACC) and 0.159 (p = 0.025; 5% CI = 0.033; 95% CI = 0.283). Furthermore, the SEM for Maria shows a path coefficient of β = - 0.091 (p = 0.170; 5% CI = - 0.035; 95% CI = 0.261) for the construct Decision and 0.214 (p = 0.003; 5% CI = 0.091; 95% CI = 0.339) for the construct Acceptance (AIACC).

After assessing the significance of the path coefficients it is necessary to evaluate the explanatory power of the model (Hair Jr. et al., 2021). Therefore the measure of R^2 explains how much of the variance of the construct is explained by the model. R^2-values of 0.75 indicate a substantial, R^2-values of 0.5 show a moderate and R^2 values of 0.25 state a low explanatory power (Hair Jr., Ringle, & Sarstedt, 2011). The measure of R^2 may increase by the number of explanatory variables. Therefore it is important to consider the measure of Adjusted R^2. The limitation of Adjusted R^2-measure is, that it may consider the number of explanatory variables but this measure is not a precise indicator as R^2 (Hair Jr. et al., 2021).

The results shown in table 13 state a moderate to low

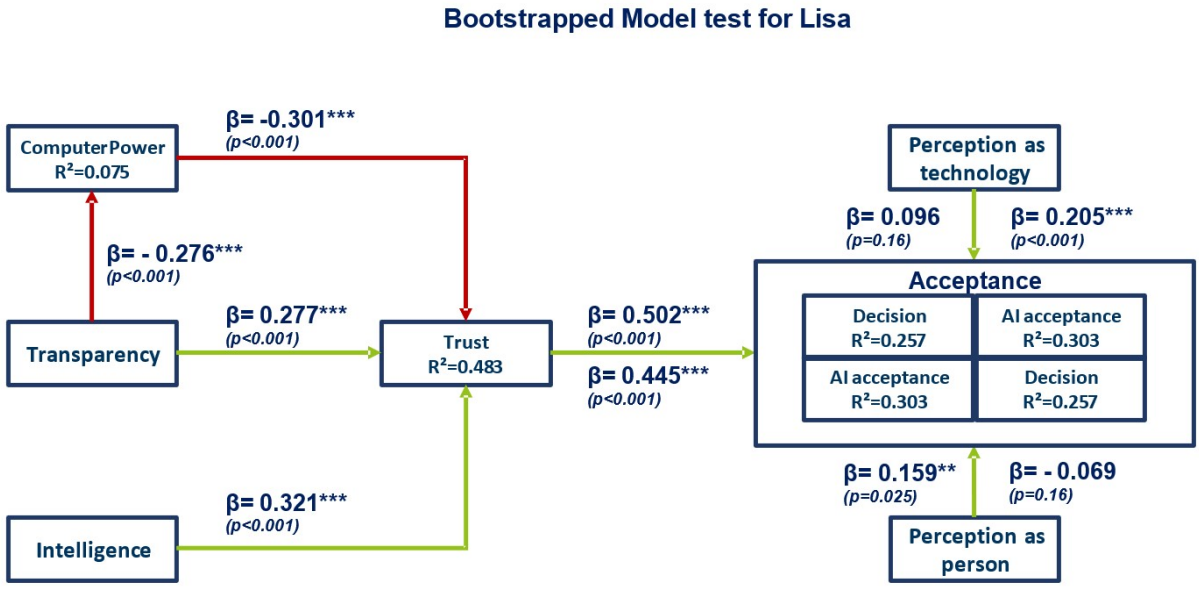

Figure 12: SEM for Lisa after Bootstrapping (Source: Own illustration)

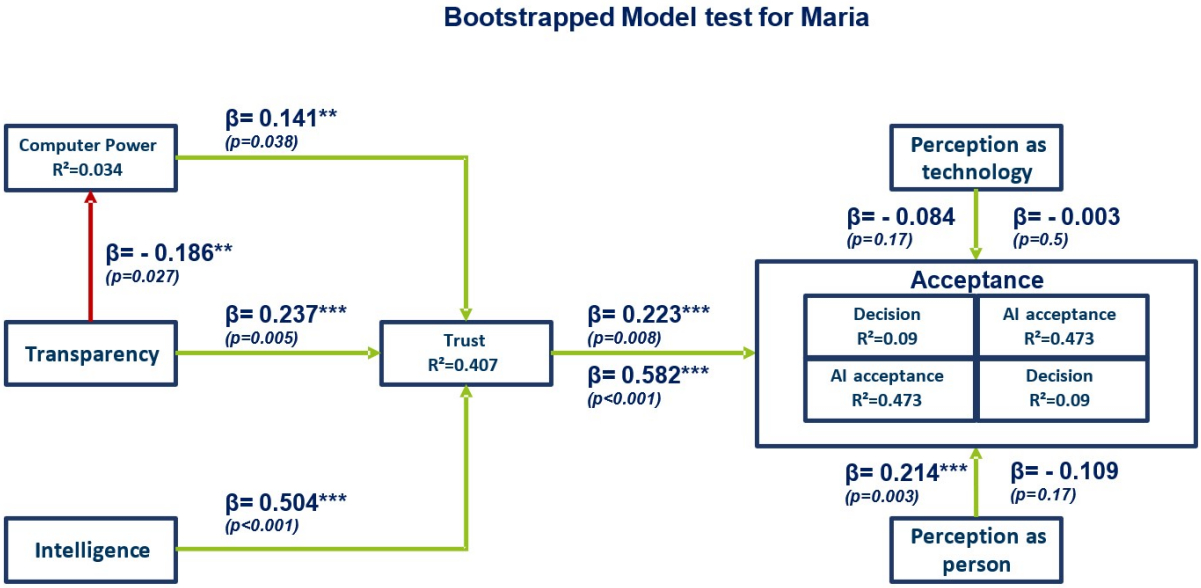

Figure 13: SEM for Maria after Bootstrapping (Source: Own illustration)

Table 13: Explanatory Power of model: R^2

	R-squared								
Lisa	AIACC	TRU	CPOW	ACC	**Maria**	AIACC	TRU	CPOW	ACC
R²	0.303	0.483	0.075	0.257		0.473	0.407	0.034	0.090
Adj. R²	0.289	0.473	0.069	0.242		0.460	0.393	0.027	0.068

explanatory power of both models. Furthermore, the model of Lisa and Maria only describes 7.5% and 3.4% of the variance of the construct of Computer Power. This may indicate that Computer Power is influenced by unobserved variables which are not measured by the model. The effect size f^2 may be a further measure to evaluate the explanatory power of the model (Hair Jr. et al., 2021). Results of f^2-measure are shown in the appendix.

Furthermore, the assessment of the predictive power of the model is the next step in order to evaluate the structural

model (Hair Jr. et al., 2021). Predictive power is defined as the ability of a model to predict new observations (Hair Jr. et al., 2021). Therefore the sample is divided into a holdout and multiple training samples. The training sample are is estimated and evaluated by predicting performance while comparing the results to the holdout sample (Hair Jr. et al., 2021). In order to perform cross validation, this process is repeated by the number of subsamples where the holdout sample is changed to a training sample and a further training sample is changed to a holdout sample. Therefore the measure of root-mean-square error (RMSE) and mean absolute error (MAE) is calculated. Furthermore, prediction errors from a linear regression model for each indicator are calculated. The structural model needs to show lower prediction errors than the benchmark of prediction errors generated by the linear model.

In order to perform the prediction, the sample was divided into 10 subsamples. Furthermore the process calculation of prediction errors is repeated 10 times. The results generated by the "seminr"-package in R (Hair Jr. et al., 2021) are shown in table 14.

The results show that six out of seven indicators of the model Lisa have lower prediction errors (RMSE) than the benchmark of the linear model. Furthermore, five out of seven indicators of the model Maria have lower prediction errors than the benchmark of the linear model. According to Hair Jr. et al. (2021) a majority of indicators under the benchmark of the linear model imply medium predictive power.

The evaluation of the structural model showed no issues with collinearity in constructs, significant path coefficients, moderate explanatory power and medium predictive power for new observations.

4.4. Discussion of study results

After evaluating the structural model, the next section will interpret the results. Therefore the previously formulated hypotheses are evaluated for validity. Furthermore, the findings of the study are reflected in prior findings in research. Possible explanations for the findings are given, derived from previous research.

4.4.1. Interpreting study results

The hypothesis that an anthropomorphizing of a system leads to an acceptance (H1) is not supported by the study. The descriptive statistics show higher mean values for the perception of the system as technology for the anthropomorphized system than for the textual system. On the other hand, the perception of the system as a person has higher mean values of the anthropomorphized system than the textual system which may indicate appropriate system design in terms of anthropomorphizing. Furthermore, the results from the t-test indicate that there is no significant influence of anthropomorphizing the system on acceptance conditions. Despite these findings, this study shows significant differences in acceptance conditions which may be referred to an influence of anthropomorphizing features of the system on the acceptance. The results are shown in table 15.

Furthermore, the study shows empirical evidence that trust towards the system is the main indicator for creating acceptance by users since the path coefficients from Trust to AI acceptance are above 0.5. The hypothesis that higher trust in a system leads to higher acceptance (H2) is supported by this study. An anthropomorphizing of the system has higher path coefficients from Trust to AI acceptance which may indicate that higher trust towards the system has a higher influence on acceptance in more anthropomorphized systems.

The results show that trust towards the system is influenced by the transparency or the comprehensibility of the system. This study shows a significant influence of Transparency on Trust with a path coefficient of 0.277 for the textual system and a path coefficient of 0.237 for the anthropomorphized system. Therefore the hypothesis that higher transparency of a system has a positive effect on the trust towards the system (H3) is supported. Furthermore, the total effects shown in the appendix imply that the mediator variables which are influenced by transparency increase the influence of transparency of the system on trust towards the system for textual interface with a significant path coefficient of 0.362. The total effects statistic shows that transparency is a significant predictor for acceptance with a path coefficient of 0.161 and the total effects statistic for the anthropomorphized system implies that the mediating variable which is influenced by transparency decreases the influence of transparency on trust. The path from Transparency to Trust remains significant with a path coefficient of 0.123. Similar to the textual system, transparency is a significant predictor of acceptance with a path coefficient of 0.125 in anthropomorphized systems.

The tautologic relation between Transparency to Computer Power could be proven empirically. This study shows a significant effect of Transparency on Computer Power with a path coefficient of – 0.276 for the textual interface and a path coefficient of – 0.186 for the anthropomorphized system. Therefore the hypothesis that a higher comprehensibility of a system has a positive effect on the perceived participation of the user in the decision-making process (H4) is supported. Since the construct of Computer Power has low explanatory power the suggested predictor may not be sufficient and other unobserved variables would be more suitable for predictors. The anthropomorphized system has lower path coefficients than the textual interface which may indicate that anthropomorphizing features decrease the effect that transparency leads to a lower perception of a higher role in decision-making by the system (Computer Power).

Further findings of the study are that Computer Power has a significant effect on Trust with a path coefficient of -0.301 for the textual system and a path coefficient of 0.141 for the anthropomorphized system. Therefore the hypothesis that the higher the perceived participation of the system-user in the decision-making process is, the higher the perceived trust towards the system (H5), is supported partially. These findings were not expected since the literature showed that higher participation possibilities lead to an increase in trust. Similar to the literature the results suggest that a perception

Table 14: Summary of prediction errors

Prediction error measures for PLS of Lisa

	l_aiacc_1	l_aiacc_2	l_aiacc_3	l_tru_1	l_tru_2	l_tru_3	l_part_1
RMSE	0.865	0.832	0.874	0.842	0.825	0.866	1.068
MAE	0.677	0.626	0.683	0.660	0.663	0.680	0.906

Prediction error measures for LM of Lisa

	l_aiacc_1	l_aiacc_2	l_aiacc_3	l_tru_1	l_tru_2	l_tru_3	l_part_1
RMSE	0.913	0.863	0.930	0.847	0.856	0.885	1.027
MAE	0.696	0.632	0.720	0.651	0.657	0.709	0.866

Prediction error measures for PLS of Maria

	m_aiacc_1	m_aiacc_2	m_aiacc_3	m_tru_1	m_tru_2	m_tru_3	m_part_1
RMSE	0.811	0.789	0.797	0.801	0.694	0.801	1.060
MAE	0.650	0.637	0.673	0.634	0.568	0.632	0.867

Prediction error measures for LM of Maria

	m_aiacc_1	m_aiacc_2	m_aiacc_3	m_tru_1	m_tru_2	m_tru_3	m_part_1
RMSE	0.871	0.816	0.854	0.813	0.646	0.778	1.171
MAE	0.692	0.653	0.700	0.639	0.502	0.579	0.975

of higher participation of the system in decision-making decreases trust towards the system for the textual interface. For the anthropomorphized interface the perception of higher participation of the system in the decision-making process increases the trust in the system. This effect may be explained due a lower perception of high participation of the system in decision-making shown in the comparison of means in descriptive statistics. Furthermore, the total effects statistic shows that Computer Power is a significant predictor of acceptance with a path coefficient of – 0.082 for anthropomorphized interfaces. On the other hand, the path coefficient of – 0.135 is not significant for textual interfaces. This total effect statistics show that acceptance is increased if the system has higher power in decision making for anthropomorphized interfaces. On the other hand, there is no significant influence of the perceived power of the system in decision-making on acceptance for textual interfaces.

The results show that the perceived intelligence of the system has an influence on the trust in the system. This study shows a significant influence of Intelligence on Trust with a path coefficient of 0.321 for the textual interface and a path coefficient of 0.521 for the anthropomorphized interface. Therefore the hypothesis that the higher the perceived intelligence of the system is, the higher the trust (H6) is supported. The path coefficients of the anthropomorphized system show that the perceived intelligence has a greater role in predicting trust than the path coefficient of the textual interface. Furthermore, the total effects statistic shows that Intelligence is a significant predictor of acceptance with a path coefficient of 0.142 for the textual interface and a path coefficient of 0.294 for the anthropomorphized interface. This total effect statistic shows that a higher perceived intelligence of the system should be considered in order to create acceptance of the users.

The results show that the perception of the system as a technology has an influence on acceptance. This study shows a significant influence of the perception of the system as technology on the acceptance by users with a path coefficient of 0.205 for the textual interface. For anthropomorphized interfaces the path coefficient of – 0.003 is not significant. Therefore hypothesis that the higher the perception of the system as technology is, the higher the acceptance (H7), is supported partially.

Furthermore, the study results show that the perception of the system as a person has an influence on the acceptance of users. A Significant influence of the perception of the system as a person with a path coefficient of 0.159 for textual interface and path coefficient of 0.214 for an anthropomorphized system is identified. Therefore hypothesis that the higher the perception of the system as person is, the higher the acceptance (H8) is supported. The results may indicate that adding anthropomorphizing features for textual interfaces may not be necessary in order to create acceptance since the path coefficients for the perception of the system as a technology is higher than the path coefficient of the perception of the system as a person.

4.4.2. Theoretical relevance of study results

The acceptance research on the non-managerial level showed that trust is a major condition to create acceptance by users (Hastenteufel & Ganster, 2021; Rathje et al., 2021; Scheuer, 2020; Uysal et al., 2022). This study shows that findings from literature are applicable on the managerial level. Specifically, trust is identified as a major condition for creating acceptance by users. Furthermore, this study shows how trust is influenced. Since Makarius et al. (2020) iden-

Table 15: Results on acceptance conditions for algorithmic decision support

From	INT	CPOW	TRAN	TRAN	PER	TEC	TRU	CPOW	TRAN	INT
To	TRU	TRU	CPOW	TRU	AIACC	AIACC	AIACC	AIACC	AIACC	AIACC
Path coefficients: Lisa	0.321	-0.301	-0.276	0.277	0.159	0.205	0.445	-0.135	0.161	0.142
T-Statistics	3.678	-5.276	-3.606	3.691	1.973	2.490	5.574	-3.532	3.625	3.097
5 % CI	0.172	-0.395	-0.396	0.155	0.033	0.073	0.308	-0.201	0.094	0.094
95 % CI	0.460	-0.205	-0.149	0.399	0.283	0.336	0.571	-0.076	0.238	0.238
Significance	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Path coefficients: Maria	0.504	0.142	-0.186	0.237	0.214	-0.003	0.582	0.082	0.123	0.294
T-Statistics	6.420	1.790	-1.985	2.607	2.834	-0.009	9.048	1.739	2.182	4.599
5 % CI	0.374	0.011	-0.336	0.084	0.091	-0.145	0.472	0.006	0.028	0.193
95 % CI	0.633	0.272	-0.028	0.388	0.339	0.175	0.683	0.161	0.217	0.402
Significance	✓	✓	✓	✓	✓		✓	✓	✓	✓

tified cognitive issues in terms of strategic decision making where they identified the necessity to do further research in how decision-makers trust the output received from AI systems. This study shows how trust is influenced. Furthermore, Venkatesh and Davis (2000) show that perceived usefulness is an indicator of acceptance. The study results show that the perceived intelligence of the system is an acceptance condition for decision support. Furthermore, the results suggest that the system should be perceived as useful and exhibit a certain intelligence confirming the research on TAM by Venkatesh and Davis (2000). Despite no findings on the influence of perceived intelligence on trust by Scheuer (2020), this study showed empirical evidence that the perceived intelligence of system has an influence on trust. Research on acceptance states that it is necessary to have a transparent system in terms of the comprehensibility of a decision process (Gersch et al., 2021; Meske et al., 2022; Scheuer, 2020; Venkatesh & Davis, 2000). On the other hand, Newman et al. (2020) state that an increase in transparency may lead to a decontextualization of workers. Therefore the results of this study show that the findings from acceptance research are applicable on the managerial level, specifically that transparency of a result-generating process influences the trust in the system in a positive way. Transparency of the decision-making process of the system is identified as a necessary condition in order to create acceptance by users.

Further results of this study show evidence for the tautologic relationship between the transparency of result processing and the perceived participation of the system in decision-making. Orlikowski and Robey (1991) assume that more information in the decision-making process leads to a higher power of the decision-maker. Considering the manager as a decision-maker the study showed that more information for the manager increases his perceived power in decision-making. Furthermore, the perceived power of the system in decision-making decreases. This effect can be explained by the perception of authoritative correctness of algorithms. Precise algorithms may generate the perception of correctness therefore human beings can feel inferior to algorithms (Martini, 2019).

On the other hand, a higher perceived power of the system in the decision-making process may leads to an increase in trust towards the system if the system is anthropomorphized. Mcafee et al. (2012) questioned whether managers would accept a decision support system which may lead to a shift in their role in form of decreased power. The result showed that higher perceived power by the system in decision-making is an acceptance condition for anthropomorphized systems. These results are contradictory to prior research and to attribution theory by Kelley and Michela (1980).

Attribution theory states that individuals seek to understand the cause of their own behavior (Kelley & Michela, 1980). Since this study shows that the power of the system in decision-making process can be achieved by reducing the transparency of the system, it is assumable that users can have an increased trust in the system even if the system is not comprehensible. Furthermore, a low comprehensibility of a system may not lead to an understanding of the cause of own contribution on the success caused by the decision. Specifically, anthropomorphized systems cause blind trust. This assumption may be irrational in terms of research findings in the necessity of explainable systems regarding result processing (Gersch et al., 2021; Meske et al., 2022; Scheuer, 2020; Venkatesh & Bala, 2008). This irrational assumption may be explained by interpersonal acceptance. As mentioned before insufficient knowledge and a lack of trust hinder the adoption of decision support systems (Rainsberger, 2021). An anthropomorphizing of systems may build up a personal relationship by generating sympathy and affection towards the system which results in interpersonal acceptance (Rohner & Khaleque, 2002). Furthermore, an anthropomorphized system may lead to higher perception of effectiveness of the system causing automation bias. Anthropomorphized systems may be perceived as more effective leading to the tendency to over-rely on decisions made by algorithms (Meske et al., 2022). Goddard, Roudsari, and Wyatt (2012) shows that automation bias leads to a potential failure to detect mistakes made by algorithms. Expectancy theory by Isaac, Zerbe, and Pitt (2001) may explain this irrational assumption. Isaac et al. (2001) state that individuals choose a decision based on the expected outcome of a decision. Therefore a high perception of intelligence may lead to greater expectancy in the outcome of the decision. Further possible explanation for the positive effect of higher perceived power of the system on trust towards the system may be a perception of fairness. Korsgaard et al. (1995) show that participation possibilities as the consideration of an input brought for decision-making or the influence of the input brought for decision making on the outcome of a decision create procedural justice which is a prerequisite for fairness. As Lee (2018) and Newman et al. (2020) show the perception of a fair or trustworthy decision depends on whom the decision is made. Decisions made by the anthropomorphized system may be perceived fairer due to the anthropomorphizing features. Since the anthropomorphized system was more perceived as a technology than a person this explanation may be partially valid. Since the perception of the system as technology was higher in the anthropomorphized system than in the textual system, the Turing test (Turing, 1950) failed. The failure of the Turing test may purpose that the system was not perceived as intelligent by the users. In fact, the perceived intelligence of the system was higher in the anthropomorphized systems than in the textual system which may propose that Turing's definition of intelligence is outdated. Intelligence may be connected to the perception of anthropomorphizing features according to Waytz, Cacioppo, and Epley (2010) like cognition, emotions or interactivity. Furthermore, Lee (2018) shows that decisions made by humans evoke positive emotions due to the possibility of social recognition. Since anthropomorphized systems are characterized through the perception of cognitive capabilities in technology like emotions Waytz et al. (2010), users may see a psychological pleasure or social gain while interacting with the technology. Therefore, the social exchange theory

(Emerson, 1976) may be applicable in order to confirm findings on acceptance conditions. The social exchange theory states that the interaction between two humans is characterized by an exchange of costs and utilities. Utilities may be the effectiveness of the system (Goddard et al., 2012; Lee, 2018; Martini, 2019), psychological pleasure or the enjoyment of system usage (Waytz et al., 2010) and costs may be the perception of inferiority (Baumann-Habersack, 2021; Lee, 2018; Newman et al., 2020), possible detachment of decision making (Bader & Kaiser, 2019) in terms of involvement or the risk of failure due to data discrimination (Newman et al., 2020). Lawler and Thye (1999) show that emotion deepen the nature of the relationship between humans. Furthermore, they show that due to the rise of emotions, humans tend to focus on the decision rather than on the decision process in a group. Therefore social exchange theory may be a possible explanation for blind trust.

The theory of Uncanny Valley by Mori, MacDorman, and Kageki (2012) shows that anthropomorphizing features lead to an increase of acceptance influenced by trust (Scheuer, 2020). They state that an increase of anthropomorphizing features to a certain point lead to a radical reduction of acceptance. Furthermore, Mori et al. (2012) outline that after the critical point of reduction a certain high degree of anthropomorphizing leads to increasing effects on acceptance. Since the anthropomorphized system had high features of anthropomorphizing like gestures, human embodiment and voice output. The survey participants may felt an imperfection of anthropomorphizing leading to higher perception of the system as technology.

5. Acceptance conditions of algorithmic decision support for practice and research

Since the literature shows that research on acceptance conditions for management is critical in order to enhance the potential of algorithmic decision support (Grossman & Siegel, 2014; Laudon et al., 2016; Mcafee et al., 2012; Mikalef et al., 2019; Rainsberger, 2021; Reid et al., 2015). This paper identified plenty of acceptance conditions. Therefore it is necessary to categorize findings for practice and identify limitations for further research.

5.1. System design implications

This paper showed that an optimization of an interface in terms of anthropomorphizing has no effect on the acceptance. Despite no finding, the way acceptance is created differs in optimized interfaces. Therefore practitioners should first define their goal in terms of algorithmic decision support where they have to specify the role of the user. It is necessary to adjust the optimization of the interface to the intention to use the system. If a user should question the output of the decision support system, the decision-processing of the system should be transparent leading to a higher power of the user during the usage. Therefore anthropomorphized system would not be suitable.

On the other hand, if a user should rely on the output of the decision support system, the system should exhibit a higher perceived intelligence leading to a higher trust. Furthermore, the system should be perceived as a person in order to create acceptance. Therefore anthropomorphized systems would be suitable. The research showed that the expected outcomes of an anthropomorphizing is dependent on the system design. Therefore practitioners should pay attention to a suitable degree of an anthropomorphized system in order to avoid the Uncanny Valley proposed by Mori et al. (2012). Practitioners should examine which degree of anthropomorphized system is beneficial in order to fulfill their goals. The implications show that system design is key in order to optimize the interface to create acceptance.

Furthermore, the decision support system should be trustworthy since trust is identified as the main indicator for creating acceptance. In order to create trust according to Lemke, Monett, and Mikoleit (2021) ethical principles should be considered while designing the system. Specifically, beneficence, transparency, nonmaleficence, autonomy, justice, and privacy are principles for an ethical usage of AI according to M. C. Barton and Pöppelbuß (2022). The decision processing of the system should be transparent leading to a higher power of the user. Further performance measurement of the decision may lead to the realization of a positive impact of own contribution on the decision (attribution theory). Systems with high power in the decision making process should be avoided since they have a negative effect on trust. On the other hand anthropomorphized systems with high power in decision-making lead to an increase in trust (blind trust). Future technology advances in hardware like neuromorphic computer architecture, DishBrain and Brain Machine Interface or advances in algorithms like Computational Intelligence or Super Artificial Intelligence may lead to an affordance of blind trust. Since anthropomorphized systems should be introduced when a reliance on the system is afforded, practitioners have the possibility to avoid ethical principles by designing a system with low transparency leading to blind trust. They should carefully evaluate whether they want to benefit from blind trust. It may be beneficial in order to create acceptance. The research showed that the benefits (total effects) from blind trust are smaller than the benefits from trust created by comprehensibility (total effects). Therefore systems with high effectiveness due to technological advances should be transparent for the user because they lead to higher trust and make it possible to identify their own contribution to the outcome of the decision (attribution theory). Furthermore, advanced systems have to exhibit intelligence. The manager should rely on the system knowing that the system processes decision aid with high precision. Therefore the effectiveness of the system should be communicated properly in order to benefit from expectancy theory (Isaac et al., 2001).

This study showed that an anthropomorphizing may not have a direct effect on the acceptance. One of the first anthropomorphized system was introduced by Microsoft called Clippy (Swartz, 2003). The rejection of this assistant was

high due to malfunction and a low effectiveness of the system (Swartz, 2003). Due to claims, Microsoft has removed the function of Clippy in Office (Swartz, 2003). Despite the failure of Clippy an interface with a similar degree of anthropomorphizing may be beneficial for advanced decision support systems in order to avoid the Uncanny Valley.

5.2. Limitations and future research

Further precise implications for practice could be derived if the study did not have limitations. The study results were based on an interaction of users with the system. Therefore vignettes have to be designed carefully which could imitate a realistic scenario. Vignettes may distort the perception of the user through the framing of information. This study carefully examined framing of information. The vignette was framed in terms of transparency of the system. The system used in the vignette was not comprehensible. Therefore the descriptive statistics confirm that on average the users do not understand the decision processing of the results of both systems. This distortion was necessary in order to examine whether users would accept the system even if it is not comprehensible. Therefore the vignette described an interaction with hybrid intelligence where the level can be classified as Decision Support System. Further levels of hybrid intelligence were not specified. Since this study showed that the participation of the user in the decision-making process is important for building a trustworthy system, further levels of hybrid intelligence should be considered for future research.

Due to measurement errors, constructs of the study contain single-items which may be not beneficial since exogenous variables are not measurable directly. Nevertheless, the literature shows that single item constructs are appropriate measures for an exploratory research. Since the research question focused on the exploration of acceptance conditions this study examined valid results through the use of PLS-SEM. In order to validate the constructs on theoretical level, a further study should be conducted where the data is analyzed by a common factor-based structural equation model (CB-SEM).

One major problem of the study is that the perception of the system as technology of the system of the anthropomorphized system was higher than that of the textual system. This may indicate that the system design of the vignette was affected by the Uncanny Valley by Mori et al. (2012). Since this study has aimed to maximize the level of anthropomorphizing a specific high degree of anthropomorphizing was reached. The degree of anthropomorphizing is not specifiable uniformly. Therefore the research has to develop a scale for identifying the degree of anthropomorphizing where features of system design are specified in order to derive the degree of anthropomorphizing. Due to the non-existence of a certain scale of anthropomorphizing the degree of anthropomorphizing was chosen arbitrarily, which may distort the results. Further research can focus on the acceptance of anthropomorphized systems with different scales of anthropomorphizing. The effect of Uncanny Valley is identified in the cancellation statistics of the survey. Most cancellations of the survey were done on the page of the introduction of the anthropomorphized system (75 survey participants). The results may be distorted since the users were annoyed by the presence of a human-like system which resulted in the cancellation of the survey. This group would have provided other results. Further research could examine whether a maximization of the anthropomorphizing features may lead to a perception of the system as a person and examine the effect of interpersonal acceptance on acceptance?

The T-test showed that anthropomorphizing has no effect on the acceptance or acceptance-creating variables. Furthermore, two PLS-SEM were estimated to identify how acceptance is created. This approach could be optimized by using anthropomorphizing as moderating variable. Since both models show similar effects except for the aspect of blind trust in anthropomorphized systems, a lack of explanatory power exists in the difference in the results of both systems. R^2 is low in the construct of system power for both SEM models highlighting the affordance of a research setting with moderating effect of anthropomorphizing. Furthermore, the method of PLS-SEM maximizes the explanatory power of the model R^2 (Hair Jr. et al., 2021). Low R^2 values indicate that variables were omitted in research, which may lead to a problem of causal identification (endogeneity). Since the research focuses on an exploration of acceptance conditions a validation of endogeneity was not necessary. Therefore future research should examine endogeneity to identify causalities for the acceptance conditions.

This study examined the acceptance conditions for a single decision-maker. In practice, decision situations may be more complex. Merendino et al. (2018) show that algorithmic decision support can create tension in boards. Therefore it is necessary to examine acceptance conditions for further decision scenarios. Future research should identify whether acceptance conditions for single managers are applicable for more complex decision scenarios, like group decisions.

6. Conclusion

The aim of this thesis was to investigate the conditions that lead to the acceptance of algorithmic decision support systems. In this study, it was especially important to consider the decision-making process of managers. According to this the target group of this study was german speaking students and employees including managers. To analyze different conditions, that may lead to the acceptance of algorithmic decision support systems it was necessary to choose a methodological approach that considers different scenarios but also provides insights on the perceptions, beliefs, and attitudes of the target group. Based on this, a vignette study along with a quantitative survey was used for the data collection for the thesis. In total 281 german speaking student and employees including managers participated in the study during the period from 25.07.22 -07.08.22.

Furthermore, to analyze the conditions of acceptance an estimation of a PLS-SEM model was conducted.

In the theoretical section, it was assumed that anthropomorphizing features may lead to a situation where the user perceives the system as a person and accordingly shows more trust and acceptance towards it. But the result show, an exact opposite behavior of the users. As in the vignette study, two scenarios were presented a textual scenario and a scenario considering anthropomorphizing features. The users perceive the anthropomorphized scenario as a technology and show more trust and acceptance towards a scenario that is not anthropomorphized. Accordingly, the results indicate that there is no significant influence of anthropomorphizing the system on acceptance.

On the other hand, this thesis shows how acceptance differs across both distinct system. This study confirms that higher trust in a system leads to higher acceptance. In addition to this, the results show that trust in the system is influenced by the transparency or the comprehensibility of the system. In this regard it might be interesting to investigate how a system can be designed to receive more trust. In other words, how can the variable transparency or comprehensibility be further elucidated to generate more trust which in the end leads to a situation where the user accepts a system? In this regard different vignette settings might be helpful to investigate scenarios that lead to more transparency and in turn to more trust and acceptance.

Moreover, this study presented several implications for managers and academics. It needs to be mentioned that exponential development in technology can help to aid strategic and operational decisions in management and can be crucial in order to be competitive in dynamic markets. Nevertheless, decision support systems are not used in practice which has many reasons. The literature shows that major challenges arise in the domain of management. Studies show that only few decision-makers understand data concepts well. Therefore the acceptance of algorithmic decision support is not given in the practice. Research on acceptance has identified many conditions in order to foster acceptance of information systems. Nevertheless, the research focuses on the acceptance on worker- or user-level. This study focuses on the gap in the existing literature on management-level. The research question is which conditions lead to an acceptance of algorithmic decision support in management.

Summing up, the literature on persuasive technology shows that an optimization of interfaces leads to more interaction with the technology. Anthropomorphizing is identified as an appropriate way to optimize interfaces. Therefore a vignette study design is conducted, where the survey participants simulate an interaction with a decision support system where the anthropomorphizing is manipulated due to two alternating degrees of anthropomorphizing (low and high). The data for both systems were measured on distinct measurement models. Initially, the results show that there is no effect of anthropomorphizing on acceptance, which may be biased by Uncanny Valley.

Practitioners should first define the level of hybrid intelligence in order to design the system. The system design should consider effects from the study. Benefits from blind trust are not recommendable since the creation through transparency has higher total effects than the total effect of the perceived power of the system in decision-making process. Furthermore, the system has to be effective which may be realized by technological advances. The effectiveness of the system has to be communicated in an appropriate level to enhance the perceived intelligence of the system.

This study showed which conditions lead to an acceptance of algorithmic decision support in management in an explorative study design. These conditions of acceptance could be confirmed by further research through a CB-SEM. All in all, it needs to be mentioned that this study firstly, provided a theoretical contribution by deriving a Structural model and based on the thoughts of the TAM. Secondly, this study provided an empirical contribution at a managerial level as 281 survey respondents participated in this study and shared their perceptions and attitudes towards two scenarios constituting two systems.

Finally, this study provided a practical contribution by showing how companies can use this model as an indicator to design systems and which conditions are necessary in order to create acceptance for users. All in all, this study contributes to the research gap on acceptance on managerial-level.

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Transparency and organizational legitimacy: an experimental study based on a fictitious company

Transparenz und organisationale Legitimität: Eine experimentelle Studie am Beispiel eines fiktiven Unternehmens

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Abstract

In this paper it was empirically reviewed, if a high level of corporate transparency leads to an increase in companies' organizational legitimacy. Through an experimental design, individually perceived organizational legitimacy was measured based on Suchman's (1995, S. 578–579) definition of pragmatic, moral, and cognitive legitimacy. For this purpose, the experimental group (n = 108) received a stimulus indicating high transparency while the control group (n = 112) was presented with a very limited amount of information indicating low transparency for a fictitious airline. The experimental stimulus consisted of legitimacy sources such as media reports, rankings, surveys, and internal press reports. The empirical results only suggest an increase in moral legitimacy for the experimental group. Nevertheless, organizational legitimacy decreases less for the experimental group compared to the control group. Also, the processing time of the transparency offer documents presented had no effect on the level of organizational legitimacy. Although a quantitatively high transparency offer has stronger effect on organizational legitimacy than a quantitatively low transparency offer, it cannot be assumed that transparency has a fundamentally legitimacy-enhancing effect. Moreover, the mere availability of information seems to play a greater role than its processing time.

Zusammenfassung

In der vorliegenden Arbeit wurde empirisch überprüft, ob ein hohes Transparenzangebot über und von Unternehmen zu einer Erhöhung ihrer organisationalen Legitimität führt. In einem experimentellen Design wurde dazu die individuell wahrgenommene organisationale Legitimität anhand der von Suchman (1995, S. 578–579) dargestellten Sub-Kategorien der pragmatischen, moralischen und kognitiven Legitimität für eine Versuchsgruppe (n = 108) mit hohem Transparenzangebot und einer Kontrollgruppe (n = 112) mit niedrigem Transparenzangebot am Beispiel einer fiktiven Fluggesellschaft gemessen. Das Transparenzangebot bildete den experimentellen Stimulus und setze sich aus den folgenden Legitimitätsquellen zusammen: Medienberichte, Rankings, Umfragewerte und unternehmensinterne Presseberichte. Die Ergebnisse der Empirie lassen lediglich für die Versuchsgruppe eine Steigerung der moralischen Legitimität erkennen. Ebenfalls zeigt sich, dass die organisationale Legitimität für die Versuchsgruppe im Vergleich zur Kontrollgruppe weniger stark sinkt. Die Verarbeitungsdauer der vorgelegten Dokumente hatte dabei keinen Einfluss auf das Niveau der organisationalen Legitimität. Ein quantitativ hohes Transparenzangebot wirkt sich damit zwar positiver auf die organisationale Legitimität aus als ein quantitativ niedrigeres Transparenzangebot, jedoch kann nicht von einem grundsätzlich legitimitätsstiftenden Effekt der Transparenz ausgegangen werden. Dabei scheint außerdem der reine Signaleffekt der Informationen eine größere Rolle als ihre Verarbeitungszeit zu spielen.

Keywords: Transparenz; Organisationale Legitimität; Fluggesellschaften; Corporate Governance; Experiment.

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1. Einleitung

Ob in Politik, Wirtschaft oder grundsätzlich allen Bereichen, in denen zwischenmenschliche Beziehungen eine Rolle spielen: Transparenz bedeutet mehr Wissen über Entscheidungen, Absichten oder allgemein die internen Prozesse eines Organismus. Sie verringert das Risiko und somit die Unsicherheit der Außenstehenden (FAZ, 2011). Unternehmen geben immer mehr Geld aus für die Transparenz ihrer Lieferketten, Kund:innen fordern Informationen über die Qualität ihrer Produkte und führende Organisationen sehen die Zukunft in Big Data (Marr, 2016, S. 4). Es wundert daher nicht, dass Unternehmen immer neue Formen der Berichterstattung veröffentlichen, um Vertrauen zu schaffen und als legitim wahrgenommen zu werden. Denn je legitimer Organisationen wahrgenommen werden, desto robuster sind diese gegen Veränderungen, ceteris paribus, desto langfristig erfolgreicher sind diese wirtschaftlich (Díez-Martín, Prado-Roman & Blanco-González, 2013, S. 1954; López-Balboa, Blanco-González, Díez-Martín & Prado-Román, 2021, S. 1; Pollack, Rutherford & Nagy, 2012, S. 915).

Transparenz ist allerdings mehr als ein Allheilmittel gegen Unsicherheit und bringt ebenfalls riskante Begleiterscheinungen mit sich. So bedeutet Wissen nach Foucault vor allem Macht, die in ihrer Extremform von ihm im sogenannten *Panoptismus*[1] beschrieben wird (vgl. z.B. Foucault, 2016). Diese Macht kann in der Theorie utilitaristisch genutzt werden, bietet durch Informationsasymmetrien aber auch die Möglichkeit des Missbrauchs und stellt daher ein Risiko für Individuen und Organisationen dar. Die Akteure werden also versuchen, das Risiko zu minimieren, indem sie Verschwiegenheit bewahren.[2] Die Verbreitung von Informationen ist außerdem mit Kosten verbunden, die aufgrund eines ökonomischen Entscheidungsproblems resultieren. Transparenz ist also nicht positiv oder negativ, sondern gleichzeitig Medizin und Gift – es kommt auf die korrekte Anwendung und Dosierung an (Mayrhofer & Meyer, 2020, S. 152). Im Folgenden wird die Beziehung zwischen Transparenz und Legitimität im organisationalen Kontext näher beleuchtet.

1.1. Problemstellung und Relevanz

Zu organisationaler Legitimität existiert bereits eine Vielzahl an Erkenntnissen. Hierunter fällt auch der Einfluss diverser Informations- bzw. Signalformen, welche sich als Transparenzangebot zusammenfassen lassen. Der bisherige Forschungsstand in den Organisationswissenschaften stellt diesen Zusammenhang jedoch oft rein theoretisch auf einer abstrakten Ebene oder bezogen auf sehr spezifische Informations- oder Unternehmensformen dar. Turcan, Marinova und Rana (2012) liefern eine umfassende Zusammenfassung der Anwendung unterschiedlichster Legitimationsstrategien und konkludieren, dass es zwar sehr viele Konzepte gibt, diese allerdings oft nicht empirisch untermauert sind. Dabei steht zwar fest, dass Transparenzinitiativen zu einer Erhöhung der Legitimation beitragen können, es wird jedoch nicht weiter differenziert, ob auch die Menge des Transparenzangebots entscheidend ist. Ein Großteil der Empirie bezieht sich zudem auf den Bereich öffentlicher Organisationen und Institutionen (vgl. z.B. Curtin & Meijer, 2006; Horvath & Katuscakova, 2016; Wiedemann, 2010), wenig erforscht ist aber die Wirkungsweise für Unternehmen. Ebenso bezieht sich der bisherige Kenntnisstand entweder auf sehr eng gefasste Maßnahmen, wie beispielsweise die Unterscheidung in technische oder symbolische Berichterstattung oder erfasst diese als Teil eines Repertoires unterschiedlicher strategischer Ansätze (Elsbach, 1994; Stelzer, 2008). Diese Arbeit konzentriert sich daher auf grundsätzlich transparenzschaffende Signale und bezieht sich dabei speziell auf die Beziehung zwischen der Menge des Transparenzangebots und ihrem Effekt auf die organisationale Legitimität.

1.2. Zielsetzung

Das Forschungsvorhaben richtet sich auf Unternehmen als abgrenzbare Organisationsform zu *Non-Profit-* oder öffentlichen Organisationen (Lee & Wilkins, 2011, S. 45). Ziel ist es, den Einfluss der Quantität des Transparenzangebots auf die wahrgenommene organisationale Legitimität empirisch zu überprüfen. Der wissenschaftliche Beitrag des Forschungsvorhabens wird zum einen mehr Klarheit über die generelle Anwendbarkeit von Legitimierungsstrategien für Unternehmen im Rahmen ihrer Kommunikationsstrategien schaffen sowie die Anwendbarkeit von Transparenzmaßnahmen und den Umgang mit öffentlichen Informationen näher spezifizieren. Während Stelzer (2008) bereits die grundsätzliche Wirkungsweise von Legitimierungsstrategien im eng gefassten Segment „*junger Unternehmen*“ untersucht, bezieht sich das hier angeführte Vorhaben auf bereits etablierte Unternehmen, spezifiziert jedoch die Form der Legitimierungsmaßnahme. Die Forschungsfrage lautet daher: „*Wie beeinflusst Transparenz die wahrgenommene organisationale Legitimität von Unternehmen?*”.

1.3. Vorgehensweise

Nach der Begründung des Forschungsvorhabens im ersten Kapitel folgt im zweiten Kapitel die konzeptionelle Herleitung der Empirie. Neben der Darstellung des theoretischen Hintergrunds werden hierzu die Hypothesen abgeleitet. Im dritten Kapitel wird die Operationalisierung des entwickelten Untersuchungsmodells beschrieben, woraufhin in Kapitel vier die Ergebnisse vorgestellt und zur Beantwortung der Hypothesen genutzt werden. Anschließend erfolgt eine kritische Betrachtung der Einschränkungen dieser Arbeit in Kapitel fünf sowie der Vergleich der Ergebnisse mit bereits existierenden Forschungsbefunden in Kapitel sechs. Kapitel sieben schließt die Arbeit ab und fasst die zentralen Erkenntnisse zusammen.

[1] *Panoptismus* ist ein von dem französischen Philosophen Michel Foucault etablierter Begriff, der gesellschaftliche Überwachungsmechanismen beschreibt (Foucault, 2016).

[2] Die sogenannte *Prinzipal-Agent-Beziehung* wird auch in *Kapitel 2.2.1* dieser Arbeit aufgegriffen.

2. Konzeptioneller Bezugsrahmen

Der konzeptionelle Bezugsrahmen dient der Einordnung des Forschungsthemas in bereits existierende Forschungsergebnisse. Neben entsprechenden Ausführungen zu einem besseren Verständnis der Sachverhalte werden zentrale Begriffe erklärt und spezifiziert sowie übergreifende Konzepte und Theorien auf Basis des aktuellen Forschungsstandes erläutert.

2.1. Zentrale Begriffe

Zu Transparenz und Legitimität existieren unterschiedlichste Theorien sozialwissenschaftlicher Disziplinen. Um den Zusammenhang zwischen Transparenz und Legitimität im Rahmen dieser Arbeit erfassen zu können, ist eine nähere Auseinandersetzung der Konzepte im organisationalen Kontext notwendig.

2.1.1. Legitimität

Legitimität beschreibt ein Konstrukt, das verschiedene Begriffe, wie die organisationale Umwelt, Institutionen und institutionelle Logiken, voraussetzt. Schreyögg und Geiger (2020, S. 189–190) beschreiben die organisationale Umwelt als nicht der Organisation selbst zuzurechnendes Element, das eine Organisation abgrenzt. Je nach Organisationsform kann der Fokus auf unterschiedlichen Aspekten, wie beispielsweise Effizienz, Macht oder Kompetenz liegen. Organisationen müssen sich ebenfalls dem Einfluss von Institutionen aussetzen, die in einem sozialen Raum bestehende Erwartungen beschreiben. Nach Scott (2014, S. 59–74) spielen hier vor allem regulative, normative und kognitive Einflüsse eine große Rolle. Darauf basierend beschreibt die institutionelle Logik das jeweilige Referenzsystem einer Institution und rechnet damit Phänomenen, wie Handlungen oder Personen, entsprechende Bedeutungen zu (Thornton, Ocasio & Lounsbury, 2012, S. 2–3).

Organisationale Legitimität ist keine Ressource, die erworben oder produziert werden kann, sondern von spezifischen soziologischen Gegebenheiten abhängig (Faust, 2012, S. 32). Sie wird von den Interessengruppen einer Organisation gewährt und beschreibt, dass die Einschätzung ihrer zentralen Anspruchsgruppen dem in einem sozialen Kontext gültigen Regelwerk entspricht (Deephouse, 1996, S. 1025). Die Legitimitätsebene stellt damit die Position der Organisation innerhalb einer sozialen Gruppe dar und zeigt den Grad ihrer sozialen Anerkennung und Akzeptanz (Deephouse & Suchman, 2008, S. 61; Walgenbach & Meyer, 2008, S. 31). Diese Akzeptanz rechtfertigt die Rolle der Organisation im sozialen System und verleiht ihr das Recht zu existieren, da die Organisation somit von der Öffentlichkeit bestätigt wird (Ashforth & Gibbs, 1990, S. 177; Bitektine, 2011, S. 153; Massey, 2001, S. 156). Legitimität wird daher auch als globales Urteil beschrieben (Díez-Martín, Blanco-González & Díez-de Castro, 2021, S. 1), welches wechselwirkend von Organisationen interpretiert wird und gleichzeitig ihrer Bewertung dient (Bitektine & Haack, 2015, S. 53; Tyler, 2006, S. 383). Suchman (1995, S. 574) fasst Legitimität als *„a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs and definitions“ zusammen*. Organisationale Legitimität kann weiter in die drei Sub-Kategorien *pragmatische*, *moralische* und *kognitive Legitimität* eingeteilt werden. Die Unterteilung findet in der Literatur weitreichende Anwendung und soll daher auch für diese Arbeit verwendet werden (vgl. z.B. Deephouse, Bundy, Tost & Suchman, 2017). Nachfolgende Erläuterungen spezifizieren die Sub-Kategorien.

Pragmatische Legitimität

Im Mittelpunkt der *pragmatischen Legitimität* steht die Verfolgung der eigenen Interessen der Anspruchsgruppen. Sie wird unter den engsten Stakeholdern der Organisation gebildet (Suchman, 1995, S. 578–579). Suchman (1995, S. 578–579) unterteilt die *pragmatische Legitimität* in die drei Untergruppen *Einflusslegitimität*, *Austauschlegitimität* und *Verfügungslegitimität*. *Einflusslegitimität* bezieht sich auf den Grad des möglichen Einflusses einer Interessengruppe auf die Organisation. Nach der *Austauschlegitimität* unterstützen diese eine Organisation, da ihnen ihr Handeln hilft, eigene Ziele zu verfolgen. Dabei findet jedoch kein direkter Austausch statt. *Verfügungslegitimität* beschreibt den Zustand, dass eine Organisation als kompetenter Akteur wahrgenommen wird (Suchman, 1995, S. 578). Die *pragmatische Legitimität* steht in engem Zusammenhang mit dem Geschäftsmodell und Design einer Organisation, da diese auf Kundenschnittstellen beruht. Die Anpassung an Bedürfnisse bestehender und potenzieller neuer Interessengruppen steht dabei im Vordergrund (O'Dwyer, Owen & Unerman, 2011, S. 37).

Moralische Legitimität

Moralische Legitimität beschreibt die Rechtmäßigkeit des Handelns einer Organisation. Aus moralischer Sicht ist eine Organisation legitim, wenn sie gesellschaftlich als richtig definierte Aktivitäten durchführt, wie die Förderung des Allgemeinwohls. Die *moralische Legitimität* wird in vier Unterkategorien unterteilt: *Folgelegitimität*, *strukturelle Legitimität*, *Verfahrens-Legitimität* und *persönliche Legitimität*. Bei der *Folgelegitimität* geht es um die Gerechtigkeit einer Organisation im Hinblick auf ihre Leistung. Die *strukturelle Legitimität* beschreibt die allgemein akzeptierte Position einer Organisation in der Gesellschaft, um ihre Tätigkeiten auszuführen und zu existieren. *Verfahrens-Legitimität* hingegen konzentriert sich auf die Übernahme gesellschaftlich akzeptierter Bräuche und Handlungen. Ziel ist es, durch geeignete Verfahren und Arbeitsmethoden Legitimität zu erlangen. *Persönliche Legitimität* bezieht sich auf den Status und Ruf der Akteure innerhalb einer Organisation (Suchman, 1995, S. 579-581). Bei der Erfassung der *moralischen Legitimität* geht es um verschiedene konkurrierende Ansichten, da die Definition von moralischem Handeln komplex und abhängig

vom Umfeld der Akteure ist. Richards, Zellweger und Gond (2017) gehen von unterschiedlichen gesellschaftlichen Plattformen aus, über die Akteure versuchen, ihre eigene Legitimität aufzubauen. Plattformen können beispielsweise verschiedene Märkte und Unternehmen sowie Bürger- und Umweltbewegungen sein, die jeweils ihre eigene moralische Grundlage und Wertevorstellung vom jeweils richtigen moralischen Modell haben.

Kognitive Legitimität

Kognitive Legitimität beschreibt eine unbewusste Akzeptanz der Existenz und Notwendigkeit einer Organisation in ihrer Umwelt. Die *kognitive Legitimität* gilt im Vergleich zu anderen Legitimitätsformen als tiefer verwurzelt. Sie beruht auf Selbstverständlichkeiten und Annahmen, wie allgemein akzeptierte Praktiken und Grundprämissen und wird in zwei Untergruppen unterteilt. Einerseits die *Nachvollziehbarkeit* durch überzeugende Beschreibungen der Existenz einer Organisation, welche ebenfalls ihre Kultur definiert, sowie *Selbstverständlichkeit*, welche die stärkste Form der Legitimität darstellt, aber auch am schwierigsten zu erreichen ist (Suchman, 1995, S. 582). Der Aufbau *kognitiver Legitimität* ist der aufwändigste und langsamste Prozess, da die Organisation selbst ihre Erreichung nur schwer beeinflussen kann. Sie ist daher allerdings auch die beständigste der Legitimitätsformen (Kumar & Das, 2007, S. 1429).

In Realität existieren Formen der *pragmatischen*, *moralischen* und *kognitiven Legitimität* parallel und sind miteinander verflochten. Dabei verstärken sich *pragmatische*, *moralische* und *kognitive* Formen der Legitimität gegenseitig. Gleichzeitig können sich diese jedoch auch widersprechen, da die Wahrnehmung der Legitimität durch verschiedene Interessengruppen und die Erwartungen an ihre Entstehung nicht gleichzeitig auftreten. Eine Krise der *moralischen Legitimität* von Organisationen kann beispielsweise die *pragmatische Legitimität* von Organisationen untergraben (Kumar & Das, 2007, S. 1443).

2.1.2. Legitimierungsstrategien

Ein Großteil der Forschungsarbeiten über organisationale Legitimität lässt sich in die Kategorien der strategischen oder institutionellen Ansätze einteilen (vgl. z.B. Dutton & Dukerich, 1991). Der strategische Ansatz legt den Schwerpunkt auf die Art und Weise, wie Organisationen Symbole durch Kommunikationsverhalten strategisch manipulieren, um Legitimität zu erreichen (Massey, 2001, S. 155). Dowling und Pfeffer (1975, S. 120–122) argumentieren für den strategischen Ansatz, dass die Legitimierungsmaßnahmen für Organisationen von größter Bedeutung sind. Der institutionelle Ansatz hingegen richtet die Aufmerksamkeit auf das kulturelle Umfeld von Organisationen und auf den Druck, den dieses Umfeld auf Organisationen ausübt, damit sie sich in erwarteten, normativen Verhaltensweisen engagieren. Das Niveau der kulturellen Unterstützung für eine Organisation definiert demnach Legitimität. Kultur entspricht dabei dem gemeinsamen System von Überzeugungen, die von der Gesellschaft und den Interessengruppen der Organisation vertreten werden (Meyer, Scott, Rowan & Deal, 1983, S. 200–202). Der strategische Ansatz betrachtet Legitimität als beeinflussbares, der institutionelle Ansatz hingegen als übergeordnetes Konzept, dem sich eine Organisation unterordnen muss (Stelzer, 2008, S. 11). Suchman (1995, S. 572) knüpft hier an und beschreibt die Sinnhaftigkeit einer Kombination beider Ansätze. Auch Legitimierungstheorien lassen sich daher in strategische und institutionelle Ansätze einteilen. Dazu kann die Art und Weise untersucht werden wie Organisationen strategisch versuchen, Legitimität zu kontrollieren und wie kulturelle Erwartungen institutionalisierte Beschränkungen für das Organisationsverhalten darstellen. Nach Suchman (1995, S. 587) können diese Strategien in folgende Ansätze unterteilt werden:

- *Kreation* beschreibt die Erschaffung und Verteilung von Informationen über z.B. Produkte, Prozesse und die Unterstützung gesellschaftlicher oder gesetzlicher Normen und Regeln.
- *Selektion* beschreibt die Auswahl von z.B. Produktstandards, Zielgruppen oder Märkten.
- *Manipulation* beschreibt ein Verändern der Umwelt durch das Erschaffen von Institutionen.
- *Konformität* beschreibt die Anpassung an bestehende Prozesse und Strukturen oder an gesetzliche und gesellschaftliche Anforderungen und Wertvorstellungen (Stelzer, 2008, S. 12).

2.1.3. Transparenz

Transparenz ist ein multidisziplinäres Thema, welches unterschiedlichste, teilweise sehr vage und ungenaue Interpretationen bietet und dadurch die Untersuchung der Thematik erschwert (Albu & Flyverbom, 2019, S. 270). Im semantischen Sinn bedeutet sie *Durchsichtigkeit* (Duden, 2022). Im sozialwissenschaftlichen Kontext werden mit Transparenz oft der Zugang und die Kommunikation zu internen Informationen einer Person oder Organisation benannt. Für Organisationen stellt diese also die Offenheit diverser Faktoren, wie beispielsweise ihrer Ressourcen, Prozesse, Outputs oder Resultate dar (Grimmelikhuijsen, 2012, S. 78; Hood & Heald, 2006). Transparenz ist die Grundlage für ein besseres Verständnis von Entscheidungen und trägt damit zu einer Komplexitätsreduktion bei (Jansen, 2010, S. 27). Es scheint nicht überraschend, dass in öffentlichen Diskussionen zur Transparenz oft von der Maxime *„je mehr, desto besser“* ausgegangen wird. Dies birgt jedoch das Risiko, Schattenseiten, wie die Substitution von Vertrauen, erhöhte Kosten oder gar Einschränkungen von Persönlichkeitsrechten und autokratische Überwachungsstrukturen zu vernachlässigen (De Fine Licht & Naurin, 2022, S. 217; Mayrhofer & Meyer, 2020, S. 152; Pasquier & Villeneuve, 2007, S. 157–159). Die Grenzen von Transparenz und Intransparenz werden durch soziale Ausverhandlungsprozesse produziert, die im Kern die Ambivalenz des Transparenzbegriffs darstellen (Stehr & Wallner, 2010, S. 11). Nach Stehr und Wallner (2010, S. 17) steht fest: *„Transparenz an sich ist weder immer*

vorteilhaft noch ausschließlich mit Nachteilen behaftet. Worauf es ankommt, ist, die Ergebnisse der Transparenz durchsichtig zu machen.“ Damit wird vor allem die Zweckmäßigkeit von Transparenzinitiativen in den Vordergrund gestellt. Die Effektivität von Transparenzbemühungen hängt dabei stark von den jeweiligen Adressaten ab, so sind Produktinformationen beispielsweise relevanter für Kunden als für Arbeitnehmer (Willems, 2021, S. 48). Transparenz wird also in der Wissenschaft als zweischneidiges Schwert definiert, was eine allgemeingültige Aussage über ihr sinnvolles Ausmaß erschwert. Diese Überlegung legt jedoch ebenfalls nahe, dass es ein optimales Niveau an Transparenz im Hinblick auf ein Kosten-Nutzen Verhältnis gibt (Hermalin, 2014, S. 342–348). Organisationen haben allerdings Schwierigkeiten, das richtige Level an Transparenz zu finden und die positiven Effekte, wie erhöhtes Vertrauen bei zentralen Stakeholdern sowie die negativen Effekte, wie steigende Kosten, richtig einzuschätzen (Jansen, Schröter, Stehr & Wallner, 2010; Mayrhofer & Meyer, 2020, S. 152; Willems, 2021, S. 46–48).

Um das theoretische Konstrukt der Transparenz in greifbare Elemente zu strukturieren, ist eine Einteilung in konkrete transparenzschaffende Maßnahmen im organisationalen Kontext sinnvoll. Ein zentrales Unterscheidungskriterium ist die Kommunikationsquelle, dabei sind interne und für eine Organisation beeinflussbare sowie externe und damit weniger oder nicht beeinflussbare Formen der Transparenz gemeint (Theuvsen, 2012, S. 7). Zu ersteren zählen in vielen europäischen Ländern beispielsweise Jahresabschlüsse ab einer bestimmten Organisationsform und -größe, zu letzteren zählen nicht verpflichtende Berichterstattungen, wie teilweise Umweltberichte oder Pressemitteilungen. Eine weitere Differenzierung der internen Informationen bietet die *Corporate Governance-Literatur*, in welcher Transparenz als Ziel und Maßnahme fest verankert ist (vgl. z.B. Ansell & Torfing, 2022; Wright, Siegel, Keasey & Filatotchev, 2013). Dabei geht es vor allem um obligatorische Kommunikations- und Rechenschaftsablegungs-Instrumente, welche extern von Gesetzgebern festgelegt werden sowie um freiwillige Berichterstattungsformen einer Organisation (Fox, 2007, S. 666). Hofstede (2003, S. 17) unterscheidet außerdem hinsichtlich des zeitlichen Kontexts zwischen historischer, operativer und strategischer Transparenz. Erstere ermöglicht dabei, Geschehnisse retrograd nachzuvollziehen, operative Transparenz beschreibt die verfügbaren Informationen über aktuelle Sachverhalte und strategische Transparenz den zukunftsgerichteten Blickwinkel. Fox (2007, S. 667–668) wiederum befasst sich mit dem Informationssignal als solchem und beschreibt Transparenz als undurchsichtig oder klar. Verbreitung von Informationen, aus denen nicht hervorgeht, wie sich die Organisationen in der Praxis in Bezug auf Entscheidungsprozesse oder die Ergebnisse ihres Handelns tatsächlich verhalten, sind zwar transparent, jedoch undurchsichtig. Klare Transparenz hingehen löst diese Felder demnach auf und verringert durch echte Rechenschaftsablegung das wahrgenommene Risiko der Ungewissheit.

Eine weitere Klassifizierung, welche Transparenz als strategisches Werkzeug untersucht, unterscheidet diese nach ihrer Kommunikationsrichtung: Transparenz nach oben, nach unten, nach innen und nach außen. Demnach kann ein Zustand der Transparenz-Symmetrie eintreten, wenn aus allen vier Richtungen gleichzeitig die gleiche Menge an Informationen preisgegeben wird (Heald, 2006, S. 27–29). Die Unterscheidung selbst setzt allerdings voraus, dass Transparenz Machtverhältnisse impliziert (Flyverbom, 2015, S. 173). Transparenz nach oben findet statt, wenn ein vorgesetzter Akteur das Verhalten und die Ergebnisse seiner Untergebenen beobachtet. Diese Art von Transparenz hat den Charakter einer *Prinzipal-Agent-Beziehung* (siehe *Kapitel 2.2.1*). Im Gegensatz dazu impliziert Transparenz nach unten die Beobachtung der übergeordneten Akteure durch ihre Untergebenen. Dieser Richtung der Transparenz liegt eine Logik des demokratischen Denkens und der Rechenschaftspflicht zugrunde. Transparenz nach innen bedeutet, dass Außenstehende einer Organisation beobachten können, was innerhalb der Organisation vor sich geht. Diese Richtung basiert auf einer Überwachungslogik und funktioniert als eine Form der sozialen Kontrolle, die sozial erwünschte Verhaltensweisen verstärkt. Die bestehende Debatte über Privatsphäre und Persönlichkeitsrechte versucht, Transparenz nach innen zu begrenzen. Transparenz nach außen bedeutet, dass *Insider* einer Organisation das Geschehen außerhalb der Organisation beobachten. Diese Art von Transparenz ist für eine Organisation von hoher Relevanz, um ihre Umwelt und damit auch das Verhalten ihrer Mitarbeiter und Konkurrenten zu analysieren (Flyverbom, 2015, S. 176).

Weitere Charakteristika der Transparenz sind Zeitpunkt, Menge oder Art bzw. das Medium der Informationen und vervollständigen damit das Bild (Albu & Flyverbom, 2019, S. 272–280; Henriques, 2013, S. 17–32). *Abbildung 1* fasst die beschriebenen Unterscheidungskriterien zusammen.

2.2. Theorien und Modelle

In der Literatur existieren unterschiedlichste Modelle zur Erklärung der Wirkweise von Transparenz und möglicher Anknüpfungspunkte zu Legitimitätstheorien. Im Folgenden liegt der Fokus auf Modellen, welche bereits den Zusammenhang zwischen Transparenz und Legitimität im organisationalen Kontext aufgreifen und daher für diese Arbeit relevant sind.

2.2.1. Prinzipal-Agent-Theorie

Die *Prinzipal-Agent-Theorie* (auch *Agency-Theorie*) beschreibt den Zustand eines Auftraggebers oder einer Auftraggeberin (der/die *Prinzipal:in*), einen Auftragnehmer oder eine Auftragnehmerin (der/die *Agent:in*) in seinem oder ihrem Namen handeln zu lassen. Voraussetzung ist ein Rahmen der rationalen Entscheidung. Durch unterschiedliche persönliche Ziele des Agenten oder der Agentin, kann er oder sie bei seinen Handlungen in Konflikt mit den Interessen des Prinzipals oder der Prinzipalin geraten (Eisenhardt, 1989). Die Theorie findet in den Sozialwissenschaften breite Anwendung und sollte nach Jensen und Meckling (1976, S. 309) grundsätzlich ein zentraler Bestandteil bei der Betrachtung von Problemen in den Organisationswissenschaften sein.

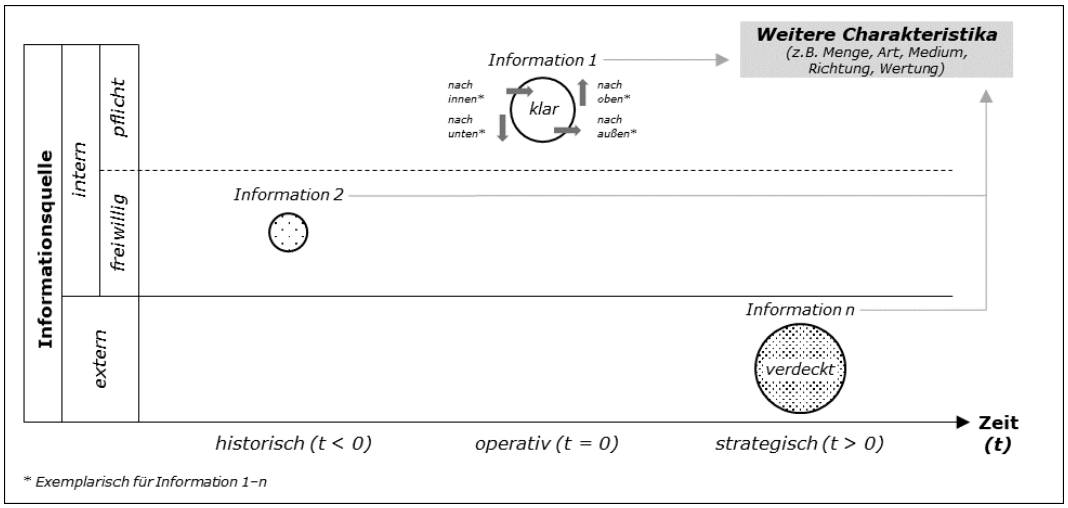

Abbildung 1: Unterscheidungskriterien organisationaler Transparenz (Quelle: Eigene Darstellung)

Eine *Prinzipal-Agent-Beziehung* geht von einer Informationsasymmetrie zum Vorteil des Agenten oder der Agentin aus, sowohl über den Zustand der Umwelt als auch über die eigenen Präferenzen, Kompetenzen und Handlungen. Lässt man den Prinzipal oder die Prinzipalin die Perspektive des Agenten oder der Agentin einnehmen, kann das Misstrauen verringert und somit die Legitimität des Auftragnehmers oder der Auftragnehmerin erhöht werden. Agent:innen, die diesen Effekt berücksichtigen, bieten ihrem Auftraggeber oder ihrer Auftraggeberin im Gegenzug für weitere Investitionen in die eigenen Befugnisse wahrscheinlich eine größere Offenheit ihrer Handlungen an (Ferejohn, 1999, S. 141). Weiter legt die Theorie nahe, dass Transparenz die Unsicherheit über das Verhalten des Agenten oder der Agentin in Situationen, die durch moralisches Risiko gekennzeichnet sind, verringern kann. Durch eine steigende Transparenz erlangt der Prinzipal oder die Prinzipalin mehr Vertrauen in die Übertragung von Befugnissen an den Agenten oder die Agentin (Holmström, 1979, S. 75). Dieser *Rational-Choice-Mechanismus* gilt in erster Linie für die Prozesstransparenz und weniger für die Transparenz der dahinterliegenden Beweggründe. Letztere bezieht sich auf das Bemühen des Agenten oder der Agentin, seine oder ihre Entscheidungen gegenüber dem Auftraggeber oder der Auftraggeberin im Nachhinein durch die Angabe überzeugender Gründe zu rechtfertigen. Ein solches Verhalten kann jedoch als manipulativ abgetan werden und damit die Glaubwürdigkeit senken (De Fine Licht, Naurin, Esaiasson & Gilljam, 2014, S. 114). Dies stellt damit ein weiteres Beispiel der negativen Auswirkung von steigender Transparenz dar. Grundsätzlich lässt sich jedoch zusammenzufassen, dass Transparenz nach der *Prinzipal-Agent-Theorie* einen vertrauensfördernden Effekt haben kann und sich damit ebenfalls positiv auf die wahrgenommene Legitimität von Organisationen auswirkt (Woodward, Edwards & Birkin, 1996, S. 337–339).

2.2.2. Verfahrensgerechtigkeitstheorie

Nach der Theorie der Verfahrensgerechtigkeit kann das Verfahren, mit dem eine Entscheidung zustande kommt, zu ihrer Legitimität beitragen. Dem Verfahren wird ein Wert zugewiesen, der sich auf die Bewertung der Entscheidung, der Entscheidungsträger und der Entscheidungs-Institutionen auswirkt. Die sozialpsychologische Forschung hat gezeigt, dass Menschen Entscheidungen, die aus als gerecht eingestuften Verfahren resultieren, eher hinnehmen (Fischer, 2019, S. 139). Ebenfalls sind sie zufriedener mit Organisationen, wenn diese als gerecht eingestuft werden (Napier & Tyler, 2008, S. 509; Thibaut & Walker, 1975).

Zu den Aspekten des Verfahrens, die in der Literatur als relevant eingestuft wurden, gehören Mitsprachemöglichkeiten, Unparteilichkeit und respektvolle Behandlung. Die Transparenz des Verfahrens ist eine Voraussetzung für den Effekt der Verfahrensfairness, da nur so Verfahren und damit dessen Fairness beurteilt werden können. Die Erklärung der Prozesse durch mehr Transparenz trägt daher zur Legitimität bei, falls diese auch als gerecht eingestuft werden. Transparenz wird dabei auch allgemein als vertrauensstiftend beschrieben. Daher könnte ein transparentes Verfahren intuitiv als gerechter und damit legitimer angesehen werden (De Fine Licht et al., 2014, S. 115). Weiter sind Personen, die ein Mitspracherecht in Bezug auf die Entscheidung haben, auch wenn dies erst im Nachhinein geschieht, eher geneigt, diese Entscheidungen zu akzeptieren. Der negative sogenannte *No-Voice-Effekt* ist jedoch stärker, wenn die Menschen ausdrücklich daran erinnert werden, dass sie kein Mitspracherecht haben (Van den Bos, Bruins, Wilke & Dronkert, 1999, S. 332–334). Darüber hinaus gibt es auch Hinweise aus der experimentellen Forschung, dass ein Mitspracherecht mit wenig Einfluss mehr negative Reaktionen hervorruft als überhaupt kein Mitspracherecht (Ulbig, 2008, S. 525). Dieser Mechanismus dürfte vor allem für die Transparenz von Prozessen gelten, die es einer Anspruchsgruppe ermöglicht, das Geschehen zu beobachten, ohne die Möglichkeit zu ha-

ben, einen Einfluss auszuüben (De Fine Licht et al., 2014, S. 116).

2.2.3. Signaltheorie

Die Signaltheorie baut auf der Grundlage auf, dass ein Signalempfänger auf beobachtbare Informationen eines Signalsenders angewiesen ist, um die Unsicherheit über nicht beobachtbare Eigenschaften zu verringern (Spence, 1973). Der Empfänger interpretiert ein Signal und verwendet es, je nach wahrgenommener Validität als Ersatz für verdeckte Informationen. Wichtig nach Connelly, Certo, Ireland und Reutzel (2011, S. 56–62) ist, dass die formellen und informellen Institutionen des Signalisierungsumfelds den gesamten Signalisierungsprozess beeinflussen. Dabei eingeschlossen ist der Signalgeber, das Signal selbst und die Interpretation des Signals durch den Empfänger. Darüber hinaus variiert die Wirksamkeit von Signalen in Abhängigkeit von verschiedenen Bedingungen. So kann eine Organisation beispielsweise mehrere Signale gleichzeitig aussenden, die sich gegenseitig beeinflussen (Steigenberger & Wilhelm, 2018, S. 529). Bei zwei inkonsistenten Signalen kann der Empfänger verwirrt sein oder an der Echtheit des Signals zweifeln, was zu einer weniger effektiven Übertragung des Signals führt (Connelly et al., 2011, S. 54). Ferner neigt der Empfänger dazu, sich kognitiv stärker auf das negative Signal zu konzentrieren, wodurch die ursprüngliche Absicht der Signalgeber weiter verzerrt und die Wirksamkeit des Signals geschwächt werden (Miyazaki, Grewal & Goodstein, 2005, S. 146). Diese Logik lässt sich auch auf die Veränderung der wahrgenommenen Legitimität übertragen, wonach konsistente Informationsangebote zu steigender Glaubwürdigkeit führen.

Heinberg, Liu, Huang und Eisingerich (2021, S. 47–48) analysieren im Kontext der Beziehungen zwischen Verbrauchern und Marken den Zusammenhang des Informationsflusses von Unternehmen zu externen Interessengruppen. Unternehmenstransparenz ist dabei eine Eigenschaft, die bestimmt, ob Informationen objektiv und für die Interessengruppen zugänglich sind (vgl. auch Liu, Eisingerich, Auh, Merlo & Chun, 2015). Verbraucher können Informationsasymmetrien in Bezug auf den moralischen Charakter oder das Wohlwollen der Organisation abbauen, indem sie sich auf die Transparenzbemühungen der Organisation als Hinweis verlassen. Wenn eine Organisation in einem bestimmten Bereich weniger offen ist, hat sie möglicherweise einen triftigen Grund, diese Informationen zu verbergen, was zu Zweifeln am moralischen Charakter der Organisation auf einer allgemeineren Ebene führen könnte. Umgekehrt ermöglicht eine hohe organisationale Transparenz, den Verbrauchern klare und wertvolle Informationen zu erhalten, was ihre wahrgenommene Unsicherheit in einem Austausch verringern und ihr allgemeines Vertrauen erhöhen kann. Die Qualität der Beziehung zwischen Verbraucher und Marke würde dadurch verbessert (Lin, 2007, S. 421–423). Insbesondere sollten Organisationen demnach Informationen weitergeben, die klar und leicht verständlich sind, und den Zugang zu Informationen Dritter erleichtern. Organisationen sollten relevante und gültige Informationen verbreiten, die Wahrheit, Ehrlichkeit, Offenheit und Aufrichtigkeit verkörpern und möglichst frei von Täuschung oder Verschleierung sind (Bell, Auh & Eisingerich, 2017, S. 318).

2.3. Kritische Würdigung der Literatur zu Transparenz und Legitimität

Die verschiedenen Sichtweisen zum postulierten verstärkenden Zusammenhang von Transparenz auf Legitimität im organisationalen Kontext besitzen oft einen intuitiven Charakter. Es existieren allerdings auch empirische Befunde, welche im Folgenden zusammengefasst werden.

Transparenz wird in der *Governance-Literatur* als zentraler Bestandteil der Vertrauensbildung von Organisationen beschrieben (vgl. z.B. Willems, 2021, S. 48). Vertrauen beschreibt die allgemeine Erwartung des Handelns im Sinne eines Persönlichkeitsausdrucks sowie den geplanten Verzicht auf mögliche weitere Informationen und stellt damit eine persönliche Vorleistung dar, mit dem Ziel, soziale Komplexität zu reduzieren (Jansen, 2010, S. 29). Vertrauen beeinflusst Legitimität positiv und ist wichtiger Bestandteil in ihrem langfristigen Fortbestand. Beide Konzepte verstärken sich dabei gegenseitig und erzeugen positive Wechselwirkungen (Moreno-Luzon, Chams-Anturi & Escorcia-Caballero, 2018, S. 283). Dabei liegen allerdings auch Einschränkungen vor. So bestimmt die Glaubwürdigkeit von Unternehmen ihre wahrgenommene Legitimität maßgeblich und muss daher als Grundvoraussetzung gesehen werden (Bachmann & Ingenhoff, 2017, S. 79). Dieser Sachverhalt wird auch von Massey (2001, S. 168) herausgestellt, indem er aufdeckt, dass sich konsistente Signale positiver auf die organisationale Legitimität als inkonsistente Signale auswirken. Generalistische Organisationen werden in diesem Zusammenhang, im Vergleich zu Nischen-Organisationen, als legitimer wahrgenommen. Ein weiteres Kriterium der Legitimitätsbildung ist der Reifegrad einer Organisation, demnach werden etablierte Organisationen grundsätzlich legitimer wahrgenommen als Organisationen, welche diesen Status erst erlangen müssen (DiMaggio & Powell, 1983, S. 155).

Organisationen können außerdem nur überleben, wenn sie eine Koalition von unterstützenden Interessenvertretern aufrechterhalten, die für ihr Funktionieren notwendig ist. Das bedeutet, dass die Mitglieder dieser Koalition eine legitimitätsbestimmende Macht haben. Durch die Offenlegung von Informationen wird ersichtlich, wie eine Organisation wirklich ist. Die Informationsempfänger sind anschließend in der Lage, die Legitimität zu beurteilen und entsprechend zu handeln (Albu & Flyverbom, 2019, S. 283). Um den Effekt von Transparenz auf organisationale Legitimität erfassen zu können, ist daher eine Einteilung der Legitimitäts-Quellen in Bezug auf Transparenzangebote sinnvoll.

Etter, Colleoni, Illia, Meggiorin und D'Eugenio (2018, S. 61) argumentieren, dass organisationale Legitimität vor allem über die drei Kanäle *Ratings*, *Umfragewerte* und *Nachrichtenmedien* quantitativ erfasst werden kann, welche nachfolgend näher vorgestellt werden. Nach Boyd (2000, S. 345) kann Legitimität außerdem nicht isoliert entstehen. Die Bemühungen einer Organisation müssen an die Belange ihrer

Anspruchsgruppen angepasst werden. Er schlägt vor, dass Entscheidungen über die Legitimität auf den Botschaften an die Öffentlichkeit beruhen. Daher soll als weitere Legitimitätsquelle ebenfalls die *Rechenschaftsablegung* von Unternehmen beschrieben werden.

Ratings

Akkreditierungen werden nach Baum und Oliver (1991, S. 197) als ausgewogene Expertenbewertungen mit hohem Einfluss auf die wahrgenommene Legitimität von Organisationen beschrieben. Gauthier und Wooldridge (2018, S. 148) fassen zusammen, dass *Rating-Agenturen* eine der Hauptquellen der wahrgenommenen Legitimität von Organisationen sind. *Ratings* auf Unternehmensebene bieten vereinfachende Heuristiken für die Interessengruppen einer Organisation, um ihre Legitimität bewerten zu können. Ein ausreichend hohes *Rating* signalisiert diese Legitimität. Dabei ist es zentral, dass die Ratings als unabhängige Drittpartei vom jeweiligen *Rating-Objekt* empfunden werden. Ein niedriges *Rating* wiederum stellt eine Bedrohung für die Legitimität des Unternehmens dar, was wiederum negative Folgen in Form von beispielsweise sinkenden Aktienkursen oder fehlendem Kapitalzugang haben kann. Angesichts dieser Situation wird eine Organisation mit niedrigem *Rating* versuchen, ihre allgemeine Wahrnehmung auf möglichst ökonomische und unauffällige Weise zu schützen (Chatterji & Toffel, 2010, S. 932–933).

Während Akkreditierungsgesellschaften im wirtschaftswissenschaftlichen Kontext oft als Finanz- bzw. Risikobewertungsagenturen bekannt sind, kann Legitimität auch durch Akkreditierungsgesellschaften in unterschiedlichster Form stattfinden, solange das Akkreditierungssystem von den jeweiligen relevanten Interessengruppen anerkannt wird. Power (1997, S. 304) analysiert Wirtschaftsprüfungen als eine Spezialform der *Rating-Agenturen* und fasst als eine der wichtigsten Stärken der Rechnungsprüfung zusammen, dass diese Legitimität schafft. Jakob (2021, S. 58–59) beispielsweise benennt Transparenz als eine der Grundannahmen zur Legitimationsschaffung, welche sich u.a. durch *Peer-Review* Verfahren im akademischen Kontext äußert.

Umfragewerte

Umfragewerte ermöglichen den Zugang zur Bewertung von Organisationen durch die allgemeine Öffentlichkeit oder bestimmter Interessengruppen, deren Urteile anschließend durch verdichtete Ergebnisdarstellungen, wie *Rankings* und Indizes in die Öffentlichkeit gelangen (Fombrun, 2007, S. 144). Insgesamt werden hier jedoch wie bei Akkreditierungen nur teilweise die Vielfalt der Normen, Werte, Erwartungen und Bedenken der normalen Bürger, die aus einer normativen Perspektive eine strengere Rechenschaftspflicht für das Verhalten von Unternehmen fordern, berücksichtigt (Matten & Crane, 2005, S. 175–176). Eine Studie von Kanning und Claus (2021, S. 46) zeigt, dass negative Bewertungen auf Arbeitgeberportalen sich ebenfalls auf die organisationale Legitimität übertragen, indem Ruf, Anerkennung und die generelle Attraktivität des Unternehmens beeinträchtigt werden (vgl. auch Gruber, 2021). Diese Logik deckt sich auch mit den zuvor dargestellten Erkenntnissen aus der Signaltheorie und schreibt seriösen *Umfragewerten* einen legitimitätsbeeinflussenden Effekt zu.

Nachrichtenmedien

Nachrichtenmedien sind zentraler Bestandteil in der Distribution von Informationen für die Allgemeinheit und haben daher großes Potential, die öffentliche Meinung durch ihren direkten und selektiven Zugang zu individuellen Urteilen zu beeinflussen (Etter et al., 2018, S. 65–66). Sie sind die am umfassendsten untersuchten Quellen für organisationale Legitimität (Bansal & Clelland, 2004, S. 97). *Nachrichtenmedien* legitimieren Organisationen, indem sie organisationale Aktivitäten sichtbar machen und bewerten (Suchman, 1995, S. 598). Folglich beziehen sich Legitimitätsmessungen, die auf dem Inhalt von *Nachrichtenmedien* basieren, auf die Darstellungs- und Berichtsweise von Organisationen. Da *Nachrichtenmedien* einen großen Einfluss auf die öffentliche Meinung über Organisationen haben, wird argumentiert, dass die Analyse der *Nachrichtenmedien* auch eine gültige Methode zur Bewertung der Legitimität von Organisationen ist (Carroll & McCombs, 2003, S. 36). Darüber hinaus zeigen Studien, dass *Nachrichtenmedien* den Diskurs über Organisationen in sozialen Medien beeinflussen, indem sie beispielsweise den Rahmen während einer Krise vorgeben und somit indirekt auch die Stimmen der Allgemeinheit erfassen (Van der Meer & Verhoeven, 2013, S. 231).

Rechenschaftsablegung (unternehmensintern)

Studien, die Transparenz nach quantitativen Maßstäben, wie nach der Anzahl der freigegebenen Dokumente beurteilen, kommen zu dem Ergebnis, dass Organisationen beim Publizieren interner Informationen häufig externen Anforderungen nachgeben, um ihre Legitimität aufrechtzuerhalten (Heimstädt, 2017, S. 78). Auch hier kann also die wechselseitige Wirkung von Transparenz auf Legitimität festgehalten werden. Veröffentlichen Unternehmen Informationen bezüglich ihrer sozial-ökologischen Bemühungen, so hat dies einen positiven Effekt auf die wahrgenommene *moralische Legitimität* von Unternehmen (Milne & Patten, 2002, S. 63). Elsbach (1994, S. 80) stellt in ihrer Studie über die wahrgenommene Legitimität der Kalifornischen Fleischverarbeitungsindustrie fest, dass Presseberichte unabhängig ihres Inhalts die wahrgenommene organisationale Legitimität erhöhen. Berichte zu kontroversen Themen, die anerkennende und symbolische Inhalte verwenden, erhöhen Legitimität dabei am stärksten. Dieser Zusammenhang ist außerdem abhängig von der Zielgruppe. Dies schließt an das Argument des grundsätzlich positiven Effekts von unternehmensinterner Transparenz an, welcher durch die *Corporate-Governance-Literatur* nahegelegt wird. Stelzer (2008, S. 25) baut auf Elsbach (1994) Studie auf und stellt in einem ähnlichen Forschungsmodell fest, dass Presseberichte von jungen Unternehmen, welche

auf Konformität abzielen, sich nur auf die *kognitive Legitimität* auswirken.

2.4. Modell- und Hypothesenentwicklung

Es lässt sich zusammenfassen, dass Transparenz eine positive Signalwirkung für unterschiedlichste kognitive Wahrnehmungen – zu welcher auch Legitimität gehört – zugeschrieben wird. Dabei muss jedoch erfüllt werden, dass das Transparenzangebot neutral bis positiv, widerspruchsfrei und relevant für die entsprechende zentrale Anspruchsgruppe ist (Deephouse & Suchman, 2008, S. 342; Massey, 2001, S. 168). Einzelne Informationsbereiche, wie sozial-ökologische Informationen im Bereich der *moralischen Legitimität* oder Finanz-Informationen im Bereich der *pragmatischen Legitimität* können sich dabei stärker auf die jeweiligen Sub-Kategorien der Legitimität auswirken (Bachmann & Ingenhoff, 2017, S. 79; Milne & Patten, 2002, S. 63). Außerdem wirken Legitimationsbestrebungen generell stärker im Fall von etablierten Unternehmen (DiMaggio & Powell, 1983, S. 155).

Verschiedene Ergebnisse aus Theorie und Empirie weisen darauf hin, dass eine steigendes Transparenzangebot einen positiven Effekt auf die organisationale Legitimität von Unternehmen hat (Moreno-Luzon et al., 2018, S. 283). Daraus ergibt sich die Annahme, dass ein höheres Transparenzangebot einen stärken legitimitätsbildenden Effekt im Vergleich zu einem niedrigeren Transparenzangebot haben müsste. Folgende Hypothesen eins bis vier (*H1* bis *H4*) lassen sich daher ableiten:

> **H1:** *Ein niedriges Angebot an relevanten, konsistenten und leicht positiv wahrgenommenen Informationen wirkt sich positiv auf die wahrgenommene organisationale Legitimität eines etablierten Unternehmens aus.*
>
> **H2:** *Ein hohes Angebot an relevanten, konsistenten und leicht positiv wahrgenommenen Informationen wirkt sich positiv auf die wahrgenommene organisationale Legitimität eines etablierten Unternehmens aus.*
>
> **H3:** *Ein hohes Angebot an relevanten, konsistenten und leicht positiv wahrgenommenen Informationen verändert die wahrgenommene organisationale Legitimität eines etablierten Unternehmens positiver als ein niedriges Angebot an relevanten Informationen.*

Die wahrgenommene organisationale Legitimität beruht außerdem auf der individuellen Einstellung eines Menschen und damit auf den dahinterliegenden psychologischen Prozessen. Gerade bei kognitiven Lernprozessen ist die Verarbeitungszeit ein zentraler Einflussfaktor für ihren Erfolg (Gigerenzer, 1991, S. 254). Es kann daher angenommen werden, dass die Verarbeitungszeit der Transparenzinformationen einen erklärenden Einfluss auf die Legitimitätswahrnehmung der Öffentlichkeit ausübt. Positive Informationen sollten, basierend auf den entwickelten Hypothesen, zu mehr Legitimität führen. Demnach wäre nicht das reine Vorhandensein der Informationen ausschlaggebend, sondern die kognitive Auseinandersetzung und Durchdringung einer Thematik. Damit wird der in *Kapitel 2.2.3* vorgestellte Effekt der Signaltheorie differenzierter dargestellt und nicht nur das Signal als solches, sondern ebenfalls der Umgang mit diesem überprüft. Hieraus ergibt sich die vierte Hypothese.

> **H4:** *Die durchschnittliche Verarbeitungszeit von relevanten und leicht positiv wahrgenommenen Informationen hat einen positiven Einfluss auf die Veränderung der organisationalen Legitimität von Unternehmen.*

In allen Hypothesen kann organisationale Legitimität in aggregierter Form sowie als entsprechende Sub-Kategorie für die *pragmatische, moralische* und *kognitive Legitimität* definiert werden. Hieraus ergeben sich jeweils drei weitere Sub-Hypothesen, wie beispielsweise: *„H1a: Ein niedriges Angebot an relevanten, konsistenten und leicht positiv wahrgenommenen Informationen wirkt sich positiv auf die wahrgenommene pragmatische Legitimität eines etablierten Unternehmens aus.“* (*H1b*: *moralische Legitimität*, *H1c*: *kognitive Legitimität*, usw.).

3. Methodik

Im dritten Kapitel dieser Arbeit wird die Operationalisierung des zuvor theoretisch hergeleiteten Untersuchungsmodells dargestellt. Hier steht vor allem die Herleitung und Darstellung des experimentellen Forschungsdesigns im Vordergrund.

3.1. Ausgangssituation und Rahmenbedingungen

Organisationale Transparenz und vor allem Legitimität stellen abstrakte Konstrukte dar, die nicht eindeutig beobachtet werden können, sondern auf theoretisch entwickelten Konzepten beruhen. Speziell organisationale Legitimität gilt aufgrund ihrer hohen Komplexität als schwer zu operationalisierendes Konstrukt (Zimmerman & Zeitz, 2002, S. 418). Nach Suchman (1995, S. 574) sind Urteile über die Legitimität Wahrnehmungen, welche einen Anteil an Wissen und einen weiteren Anteil an Gefühlen beinhalten. Wissensbasierte Urteile lassen sich schwieriger manipulieren und sind damit robuster gegenüber auf Gefühlen basierenden Urteilen (Bitektine & Haack, 2015, S. 55). Demgegenüber argumentiert Hardin (2002, S. 214), dass zur Beantwortung der Frage nach komplexen Konstrukten, wie Vertrauen oder Legitimität vor allem eine auf den sogenannten Durchschnittsbürger zugeschnittene Erkenntnistheorie nötig sei. Diese richtet ihren Blick auf Inhalte, welche beim Durchschnittsbürger als Wissen gewertet werden, nicht auf jene, die in Wahrheitsbehauptungen resultieren (Stehr & Wallner, 2010, S. 15). Es ergibt sich die Anforderung, dass die in der Empirie verwendeten Inhalte einerseits wissensbasierte Urteile zulassen, jedoch ebenfalls leicht verständlich sind.

Ein experimentelles Design bietet ausreichend Spielraum, um eine Untersuchungsumgebung zu schaffen, die eine Messung von wahrgenommener organisationaler Legitimität und letztlich kausale Rückschlüsse zulässt (Stelzer, 2008, S. 16). Es ermöglicht die Erschaffung eines kontrollierten Szenarios, welches Urteile basierend auf Wissen und Gefühlen auf verständliche Art und Weise zulässt. Weiter kann eine Ausgangssituation kreiert werden, die sicherstellt, dass der Ablauf des Experiments durch die Teilnehmer:innen verstanden und zielgerichtet ausgeführt wird. Teil eines Experiments ist neben der Vorstellung des Kontextes auch die Datenerhebung, welche quantitativ oder qualitativ durchgeführt werden kann (Campbell & Stanley, 2015, S. 34).

3.2. Untersuchungsgegenstand

Der Untersuchungsgegenstand des postulierten Zusammenhangs zwischen Transparenz und wahrgenommener organisationaler Legitimität soll anhand eines beispielhaften Unternehmens und einer möglichen Anspruchsgruppe, wie potenziellen Kunden, Mitarbeitern oder Eigentümern dargestellt werden.

Um das beschriebene theoretische Konstrukt empirisch testen zu können, eignen sich Fluggesellschaften. Aufgrund der zunehmenden Kritik an ihrem emissionstreibenden Geschäftsmodell auf politischer sowie medialer Ebene, kann davon ausgegangen werden, dass ein ausreichendes Niveau an Kontroversität für die Wirksamkeit von Transparenz als Legitimitätsstrategie vorliegt. Wie Seeger (1986, S. 148) feststellt, ist es wahrscheinlich, dass Institutionen Legitimierungsstrategien in den Vordergrund stellen, falls diese in hohem Maße von günstigen Umweltbeziehungen abhängig sind. Transparenzinitiativen können dabei als besonders relevante legitimitätserhaltende oder -schaffende Maßnahme verstanden werden (Massey, 2001, S. 162).

Ebenfalls kann angenommen werden, dass Fluggesellschaften als etablierte Branche von der Allgemeinheit akzeptiert werden und damit einen festen Platz in der Gesellschaft innehaben. Laut DiMaggio und Powell (1983, S. 155) existiert Legitimität in diesem Fall bereits und muss nicht erst grundsätzlich entstehen, was sich wiederum in einer Vielzahl von Faktoren erklären könnte.

Durch die Strukturrelevanz der Branche ergibt sich die Öffentlichkeit als generelle Anspruchsgruppe. Fast zwei Drittel der Österreicher:innen fliegen mindestens einmal pro Jahr (VCÖ, 2020), was zur Annahme führt, dass ein Großteil der Österreicher:innen mit Luftverkehrsdienstleistungen vertraut ist und über persönliche Erfahrung mit Fluglinien verfügt. Durch die allgemeine Bekanntheit der Prozesse und Kommunikationen bestehender Fluggesellschaften mit ihren Interessengruppen bietet sich damit ein passender Rahmen für die Überprüfung von Transparenzinitiativen hinsichtlich ihres Effekts auf die individuell wahrgenommene organisationale Legitimität.

3.3. Forschungsdesign und Forschungsprozess

Für die Untersuchung lässt sich die wahrgenommene *organisationale Legitimität* als abhängige Variable (a.V.) identifizieren, die über Likert-basierte Fragenkonstrukte indirekt erfasst wurde. Die unabhängige Variable (u.V.) bildet das *Transparenzangebot*, welches den Stimulus (auch *Treatment*) im Experiment darstellte. Die *Verarbeitungszeit des Transparenzangebots* konnte als weitere u.V. bestimmt werden.

Den empirischen Ansatz bildet ein sogenanntes *experimentelles Pre-Test Post-Test Kontrollgruppen-Design* (Bruns, 2016, S. 103). Beim Kontrollgruppendesign mit Vorher-Nachher-Messung findet neben der Messung der a.V. nach dem experimentellen Stimulus eine zusätzliche Messung bereits vor dem Stimulus in Versuchsgruppe (VG) und Kontrollgruppe (KG) statt. Die Einteilung in VG und KG erfolgt dabei nach dem Zufallsprinzip, wodurch es sich um ein echtes Experiment handelt. Dieses Design wird auch als klassische Versuchsanordnung angesehen und ist grundsätzlich in der Lage, diverse Störvariablen zu kontrollieren, dennoch ist es anfällig für einen sogenannten *Common Method Bias* (auch Gewöhnungseffekt). Durch die Vorher-Messung könnte eine Sensibilisierung der Teilnehmer:innen für den experimentellen Stimulus stattfinden und einen systematischen und verzerrenden Einfluss auf die a.V. ausüben (Bruns, 2016, S. 103–104), der durch den kurzen Zeitraum der Messungen innerhalb des Experiments verstärkt werden würde (Podsakoff, MacKenzie, Lee & Podsakoff, 2003, S. 885). Daher wurde das Versuchsdesign um eine zusätzliche Durchführung der Post-Test Messung mit einem Zeitversatz von sieben bis zehn Tagen ergänzt (Campbell & Stanley, 2015, S. 13).

Um die Teilnehmer:innen in die Lage einer zentralen Anspruchsgruppe zu versetzen und dadurch stärker zu aktivieren als im reinen Beobachter-Status, wurde vor Beginn des Experiments neben der Abfrage demografischer Informationen ein Erklärungstext zur Ausgangslage angezeigt. Dieser enthielt die Information, dass der/die Teilnehmer:in Aktienanteile über 1000 EUR am dargestellten Unternehmen besitze. Ebenfalls wurde ein Kurztext über 78 Wörter angezeigt, der grundlegende neutrale Hintergrundinformationen zum Unternehmen bot und damit eine bessere Einschätzung des Unternehmens ermöglichen sollte (siehe *Anhang A*).

3.3.1. Operationalisierung der Variablen

Die a.V. *organisationale Legitimität* inklusive ihrer entsprechenden Sub-Kategorien wurde über sogenannte *Multi-Item-Skalen* operationalisiert, welche in einem schriftlichen Fragebogen mit Likert-basierten Antwortmöglichkeiten resultierten. Die Operationalisierung der u.V. *Transparenzangebot* geschah über ein schriftliches Szenario mit visueller Unterstützung, während die u.V. *Verarbeitungszeit* über die individuelle Lesezeit der jeweiligen Transparenzunterlagen gemessen wurde. Um Störvariablen zu kontrollieren, fand die Eliminierung und Konstanthaltung möglicher äußerer Einflüsse sowie die Messung und Überprüfung möglicher Störfaktoren über Kontrollvariablen statt (Bruns, 2016, S. 106–107).

Abhängige Variablen

Um individuell wahrgenommene organisationale Legitimität zu erfassen, hat sich die Befragung der Teilnehmer:innen mithilfe von Likert-basierten Fragebögen durchgesetzt (Alexiou & Wiggins, 2019, S. 473). Alexiou und Wiggins (2019, S. 495–496) haben dazu aus bestehenden Studien einen Fragebogen entwickelt, der mit signifikanten Faktorladungen von über 0,7 eine ausreichende Validität aufweist (Alexiou & Wiggins, 2019, S. 478; Krafft, Götz & Liehr-Gobbers, 2005, S. 75). Die Fragen wurden dazu jeweils aus dem Englischen übersetzt und an den Kontext der Studie angepasst. Die Übersetzungen orientieren sich sprachlich an der Arbeit von Stelzer (2008, S. 17–18), die auf die ursprüngliche Arbeit Elsbach (1994, S. 87) zu experimenteller Legitimitätsforschung Bezug nimmt. Alle Fragen wurden auf einer fünfstufigen Likert-Skala von „*1 = Trifft überhaupt nicht zu*“ bis „*5 = Trifft völlig zu*“ erfasst. Außerdem gab es die Möglichkeit die Option „*Ich weiß nicht*“ (Nullwerte) auszuwählen, um ihre Veränderung über die Messzeitpunkte (*t1 = Vorher-Test; t2 = Nachher-Test; t3 = Nachher-Test mit Zeitversatz*) zu erfassen. Die Veränderung der Nullwerte diente als Indikation für den grundsätzlichen meinungsbildenden Effekt der angezeigten Transparenzinformationen. Die Zeitpunkte *t1* bis *t2* werden nachfolgend auch als *Teil 1* bzw. zweistufiges Experiment und die Zeitpunkte *t1* bis *t3* als *Teil 2* bzw. dreistufiges Experiment beschrieben. Zur Messung des Konstrukts der *pragmatischen Legitimität* dienten vier Fragen, die auf die Einhaltung geltender Regeln, das Wissen über das Unternehmen und die Verständlichkeit der Geschäftstätigkeit abzielten. Eine Frage dazu lautete beispielsweise: „*Im Allgemeinen schafft diese Organisation einen Wert für ihre Interessensgruppen.*“ Zusätzlich wurde die Sub-Kategorie um vier weitere handlungsorientierte Fragen ergänzt, mit dem Ziel, die Involvierung und damit verbundene Aktivierung der Teilnehmer:innen zu erhöhen. Eine exemplarische Frage dazu lautete: „*Ich würde die Organisation weiterempfehlen.*“. Um die Konformität zu Werten und Normen einer Gesellschaft und damit das Konstrukt der *moralischen Legitimität* zu messen, wurden fünf Fragen des folgenden Formats ausgewählt: „*Im Allgemeinen schafft diese Organisation einen Wert für ihre Interessensgruppen.*“. Die *kognitive Legitimität*, welcher die Selbstverständlichkeit der Idee, die Zuverlässigkeit des Unternehmens und das Vertrauen in die Organisation zugrunde liegen, wurde über vier Fragen im folgenden Format gemessen: *„Ich glaube, dass Organisationen wie diese notwendig sind.“* (Alexiou & Wiggins, 2019, S. 478; Stelzer, 2008, S. 17–18). Eine Übersicht des gesamten Fragenbogens wird in *Anhang B* dargestellt.

Unabhängige Variablen

Die Operationalisierung der u.V. *Transparenzangebot* fand über zwei Szenarien statt. Dabei wurde das erste Szenario mit einem hohen Angebot an Informationen der VG und das zweite Szenario mit einem niedrigen Angebot an Transparenz der KG zugeteilt. Das verwendete Versuchsmaterial diente dem Zweck der Simulation der unterschiedlichen Transparenzgebote über die fiktive Fluglinie *Air Vienna*. Eine fiktive Organisation wurde gewählt, um den Bezug zu existierenden Unternehmen und die damit verbundene Voreingenommenheit möglichst gering zu halten (Massey, 2001, S. 164–165). Eine verfremdete Darstellung von existierenden Organisationen wurde ebenfalls für alle anderen in den Stimulus-Dokumenten dargestellten Organisationen vorgenommen.

Wie in *Kapitel 2.3* beschrieben, werden in der Literatur vor allem (1) *Nachrichtenmedien*, (2) *Ratings* und (3) *Umfragen* als externe Legitimitätsquellen verwendet. Für die VG wurden dafür je zwei Dokumente per Kategorie auf Basis von realen frei verfügbaren Informationen (u.a. Geschäftsbericht und Jahresabschluss der *Lufthansa Group*, *Skytrax Ratings*, Arbeitnehmer-Umfragen der *International Pilot Association*, Zeitungsartikel des Branchenportals *Aero*) dargestellt. Als (1) *Nachrichtenmedien* dienten zwei Zeitungsartikel über einerseits Nachhaltigkeitsbestrebungen sowie andererseits pandemiebedingte Einsparungen. (2) *Ratings* wurden durch ein Branchen- sowie ein Finanzrating abgebildet. (3) *Umfragen* wurden durch die Ergebnisse einer Arbeitnehmer- sowie einer Kundenumfrage ausgedrückt. Damit wurde versucht ein breites Spektrum an relevanten Informationen für unterschiedlichste Interessengruppen und somit für die Allgemeinheit abzubilden. Um auch die von innen nach außen gerichtete Transparenz in Form von *Rechenschaftsablegung* darzustellen, wurde ein fiktiver Geschäftsbericht zur Verfügung gestellt, der sich am Geschäftsbericht 2021 der *Deutschen Lufthansa AG* orientierte und vorrangig qualitative Informationen enthielt. Im *Oxford Handbook of Corporate Governance* werden hohe Transparenz im Sinne der *Corporate Governance* über die Offenlegung der Vergütung von Führungskräften auf individueller Ebene, die Offenlegung jeglicher Transaktionen zwischen *Management* und Unternehmen und die Veröffentlichung von Finanzberichten in mindestens dreimonatiger Frequenz beschrieben (Martynova & Renneboog, 2013, S. 106). Auf Basis dieser Einstufung wurden neben generellen Informationen zum Geschäftsmodell und zu den jährlichen Ergebnissen der Fluglinie auch Vorstandgehälter und Informationen zu den offiziellen Rechenschaftsablegungen *Air Viennas* genannt. Weiter richtete sich ein Absatz explizit auf *Air Viennas* Maßnahmen zum Umweltschutz. Neben den qualitativen Informationen wurden auch quantitative Informationen in Form einer separaten Bilanz sowie Gewinn- und Verlustrechnung (GuV) dargestellt. Um ein möglichst realistisches Bild abzuliefern, wurde die wirtschaftliche Lage *Air Viennas* aufgrund der aktuellen Pandemie als herausfordernd mit positivem Ausblick beschrieben. Die KG erhielt lediglich das Dokument zu den Branchenrating-Informationen. Damit sollte sichergestellt werden, dass auch für die KG ein Mindestmaß an Stimulation vorlag.

Heinberg et al. (2021, S. 58) stellen fest, dass sich Transparenz für Unternehmen nur im Falle positiver und unterschiedlicher Art der Informationen vorteilhaft auf die *Corporate Social Responsibility* (CSR) auswirkt. Sie argumentieren

weiter, dass Menschen dazu neigen, die Ehrlichkeit eines Signals in Frage zu stellen, wenn es nicht mit anderen Signalen übereinstimmt. Da auch nach Deephouse und Carter (2005, S. 342) eine negative Signalwirkung zu einem Verlust von Legitimität führen kann, wurde darauf geachtet, dass die dargestellten Informationen in sich schlüssig sowie insgesamt als neutral bis positiv bzw. leicht positiv bewertet werden. Um die Wahrnehmung der Teilnehmer:innen möglichst wenig zu beeinflussen, enthielten die einzelnen Versuchsmaterialien unterschiedliche Informationen, waren jedoch innerhalb der einzelnen Dokumente und auch als Gesamtbild leicht positiv zu bewerten. Um diese Kalibrierung vorzunehmen, wurden die einzelnen Stimulus-Dokumente in einem Vorab-Test mit sechs Masterstudierenden der Wirtschaftsuniversität Wien (WU) auf die wahrgenommene Bewertung der Informationen überprüft und iterativ angepasst. Die Teilnehmer:innen wurden dafür gebeten, am Experiment teilzunehmen und ihre Gedanken bei der Durchführung laut auszusprechen. Dabei wurden sie beobachtet und ihre Kommentare festgehalten. Nach jeder Runde wurden Anpassungen der Versuchsmaterialien vorgenommen und entsprechend das Experiment angepasst. Nach dem Durchlauf der sechs Vorab-Teilnehmer:innen wurden die final angepassten Informationen den Teilnehmer:innen erneut vorgelegt, um ein abschließendes Bild zu erhalten. Zwei Personen schätzten das gesamte Transparenzangebot als neutral ein, drei der Personen sprachen sich für eine leicht positive Einschätzung aus und eine Person empfand die Informationen als positiv. Insgesamt kann also angenommen werden, dass die Informationen als leicht positiv empfunden wurden. Darüber hinaus wurden die Dokumente zwecks einer besseren Lesbarkeit auf die Größe einer DIN A4 Seite begrenzt und grafisch sowie sprachlich so adaptiert, dass diese möglichst realen Informationen entsprechen und ebenso genügend Informationen enthielten, um eine differenzierte Urteilsbildung zu ermöglichen. Die finalen Dokumente finden sich in den *Anhängen C* bis *K*.

Die Messung der u.V. *Bearbeitungszeit* beschreibt die individuelle Abrufzeit der einzelnen Dokumentkategorien (*Nachrichtenmedien, Ratings, Umfragen, Rechenschaftsablegung qualitativ und Rechenschaftsablegung quantitativ*) je Teilnehmer. Diese fand automatisiert während des Experiments statt und bedurfte keiner weiteren Vorbereitung.

Kontrolle von Störvariablen

Um Störvariablen zu kontrollieren, stehen unterschiedliche Maßnahmen zur Verfügung, die sich nach Zeitpunkt und Art unterscheiden (Koschate, 2008, S. 113–114). Bereits vor der Durchführung des Experiments können Maßnahmen zur Kontrolle potenzieller Störvariablen ergriffen werden. Dabei zählt die Zufallseinteilung als eine der zentralen Methoden bei experimentellen Forschungsdesigns (Berekoven, Eckert & Ellenrieder, 2007, S. 46). Diese sogenannte Randomisierung stellt sicher, dass personenbezogene Charakteristika, wie Geschlecht, Alter oder Bildungsgrad gleichmäßig auf VG und KG verteilt sind und keinerlei systematischen Einfluss auf die a.V. ausüben (Bruns, 2016, S. 103; Steinhoff, 2014, S. 135). Für das vorliegende Experiment ergibt sich, dass die Zuordnung zu VG oder KG randomisiert stattfindet und ebenfalls die definierten Frage-Items zur Messung der a.V. sowie das Transparenzangebot hinsichtlich ihrer dargestellten Reihenfolge zufällig eingeteilt werden. Potenzielle Störvariablen, wie die Kundenbeziehung zu einem existierenden Unternehmen vor Eintritt des Stimulus, können durch die verfremdete Darstellung eliminiert werden (Steinhoff, 2014, S. 50). Zusätzlich wurden zu Beginn des Experiments die unabhängigen Kontrollvariablen Alter, Geschlecht, Studienerfahrung und Berufserfahrung abgefragt, um diese anschließend in der statistischen Auswertung auf mögliche Korrelationseffekte überprüfen zu können. Die Auswahl der Kontrollvariablen begründet sich auf die zuvor im Zusammenhang der organisationalen Legitimität durchgeführten Versuche durch Stelzer (2008, S. 20), die einen ähnlichen empirischen Ansatz wählte. Ebenso wurde die Matrikelnummer oder alternativ eine persönliche Kennung der Teilnehmer:innen abgefragt, um die Ergebnisse aus den ersten beiden Messzeitpunkten (*t1*, *t2*) mit dem zeitversetzten dritten Messzeitpunkt (*t3*) verknüpfen zu können. Um ein Mindestmaß der Teilnehmer:innen-Aufmerksamkeit kontrollieren zu können, wurde bei der Messung der a.V. durch die jeweiligen Likert-basierten Frage-Items zu jedem Messzeitpunkt die Kontrollfrage „*Bitte wählen Sie 5 aus*“ an einer zufälligen Stelle angezeigt. Das beschriebene Forschungsdesign wird in nachfolgender *Abbildung 2* visualisiert und fasst den dargestellten Versuchsplan zusammen.

3.3.2. Stichprobenauswahl

Um eine maximale Validität des Experiments zu erreichen, wäre ein exaktes Abbild der Bevölkerung Österreichs bzw. der Kleininvestorenstruktur als wichtige Anspruchsgruppe einer österreichischen Fluglinie notwendig. Da die Operationalisierung dieser Stichprobe jedoch unrealistisch schien, wurde eine geeignete alternative Teilnehmer:innengruppe definiert. Ferber (1977, S. 58) empfiehlt in einem solchen Fall nur bezugsfähige Inhalte zu überprüfen. Im Rahmen der vorliegenden Arbeit boten sich Studierende als potenzielle Teilnehmer:innen an. Diese bildeten eine homogene Gruppe bezüglich ihres Bildungsabschlusses und des fachspezifischen Verständnisses wirtschaftlicher Prozesse. Sie eigneten sich daher, das Profil der Interessengruppe Kleininvestor:innen abzubilden. Limitierend ist dennoch, dass diese Stichprobenauswahl keinen Querschnitt der Gesamtbevölkerung oder einer zentralen Interessengruppe entsprach, sondern sich hauptsächlich aus einer spezifischen Gruppe (hier Studierende) zusammensetzte.

Nach dem Grundsatz, dass Laborexperimente eine hohe interne und Feldexperimente eine hohe externe Validität aufweisen, wurde eine Kombination beider Ansätze gewählt (Steinhoff, 2014, S. 133). Dazu wurde die gesamte Kohorte von ca. 120 *Master Management-Studierenden* des zweiten Semesters der WU während ihres Kurses *Organizational Behavior* gebeten, am vorliegenden Experiment teilzunehmen. Dieser Teil der Stichprobe kommt durch die kontrollier-

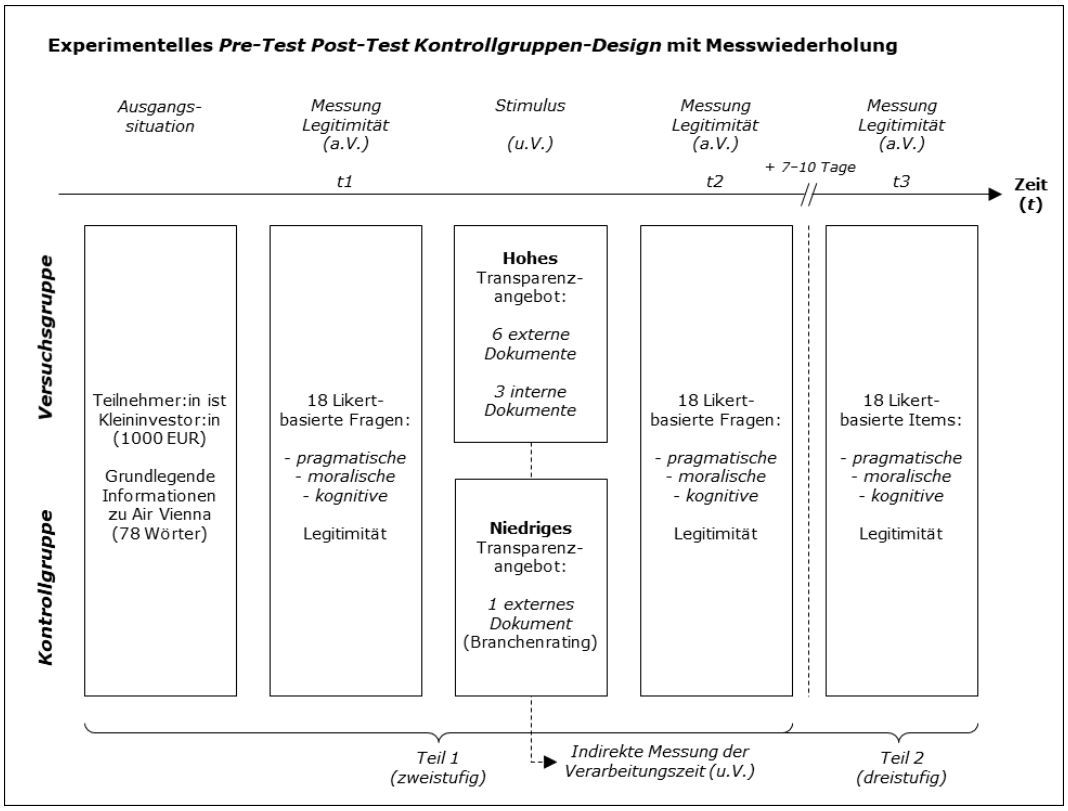

Abbildung 2: Versuchsplan (Quelle: Eigene Darstellung)

te und gleiche Versuchsanordnung einem Laborexperiment am nächsten und sichert damit ein hohes Niveau an interner Validität. Darüber hinaus wurde der E-Mail-Verteiler für wissenschaftliche Arbeiten der WU und ein Verteiler für Wirtschaftsstudierende der Universität Wien genutzt, um auch die externe Validität des Experiments sicherzustellen. Es ergab sich, dass die Teilnehmer:innen teilweise in einer kontrollierten und teilweise in einer unkontrollierten Umgebung am Versuch teilnahmen.

3.3.3. Datenerhebung

Für die Darstellung der schriftlichen Unterlagen und der anschließenden Datenerhebung wurde das Online-Umfrage-Programm *LimeSurvey* genutzt. Über die Applikation konnte einerseits die zufällige Einteilung in VG und KG vorgenommen und ebenfalls die Transparenz-Stimuli und Frage-*Items* nach dem Zufallsprinzip angezeigt werden. Die Messung der u.V. *Verarbeitungszeit* konnte mithilfe *LimeSurveys* ebenfalls automatisiert auf individueller Basis erfolgen.

Bei der Datenerhebung der Management-Studierenden im Kurs *Organizational Behavior* wurden vorab die Lehrveranstaltungsleiter:innen der vier Kurse kontaktiert und mit diesen jeweils zwei Termine für die Durchführung des Experiments koordiniert. In *Teil 1* des Experiments wurden die Studierenden nach einer kurzen Erklärung über den generellen Ablauf des Experiments gebeten, dieses über einen zuvor verteilten Zugang zu beginnen. Außerdem wurden die Studierenden ab dem zweiten Kurs angewiesen, nach Beendigung des Online-Experiments den jeweiligen Raum zu verlassen, um einen Austausch zu anderen Teilnehmer:innen noch während des laufenden Experiments zu verhindern. *Teil 2* des Experiments erfolgte sieben bis zehn Tage nach *Teil 1*. Dazu wurden die Kursteilnehmer:innen erneut gebeten die Umfrage über einen ihnen vorab zugesendeten Zugang zu starten, die jedoch nur noch aus der Abfrage der Matrikelnummer bzw. der persönlichen Kennung und den Fragebogen-Items zur a.V. *organisationale Legitimität* inkl. der Sub-Kategorien bestand. Die Datenerhebung über den Verteiler der WU und der Universität Wien wurde ausschließlich *online* durchgeführt. Hierzu wurde eine Nachricht verfasst, die den Ablauf von *Teil 1* grob erklärte und den Zugangslink enthielt. *Teil 2* wurde anschließend zehn Tage später freigeschaltet und es erfolgte eine Erinnerungsmail.

Insgesamt konnte für *Teil 1* des Experiments eine Rücklaufquote von 220 vollständig bearbeiteten Antworten erreicht werden. Dabei wurden 108 der Teilnehmer:innen zur VG und 112 der Teilnehmer:innen der KG zugewiesen. Für *Teil 2* des Experiments betrug die Rücklaufquote 135 Antworten, jedoch konnte nur ein Teil der Antworten den Ergebnissen aus *Teil 1* des Experiments zugeordnet werden. *Teil 2* des Experiments enthält entsprechend 103 vollständige und zuordenbare Antworten. 47 der Antworten verteilen sich dabei auf die VG, während 56 Antworten der KG zuzuordnen sind. Es kann ebenfalls festgehalten werden, dass die über den Umfrageverteiler erzielten Antworten im Vergleich zu der vor Ort durchgeführten Variante eine kleinere Rücklaufquote für so-

Tabelle 1: Zusammensetzung der Teilnehmer:innen (Quelle: Eigene Darstellung)

Zusammensetzung der Teilnehmer:innen	$n = 220, \%$		
Versuchsgruppe ($n = 108$)		Kontrollgruppe ($n = 112$)	
Geschlecht		*Geschlecht*	
Männlich	52,78%	Männlich	49,11%
Weiblich	46,30%	Weiblich	50,89%
Divers	0,93%	Divers	-
Alter		*Alter*	
18–25	61,11%	18–25	63,89%
26–30	35,19%	26–30	29,63%
31–40	2,78%	31–40	4,63%
41–50	0,93%	41–50	1,85%
Ausbildung		*Ausbildung*	
Matura/Abitur	19,44%	Matura/Abitur	12,50%
Bachelor	71,30%	Bachelor	81,25%
Master/Diplom/Magister	9,26%	Master/Diplom/Magister	6,25%
Praxiserfahrung		*Praxiserfahrung*	
<2	25,00%	<2	26,79%
2–5	49,07%	2–5	54,46%
<5	25,93%	<5	18,75%
Studienrichtung		*Studienrichtung*	
Wirtschaftswissenschaften	94,44%	Wirtschaftswissenschaften	95,54%
Andere	5,56%	Andere	4,46%

wohl *Teil 1* wie auch *Teil 2* des Experiments verzeichnete.

Demographische Werte

Die Teilnehmer des Experiments teilten sich für VG sowie KG homogen nach Geschlechtern auf (*Männer*$_{(VG)}$ *= 52,8 %; Frauen*$_{(VG)}$ *= 46,3 %; Männer* $_{(KG)}$ *= 49,1 %; Frauen* $_{(KG)}$ *= 50,9 %*). In beiden Gruppen war ein Großteil der Teilnehmer:innen zwischen 18 bis 25 Jahre alt (*VG = 61,1 %; KG = 63,9 %)*, was auf das natürliche Durchschnittsalter von Studierenden zurückgeführt werden kann. Das Durchschnittsalter lag in der VG bei 24,6 Jahren und in der KG bei 24,8 Jahren. Der Anteil der Teilnehmer:innen mit einem Bachelorabschluss war in beiden Gruppen am höchsten (*Bachelor*$_{(VG)}$ *= 71,3 %; Bachelor*$_{(KG)}$ *= 81,3 %*), vermutlich da ein Großteil der Teilnehmer:innen aus Master-Studierenden bestanden. Etwa die Hälfte beider Gruppen verfügte zudem über Praxiserfahrung zwischen zwei bis fünf Jahren (*Praxiserfahrung 2–5 Jahre*$_{(VG)}$ *= 49,1 %; Praxiserfahrung 2–5 Jahre*$_{(KG)}$ *= 54,5 %*). Die durchschnittliche Praxiserfahrung lag in der VG bei 3,6 Jahren und in der KG bei 3,5 Jahren. Die deutliche Mehrheit der Teilnehmer:innen hatte erwartungsgemäß einen wirtschaftswissenschaftlichen Studienhintergrund (*Wirtschaftshintergrund*$_{(VG)}$ *= 94,4 %; Wirtschaftshintergrund*$_{(KG)}$ *= 95,5 %*). Die Zusammensetzung der Teilnehmer:innen nach den erhobenen Kontrollparametern ist für VG sowie KG insgesamt homogen und wird in nachfolgender *Tabelle 1* detailliert dargestellt. Es kann zusammenfassend davon ausgegangen werden, dass beide Gruppen sich nicht systematisch unterscheiden, wodurch die Prämisse der zufälligen Gruppeneinteilung für weitere statistische Untersuchungen erfüllt ist.

3.3.4. Datenanalyse

Die Auswertung der erhobenen Daten erfolgte mit dem Statistik Programm *IBM SPSS Statistics 28*. Da das Konstrukt der *organisationalen Legitimität* bereits von Alexiou und Wiggins (2019) auf Basis von bestehenden Fragebögen weiterentwickelt und entsprechend statistisch getestet wurde, kann hier grundsätzlich von einer positiven Validität und Reliabilität ausgegangen werden. Dennoch wurde hinsichtlich der veränderten Sub-Kategorie *pragmatische Legitimität* über die Messung des *Cronbachs Alpha* eine erneute Validierung der internen Konstrukt-Konsistenz vorgenommen.

Um den Unterschied der Mittelwerte (MW) für die VG und KG der u.V. *Transparenzangebot* zu überprüfen, wurden

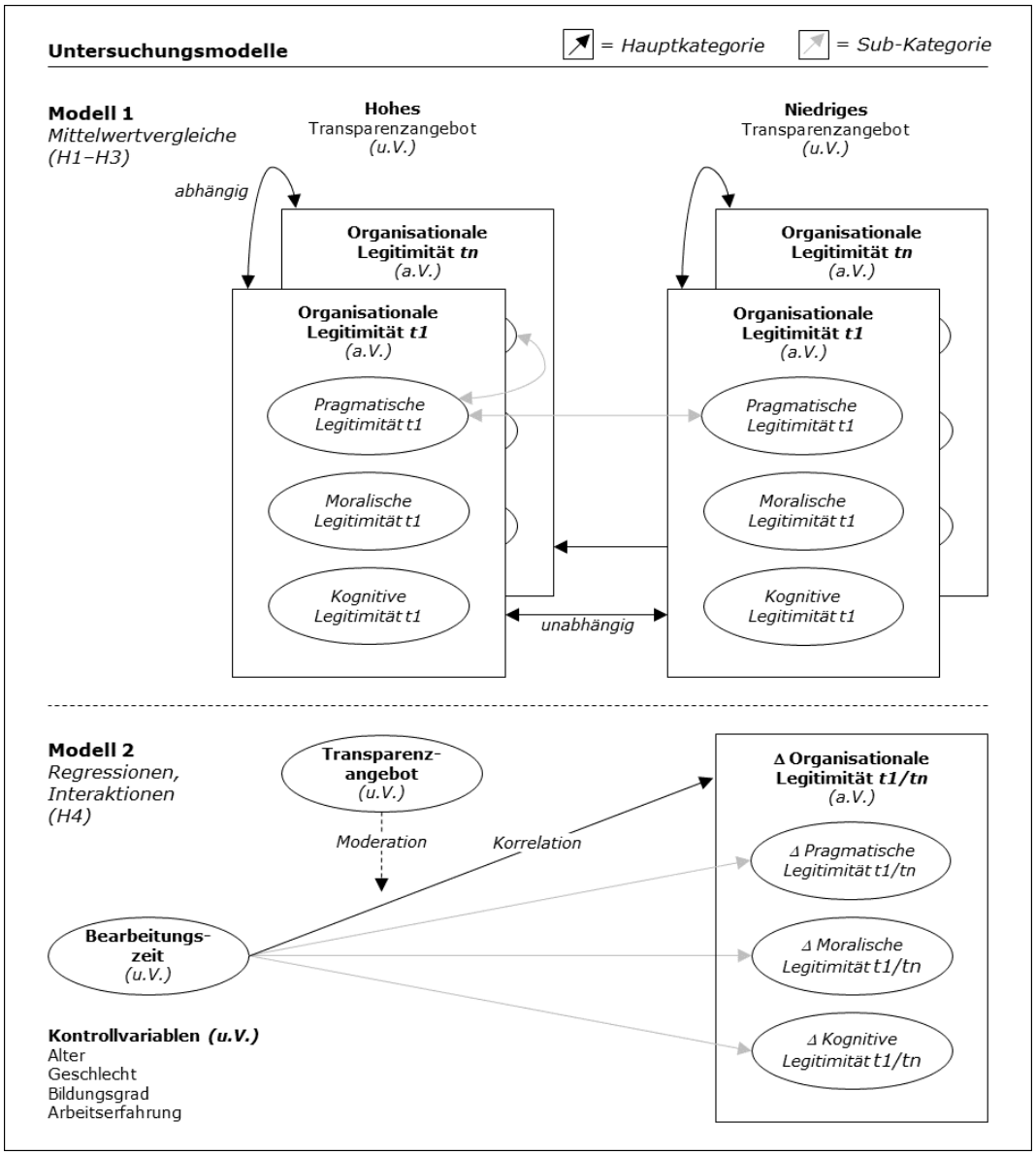

Abbildung 3: Untersuchungsmodell (Quelle: Eigene Darstellung)

deskriptive Werte, wie Mittelwerte und Varianzen analysiert und anschließend mittels abhängigen (auch gepaarten) und unabhängigen (auch ungepaarten) t-Tests und einer Varianzanalyse (ANOVA) auf Signifikanz geprüft. Der Zusammenhang zwischen der u.V. *Bearbeitungszeit* sowie den unabhängigen Kontrollvariablen und der a.V. *organisationale Legitimität* wurde mittels multipler Regressionsanalysen vorgenommen. Aufgrund der geringen Stichprobengröße und der damit verbundenen geringen sogenannten *statistischen Power* für *Teil 2* des Experiments ($n_{(gesamt)} = 103$; $n_{(VG)} = 47$; $n_{(KG)} = 57$), wurde die multiple Regressionsanalyse nur für *Teil 1* des Experiments durchgeführt. Ebenfalls wurden die *„Ich weiß nicht"*-Angaben nur im Rahmen der deskriptiven Bewertung der Veränderung zwischen den Messzeitpunkten ausgewertet. Für die weiteren statistischen Analysen (*t-Test, ANOVA und multiple lineare Regression*) wurden die Nullwerte daher durch den mittleren Wert drei ersetzt, da im Rahmen des Vorab-Tests von den sechs Teilnehmer:innen mitgeteilt wurde, dass diese ohne die „*Ich weiß nicht*"-Auswahlfunktion im Fall von Unentschlossenheit den mittleren Wert drei gewählt hätten. Nachfolgende *Abbildung 3* visualisiert die Untersuchungsmodelle und fasst damit das beschriebene Forschungsdesign zusammen.

4. Ergebnisse

Aus Gründen der besseren Lesbarkeit erfolgt die Präsentation der Ergebnisse des Experiments analog zum Versuchsplan in zwei Schritten. Dabei werden zuerst die Ergebnisse des zweistufigen Experiments (*Teil 1*) und anschließend die Ergebnisse des dreistufigen Experiments (*Teil 2*) erläutert. Für eine bessere Übersicht und Vergleichsmöglichkeit enthal-

ten die Ergebnistabellen der *Anhänge L* bis *O* jedoch die Werte für beide Teile des Experiments. Für eine bessere Lesbarkeit wurden die Legitimitätsdimensionen im vierten, fünften und sechsten Kapitel wie folgt abgekürzt dargestellt: *Organisationale Legitimität* (*OL*), *pragmatische Legitimität* (*PL*), *moralische Legitimität* (*ML*) und *kognitive Legitimität* (*KL*).

4.1. Reliabilität

Um die interne Konsistenz der Skalen zu analysieren, wurde das *Cronbachs Alpha* je Item-Konstrukt berechnet. Voraussetzung dafür sind mindestens drei Fragen je Konstrukt, die gleiche Interpretation des Wertebereichs sowie eine einheitliche Reihung (Streiner, 2003, 99–100). Da alle Fragen positiv formuliert sind, über eine eins bis fünf skalierte Likert-Skala verfügen und die Konstrukte über drei bis acht Fragen bzw. Sub-Skalen[3] bestehen, treffen die Voraussetzungen zu.

Die Ergebnisse der Analyse zeigen für *t1* Werte von mindestens 0,70 für alle Sub-Kategorien der Gesamtstichprobe ($PL = 0,71$; $ML = 0,71$; $KL = 0,70$) und Werte von 0,84 für die aggregierte Form der *OL*. Für *t2* wurden sogar leicht höhere Werte von bis zu 0,86 für die *OL* berechnet. Die VG erzielte Werte zwischen 0,65 für die *PL* in *t3* sowie 0,67 für die *ML* und 0,65 für die *KL* in *t1*. Die Werte sind grundsätzlich als gut bis vereinzelt fragwürdig zu bewerten. Die Ergebnisse der anderen Messzeitpunkte erreichten jedoch Werte von 0,71 bis 0,85 und sind damit als gut einzuordnen. Auch die Werte der *PL*, als das am meisten angepasste Konstrukt, weisen eine zufriedenstellende Höhe auf. Der überwiegende Teil des Konstrukts *OL* erreichte insgesamt Werte von deutlich über 0,80. Die Sub-Kategorien erreichten vorrangig Werte von über 0,70 innerhalb der einzelnen Gruppen und Messzeitpunkte. Insgesamt kann damit von einer ausreichend guten Reliabilität aller Konstrukte für weitere statistische Analysen ausgegangen werden (Streiner, 2003, S. 103). Die gesamte Übersicht der *Cronbachs Alpha* Werte findet sich in *Tabelle 7* (siehe *Anhang L*).

4.2. Ergebnisse der Mittelwertvergleiche des zweistufigen Experiments

Deskriptive Ergebnisse

Zur Überprüfung der generellen Aussagekraft des Transparenzangebots, wird zu Beginn die Veränderung der sogenannten „*Ich weiß nicht*"-Werte zwischen VG (hohes Transparenzangebot) und KG (niedriges Transparenzangebot) über die Messzeitpunkte dargestellt. Die durchschnittlichen Werte pro Teilnehmer:in pro Frage verringern sich für alle Konstrukte in der VG von ca. 0,07 auf ca. 0,02 um ca. 65 %. In der KG sinken die Durchschnittswerte ebenfalls, jedoch nur etwa halb so stark, von ca. 0,06 auf ca. 0,04 um ca. 35 %. Besonders bei Fragen zur Wahrnehmung der *PL* sowie *ML* sinken die Nullwerte pro Teilnehmer in der VG etwa doppelt so stark, verglichen mit der KG. Die gesamte Übersicht der Werte findet sich in *Tabelle 8 und 9* (siehe *Anhang M*). Zusammengefasst weisen die Veränderungen der Nullwerte darauf hin, dass die im Experiment dargestellten Transparenzangebote in der beabsichtigten Weise gewirkt und dazu geführt haben, dass die Teilnehmer:innen sich Urteile über die wahrgenommene Legitimität *Air Viennas* bilden konnten bzw. sich die Unsicherheit verringerte. Dabei hatte das hohe Transparenzangebot einen größeren Effekt als das niedrige Transparenzangebot.

Die Mittelwerte und Varianzen der Konstrukte sind in *t1* nahezu identisch, wobei die Konstrukte *PL*, *ML* und *OL* in der KG ($MW: PL_{(KG)} = 3,37$; $ML_{(KG)} = 2,82$; $OL_{(KG)} = 3,21$) leicht höher ausfallen als in der VG ($MW: PL_{(VG)} = 3,48$; $ML_{(VG)} = 2,84$; $OL_{(VG)} = 3,24$). Die Veränderung zwischen *t1* und *t2* verhält sich für alle Konstrukte in VG wie auch KG leicht negativ, dabei verändert sich die wahrgenommene Legitimität vor allem in der VG ($\Delta MW\, t1/t2$: $PL(KG) = -0,11$; $ML_{(KG)} = -0,17$; $KL_{(KG)} = -0,17$; $OL_{(KG)} = -0,03$) stärker negativ als in der KG ($\Delta MW\, t1/t2$: $PL_{(VG)} = -0,25$; $ML_{(VG)} = -0,07$; $KL_{(VG)} = -0,27$; $OL_{(VG)} = -0,20$). Die gesamte deskriptive Auswertung für *Teil 1* des Experiments wird in nachfolgender *Tabelle 2* dargestellt. Die deskriptiven Werte des zweistufigen Experiments liefern die Indikation, dass sich die wahrgenommene Legitimität bei einem niedrigen sowie hohen Transparenzangebot verringert, wobei sich die Werte grundsätzlich bei niedriger Transparenz stärker negativ verändern. Die Standardabweichung der Werte reicht von 0,50 bis 0,82 und bewegt sich damit auf einem Niveau von ca. 10–20% der Skala.

Abhängige Mittelwertvergleiche (Vergleich der Messzeitpunkte)

Zum Vergleich der abhängigen Mittelwerte des ersten und zweiten Messzeitpunkts innerhalb der VG sowie KG hinsichtlich ihrer Signifikanz eignet sich der gepaarte t-Test. Dieser setzt voraus, dass die Daten normalverteilt sind, was vorab grafisch überprüft wurde und zutrifft. Da zwar die Vermutung einer einseitig positiven Veränderung der Mittelwerte vorlag, diese sich jedoch weitestgehend als negativ herausstellte, wurde die zweiseitige statt der einseitigen Signifikanz zur Bewertung der *OL*, *PL* und *KL* verwendet. Nur für die Untersuchung der Signifikanz der *ML* in der VG kann die einseitige Signifikanz berücksichtigt werden, da ihre Mittelwerte wie in *H2* angenommen, gestiegen sind.

In der KG zeigen die Ergebnisse der zuvor dargestellten Mittelwertdifferenzen signifikante Unterschiede für die *OL* ($\Delta MW_{(KG)} t1/t2 = -0,20$; $p < 0,001$) und die Sub-Kategorien *PL* ($\Delta MW_{(KG)} t1/t2 = -0,11$; $p < 0,001$) und *KL* ($\Delta MW_{(KG)} t1/t2 = -0,17$; $p = 0,005$). Nach Cohen (1988, S. 25–26) können die Effektstärken (*Cd*) der Veränderung der *OL* ($Cd > 0,5$) und *PL* ($Cd > 0,5$) als mittelstark und der *KL* ($Cd = 0,19$) als sehr gering eingestuft werden. In der VG wiederum weisen asyynur die Veränderungen der Sub-Kategorien *ML* ($\Delta MW_{(VG)} t1/t2 = 0,17$; $p = 0,003$) und *KL* ($\Delta MW_{(VG)} t1/t2 = -0,17$; $p = 0,005$) signifikante Unterschiede mit jeweils geringen Effektstärken auf. Nachfolgende

[3] Im Falle der *organisationalen Legitimität* wurden die jeweiligen Mittelwerte der Sub-Kategorien (PL, ML und KL) verwendet, sodass diese zu je einem Drittel gleichverteilt waren.

Tabelle 2: Deskriptive Werte der Mittelwertvergleiche Teil 1 (Quelle: Eigene Darstellung)

Teil 1 (zweistufig): Deskriptive Werte der Mittelwertvergleiche

	t1	$\Delta t1/t2$	*t2*	*t1*	$\Delta t1/t2$	*t2*
	Versuchsgruppe		$n = 108$	*Kontrollgruppe*		$n = 112$
Legitimität						
Pragmatische Legitimität						
Mittelwert	3,37	-0,11	3,26	3,48	-0,25	3,23
Standardabweichung	0,57		0,64	0,54		0,58
Moralische Legitimität						
Mittelwert	2,82	0,17	2,99	2,84	-0,07	2,77
Standardabweichung	0,58		0,71	0,64		0,65
Kognitive Legitimität						
Mittelwert	3,45	-0,17	3,28	3,40	-0,27	3,13
Standardabweichung	0,79		0,82	0,84		0,86
Organisationale Legitimität						
Mittelwert	3,21	-0,03	3,18	3,24	-0,20	3,04
Standardabweichung	0,50		0,60	0,58		0,58

Tabelle 3 fasst die beschriebenen Ergebnisse zusammen. Diese legen nahe, dass ein geringes Transparenzangebot zu leicht niedrigerer *PL*, *KL* und insgesamter *OL* führt. Ebenso zeigen sie, dass die *ML* bei einem hohen Transparenzangebot leicht steigt und die *KL* im gleichen Fall leicht sinkt.

Unabhängige Mittelwertvergleiche (Vergleich der Experimentalgruppen)

Der Vergleich der Signifikanz der unabhängigen Mittelwertunterschiede des zweistufigen Experiments zwischen VG und KG wurde mittels eines ungepaarten t-Test vorgenommen, da die Voraussetzungen der Normalverteilung und der homogenen Varianzen gegeben waren. Da für *t1* aufgrund der gleichen Informationslage des Ausgangszustands keine Veränderungsrichtungen angenommen werden konnten, musste die Aussagekraft auf Basis der zweistufigen Signifikanz festgestellt werden. Für *t1* konnten zwischen VG und KG keine signifikanten Unterschiede ermittelt werden ($p > 0,05$), was aufgrund der gleichen Ausgangssituation im Experiment zu erwarten war und für die intendierte Funktionsweise des Versuchsaufbaus spricht. Der Vergleich des zweiten Messzeitpunkts zeigt signifikante Ergebnisse für die Variable *OL* ($\Delta MW_{(t2)}VG/KG = 0,13; p = 0,024$) sowie *ML* ($\Delta MW_{(t2)}VG/KG = -0,05$; $p = 0,016$). Demnach führt ein höheres Transparenzangebot zu einer leicht höheren *OL* ($Cd = 0,23$) sowie *ML* ($Cd = 0,33$). Beide Effektstärken können als klein eingestuft werden. Da die Mittelwerte jedoch bereits zu *t1* unterschiedliche, jedoch nicht signifikante, Mittelwerte für VG sowie KG aufweisen, reicht der reine Vergleich Mittelwerte für VG und KG nicht aus und es mussten ebenfalls die Mittelwertveränderung zwischen *t1* und *t2* der VG und KG überprüft werden. Diese ermöglichten anschließend eine Aussage über die Ausprägung ihrer Veränderung.

Beim Vergleich der Mittelwertdifferenzen zeichnet sich ein aussagekräftigeres Bild ab. Die Veränderung der Mittelwerte von *t1* auf *t2* fällt für die *OL* ($\Delta MW_{(t1/t2)}VG/KG = 0,159$; $p < 0,01$) in der VG größer aus als in der KG, bei einer kleinen Effektstärke ($Cd = 0,45$) nach Cohen (1988, S. 25–26). Die *ML* weist einen negativen Zusammenhang auf ($\Delta MW_{(t1/t2)}VG/KG = -0,021$; $p < 0,01$) bei mittlerer Stärke ($Cd = 0,55$). Damit verringert sich die *ML* in der VG stärker als in der KG. Für die Variable *KL* konnten keine statistisch signifikanten Ergebnisse festgestellt werden. Ausgehend von der im Untersuchungsmodell dargestellten Argumentation, kann davon ausgegangen werden, dass sich die *PL* in der VG weniger negativ verändert als in der KG. Demnach konnte die einseitige Signifikanz berücksichtigt werden, welche ebenfalls signifikant positive Werte bei mittlerer Effektstärke aufzeigt ($\Delta MW_{(t1/t2)}VG/KG = 0,136$; $p < 0,05$; $Cd = 0,54$). Diese Argumentation kann unter Berücksichtigung des unerwarteten negativen Zusammenhangs der *ML* jedoch nur als bedingt belastbar eingestuft werden. *Tabelle 10* (siehe *Anhang N*) stellt die gesamten Ergebnisse des durchgeführten ungepaarten t-Test dar.

4.3. Ergebnisse der Mittelwertvergleiche des dreistufigen Experiments

Deskriptive Ergebnisse

Wie auch im zweistufigen Experiment sind die Nullwerte im dreistufigen Verfahren in der VG (hohes Transparenzangebot) stärker als in der KG (niedriges Transparenzangebot) gesunken. Dabei sind die durchschnittlichen Werte pro Teilnehmer pro Frage in der VG zwischen *t1* und *t2* von ca. 0,06 auf ca. 0,01 um 78 % und in der KG von ca. 0,06 auf ca. 0,03 um 45 % gesunken. Zwischen *t2* und *t3* gab es anschließend nur noch leichte Schwankungen. Die Ergebnisse sprechen damit auch im dreistufigen Verfahren für die vorgesehene Funktionsweise des Experiments. Die gesamte Darstellung der Werte findet sich in *Tabelle 8* und *9* (siehe *Anhang M*).

Die Mittelwerte im dreistufigen Experiment weisen ähnliche Ergebnisse wie *Teil 1* des Experiments auf. Die KG erzielte

Tabelle 3: Abhängiger t-Test Teil 1 (Quelle: Eigene Darstellung)

Teil 1 (zweistufig): Abhängiger t-Test

	Pragmatische Legitimität		*Moralische Legitimität*		*Kognitive Legitimität*		*Organisationale Legitimität*	
	VG	*KG*	*VG*	*KG*	*VG*	*KG*	*VG*	*KG*
Mittelwerte								
t1	3,370	3,475	2,817	2,843	3,451	3,395	3,213	3,238
t2	3,260	3,230	2,991	2,770	3,280	3,130	3,177	3,043
Mittelwertvergleich								
$\Delta(t1/t2)$	-110	-246	0,174	-73	-171	-266	-36	-195
Signifikanz (zweiseitig)	* 0,058	*** <0,001	*** 0,006	* 0,084	*** 0,005	*** <0,001	0,458	*** <0,001
Signifikanz (einseitig)	** 0,029	*** <0,001	*** 0,003	** 0,042	*** 0,003	*** <0,001	0,229	*** <0,001
Effektstärke								
Cohens d	0,185	°° 0,501	° 0,272	0,165	° 0,278	° 0,494	0,072	°° 0,501

***	p-Wert <,01	°°°	Cohens d >,80
**	p-Wert <,05	°°	Cohens d >,50-0,80
*	p-Wert <,10	°	Cohens d >,20-0,50

bereits in *t1* leicht höhere Mittelwerte als die VG und ebenfalls wie für das zweistufige Experiment festgestellt, sind die Mittelwerte zwischen *t1* und *t2* leicht gesunken. Zwischen *t2* und *t3* haben sich die Werte geringer als zwischen *t1* und *t2* verändert. In der VG hat erneut eine sehr geringe Absenkung der Werte für die Sub-Kategorien *PL*, *ML* und das Hauptkonstrukt *OL* stattgefunden. In der KG sind nur die Werte der Sub-Kategorien *PL* und *ML* gefallen. Insgesamt lässt sich der Unterschied zwischen *t1* und *t2* jedoch als sehr gering beschreiben, was darauf hindeutet, dass in *Teil 1* des Experiments keine Verzerrung durch den *Common Method Bias* stattfand. Auch die Standardabweichungen zeigen ähnliche Werte zwischen 0,50 und 0,85 je nach Kategorie auf, wie bereits in *Teil 1* des Experiments festgestellt. Nachfolgende *Tabelle 4* fasst die beschriebenen Ergebnisse zusammen.

Abhängige Mittelwertvergleiche (Vergleich der Messzeitpunkte)

Zur Überprüfung der drei Messzeitpunkte des dreistufigen Experiments wurde eine *„zwei mal drei faktorielle gemischte ANOVA“* mit dem Zwischensubjekt-Faktor *Transparenzangebot* über zwei Faktorstufen (VG und KG) und dem Innersubjektfaktor *Messzeitpunkte* mit drei Faktorstufen (*t1, t2* und *t3*) durchgeführt. Die Voraussetzungen der Normalverteilung und die Varianzhomogenität wurde zuvor überprüft und sind für den Datensatz erfüllt. Dazu wurde mittels eines Levene-Tests die Signifikanz der Nullhypothese, welche aussagt, dass die Varianzen homogen sind, berechnet und als nicht signifikant eingestuft ($p > 0{,}05$).

Im Vergleich zwischen *t1* und *t2* weist die KG signifikante Veränderungen für die Sub-Kategorien *PL* sowie *KL* und das Hauptkonstrukt *OL* auf. Die Veränderungen sind für alle Werte leicht negativ und können nach Cohen (1988, S. 25–26) mit einer geringen Effektstärke beschrieben werden. In der VG weisen nur die Sub-Kategorien *ML* und *KL* signifikante Unterschiede auf, dabei steigt die *ML* leicht, während *KL* leicht sinkt. Die Effektstärke kann dabei ebenfalls als gering eingestuft werden. Das dreistufige Verfahren ergibt demnach ein sehr ähnliches Bild wie das zweistufige Verfahren.

Bei der Mittelwertveränderung zwischen *t1* und *t3* innerhalb der KG weisen nur die Veränderungen der Variablen *PL* ($\Delta MW_{(KG)}t1/t2 = -0{,}25$; $p = 0{,}001$), *KL* ($\Delta MW_{(KG)}t1/t2 = -0{,}19$; $p = 0{,}001$) und *OL* ($\Delta MW_{(KG)}$ $t1/t2 = -0{,}18$; $p = 0{,}007$) teilweise signifikante Werte auf. Die Veränderungen innerhalb der VG zeigen keine signifikanten Ergebnisse. Für die Mittelwertveränderung zwischen *t2* und *t3* konnte nur für die *PL* ($\Delta MW_{(KG)}t2/t3 = -0{,}03$; $p = 0{,}001$) der KG ein signifikanter Wert festgestellt werden. Es folgt die Schlussfolgerung, dass es in der VG keine systematische Veränderung der Wahrnehmungen zwischen den Zeitpunkten *t2* und *t3* sowie *t1* und *t3* gab. Daher kann davon ausgegangen werden, dass zwischen den Zeitpunkten *t1* und *t2* keine Gewöhnungseffekte oder sonstige Einschränkungen des *Common Method Bias* vorlagen. Demgegenüber steht allerdings der signifikante Wert der *PL* in der KG, welcher jedoch als sehr gering einzustufen ist. Nachfolgende *Tabelle 5* fasst die dargestellten Ergebnisse zusammen.

Unabhängige Mittelwertvergleiche (Vergleich der Experimentalgruppen)

Der Vergleich der Signifikanz der unabhängigen Mittelwertunterschiede zwischen der VG und KG wurde auch für das dreistufige Experiment mittels eines ungepaarten t-Test vorgenommen, da hier ebenfalls die Voraussetzungen der Normalverteilung und der Varianzhomogenität gegeben sind. Der Vergleich der Mittelwerte zwischen KG und VG führt in *t1* zu leicht geringeren Werten aller Dimensionen und nach Einführung des Stimulus in *t2* zu leicht höheren Werten der VG gegenüber der KG. Auch in *t3* setzt sich dieser Effekt fort und die VG erzielt höhere Werte als die KG obwohl die Werte über die Messzeitpunkte hinweg sinken. Dennoch kann nur für die Veränderung der *ML* in *t2* ($\Delta MW_{(t2)}VG/KG = 0{,}21$; $p = 0{,}049$) ein signifikanter Unterschied bei geringer Effektstärke ($Cd = 0{,}33$) festgestellt werden. Dies ist ein weiterer Indikator dafür, dass die *ML* bei einem hohen Transparenzangebot steigt sowie, dass es in *t1* keinen strukturellen Unterschied zwischen VG und KG gibt.

Um auch hier die Ausprägung der Veränderung zwischen den Zeitpunkten *t1*, *t2* und *t3* beurteilen zu können, wurden ebenfalls die Veränderungen zwischen *t1* und *t2* sowie *t2* und *t3* mittels eines ungepaarten t-Tests überprüft. Es ergeben sich keine signifikanten Werte aller Variablen für die Veränderung zwischen *t2* und *t3*, was gegen einen strukturellen Störeffekt in *Teil 1* des Experiments spricht. Für die Veränderung zwischen *t1* und *t2* finden sich signifikant positive Werte für die Variablen *OL* ($\Delta MW_{(t1/t2)}VG/KG = 0{,}179$; $p < 0{,}05$; $Cd = 0{,}40$), *PL* ($\Delta MW_{(t1/t2)}VG/KG = 0{,}197$; $p = 0{,}05$; $Cd = 0{,}50$) und *ML* ($\Delta MW_{(t1/t2)}VG/KG = 0{,}312$; $p < 0{,}01$; $Cd = 0{,}58$). Die Werte der *KL* sind nicht signifikant. Damit werden die Ergebnisse des zweistufigen Verfahrens teilweise unterstützt, unterscheiden sich jedoch bezüglich der *ML*. Hier findet im dreistufigen Verfahren eine weniger negative Veränderung im Vergleich zum zweistufigen Verfahren statt. Die gesamten Ergebnisse werden in *Tabelle 10* (siehe *Anhang N*) dargestellt.

4.4. Ergebnisse der hierarchischen Regressionsanalyse

Das dreistufige Experiment zielte primär darauf ab, mögliche Störeffekte durch die zeitliche Nähe des Vorher- (*t1*) und Nachher-Tests (*t2*) zu identifizieren. Zwischen *t1* und *t2* können nur sehr geringe Unterschiede bei einer sehr geringen Effektstärke (*MW < 0,10; Cd < 0,20*), festgestellt werden und nur der Unterschied der Sub-Kategorie *PL* in der KG weist signifikante, jedoch sehr geringe Werte auf. Daher wird geschlussfolgert, dass keine systematischen Methoden-Verzerrungseffekte in *Teil 1* des Experiments auftraten.

Für die multiple Regressionsanalyse wird für die Gesamtstichprobe aufgrund der größeren und heterogeneren Teilnehmerstruktur von einer höheren Robustheit für statistische Auswertungen ausgegangen. Ebenfalls lässt nur die Gesamtstichprobe einen Vergleich beider Experimentalgruppen zu. Somit wird für die Regressionsanalyse nur das zweistufige Format des Experiments (*Teil 1*) betrachtet. Um an die Darstellungsweise der vorherigen Kapitel anzuknüpfen, wird in

Tabelle 4: Deskriptive Werte der Mittelwertvergleiche Teil 2 (Quelle: Eigene Darstellung)

Teil 2 (dreistufig): Deskriptive Werte der Mittelwertvergleiche

	t1	$\Delta t1/t2$	*t2*	$\Delta t2/t3$	*t3*	*t1*	$\Delta t1/t2$	*t2*	$\Delta t2/t3$	*t3*
	Versuchsgruppe				$n = 47$	*Kontrollgruppe*				$n = 56$
Legitimität										
Pragmatische Legitimität										
Mittelwert	3,32	-0,04	3,28	-0,05	3,23	3,50	-0,24	3,26	-0,04	3,22
Standardabweichung	0,50		0,57		0,45	0,53		0,58		0,60
Moralische Legitimität										
Mittelwert	2,75	0,25	3,00	-0,15	2,85	2,85	-0,06	2,79	-0,01	2,78
Standardabweichung	0,52		0,63		0,60	0,61		0,64		0,64
Kognitive Legitimität										
Mittelwert	3,54	-0,19	3,35	0,05	3,40	3,54	-0,22	3,32	0,03	3,35
Standardabweichung	0,81		0,85		0,79	0,81		0,84		0,76
Organisationale Legitimität										
Mittelwert	3,21	0,003	3,21	-0,05	3,16	3,30	-0,18	3,12	0,00	3,12
Standardabweichung	0,43		0,53		0,46	0,54		0,59		0,54

Tabelle 5: ANVOVA Teil 2 (Quelle: Eigene Darstellung)

Teil 2: (dreistufig): 2 x 3 faktorielle ANOVA

	Pragmatische Legitimität		*Moralische Legitimität*		*Kognitive Legitimität*		*Organisationale Legitimität*	
	VG	*KG*	*VG*	*KG*	*VG*	*KG*	*VG*	*KG*
Mittelwerte								
t1	3,330	3,505	2,749	2,850	3,543	3,545	3,207	3,300
t2	3,279	3,257	3,000	2,789	3,351	3,326	3,210	3,124
t3	3,234	3,223	2,851	2,782	3,399	3,353	3,161	3,119
Mittelwertvergleich 1								
$\Delta(t1/t2)$	-0,051	-0,248	0,251	-0,061	-0,192	-0,219	0,003	-0,176
Signifikanz	1,000	*** 0,001	** 0,035	1,000	** 0,045	*** 0,005	1,000	*** 0,007
Effektgröße	0,038	0,161	0,137	0,012	0,132	0,090	0,012	0,121
Mittelwertvergleich 2								
$\Delta(t1/t3)$	-0,096	-0,281	0,102	-0,068	-0,144	-0,192	-0,046	-0,181
Signifikanz	0,579	*** 0,001	0,624	0,879	0,183	** 0,030	1,000	*** 0,005
Effektgröße	0,038	0,161	0,137	0,012	0,132	0,090	0,012	0,121
Mittelwertvergleich 3								
$\Delta(t2/t3)$	-0,045	-0,034	-0,149	-0,007	0,048	0,027	-0,049	-0,005
Signifikanz	1,000	*** 0,001	0,142	1,000	1,000	1,000	0,998	1,000
Effektgröße	0,038	0,161	0,137	0,012	0,132	0,090	0,012	0,121
Effektstärke								
Cohens d	0,038	0,163	0,138	0,012	0,133	0,090	0,012	0,122

***	p-Wert <,01	°°°	Cohens d >,80
**	p-Wert <,05	°°	Cohens d >,50-0,80
*	p-Wert <,10	°	Cohens d >,20-0,50

der deskriptiven Darstellung der für die Regressionsanalyse verwendeten Daten jedoch auch das dreistufige Experiment (*Teil 2*) aufgeführt.

Deskriptive Ergebnisse

Die Mittelwerte der Kontrollvariablen Alter und Berufserfahrung weisen für VG und KG sehr ähnliche Größenordnun-

gen auf ($MW_{(VG)} = 24,42$; $MW_{(KG)} = 24,81$; $SD_{(VG)} = 3,38$; $SD_{(KG)} = 3,95$). In *Teil 2* des Experiments sind die Werte etwas kleiner als in *Teil 1* ($MW_{(VG)} = 23,78$; $MW_{(KG)} = 23,93$; $SD_{(VG)} = 1,56$; $SD_{(KG)} = 1,67$). Die kleinere Standardabweichung in *Teil 2* kann auf die homogenere Zusammensetzung der Stichprobe zurückgeführt werden. Die durchschnittliche Praxiserfahrung der VG und KG ähnelt sich ebenfalls, allerdings ist hier der Unterschied der Standardabweichung höher ($MW_{(VG)} = 3,63$; $MW_{(KG)} = 3,48$; $SD_{(VG)} = 3,58$; $SD_{(KG)} = 4,21$).

Bezüglich der Verarbeitungszeit der VG kann bemerkt werden, dass auf Bilanz und GuV durchschnittlich am kürzesten zugegriffen wurde, ebenfalls liegt hier die geringste Standardabweichung vor (*MW = 40,58; SD = 31,63*). Auf die Ratings wurde durchschnittlich am längsten zugegriffen, jedoch liegt hier eine hohe Standardabweichung vor (*MW = 66,53; SD = 54,39*). Dabei ist festzuhalten, dass die Standardabweichung grundsätzlich sehr hohe Werte aufzeigt, was für eine breite Streuung der Daten spricht. Das Branchenrating der KG verzeichnete im Vergleich eine durchschnittliche Bearbeitungszeit von 58,7 Sekunden, bei einer Standardabweichung von 43,1 Sekunden. Für das einzige Dokument der KG (Branchenrating) wurde also mehr Zeit aufgewendet als durchschnittlich in der VG. Die deskriptiven Ergebnisse der Legitimitätsmittelwerte wurden bereits zuvor dargestellt, daher wird an dieser Stelle auf das vorherige Kapitel verwiesen. Die gesamten Ergebnisse werden als Zusammenfassung in *Tabelle 11* (siehe *Anhang O*) dargestellt.

Multiple (hierarchische) lineare Regressionsanalyse

Die multiple lineare Regressionsanalyse überprüft den linearen Zusammenhang zwischen einer a.V. und mehreren u.V. Als Voraussetzung der multiplen linearen Regressionsanalyse wurde vorab auf Multikollinearität getestet und keine hohe Korrelation der x-Variablen festgestellt. Weiter sind die Fehlerterme normalverteilt. Die Homoskedastizität wurde grafisch überprüft und es konnten keine homogen streuenden Varianzen des Fehlerterms festgestellt werden. Ebenfalls liegt keine Autokorrelation der Fehlerterme vor. Da die Werte der Verarbeitungszeit keinen natürlichen Nullpunkt enthalten und die Abweichung zu ihrem Mittelwert mehr Aussagekraft enthält als ihre reine Ausprägung, wurden diese mittelwertzentriert (Dalal & Zickar, 2012, S. 339).

Die Regression wurde zwecks Überprüfung des sich verändernden Erklärungsbeitrags hierarchisch durchgeführt, dabei wurden über mehrere Modellstufen weitere Prädiktoren ergänzt. In diesem Kontext wurde die durchschnittliche mittelwertzentrierte Verarbeitungszeit für VG und KG abgeleitet und als Prädiktor überprüft. Eine Differenzierung der einzelnen Transparenzdokumente wurde vorerst nicht vorgenommen, da sich diese nur auf die VG beziehen. Aufgrund der unterschiedlichen Transparenzangebote innerhalb VG und KG konnte ebenfalls angenommen werden, dass das Transparenzangebot als Moderator für den Effekt der durchschnittliche Verarbeitungszeit agiert. Um die Moderator-Variable zu operationalisieren, wurde diese mit den Werten eins für die VG und null für die KG als *Dummy-Variable* umkodiert. *Modell 2.4* zielt auf den sogenannten Interaktionseffekt ab. Alle Modelle wurden jeweils für die Sub-Kategorien $\Delta PL_{(t1/t2)}$, $\Delta ML_{(t1/t2)}$ und $\Delta KL_{(t1/t2)}$ sowie für das Gesamtkonstrukt $\Delta OL_{(t1/t2)}$ überprüft. Nachfolgende Auflistung beschreibt die schrittweise Durchführung; eine schematische Übersicht bietet *Modell 2* in *Abbildung 3* (siehe *Kapitel 3.3.4*):

- *Modell 2.1:* Kontrollvariablen.
- *Modell 2.2:* Kontrollvariablen und ∅-Verarbeitungszeit.
- *Modell 2.3:* Kontrollvariablen, ∅-Verarbeitungszeit und Transparenzangebot (Moderator).
- *Modell 2.4:* Kontrollvariablen, ∅-Verarbeitungszeit, Transparenzangebot (Moderator) und Interaktionseffekt zwischen ∅-Verarbeitungszeit und Transparenzangebot.

Gemessen wurde der sogenannte Regressionskoeffizient (β), welcher der Veränderungsausprägung der a.V. (*Legitimitätsdifferenz* zwischen *t1* und *t2*) bei einem Anstieg der u.V. (*Transparenzangebot*) um einen Wert bei entsprechendem Konfidenzniveau (*p-Wert, t-Wert*) entspricht. Das Bestimmtheitsmaß (R^2) und die Varianzabweichung (*F-Modell, p-Wert*) bestimmen die Aussagekraft des jeweiligen Modells.

Die Ergebnisse zeigen lediglich signifikante Werte für die u.V. *Transparenzangebot* bei der Veränderung der a.V. Δ *OL* (*Modell 2.3: $\beta = 0,157$; $p < 0,05$; $t = 2,595$ und Modell 2.4: $\beta = 0,157$; $p < 0,05$; $t = 2,587$*) und Δ *ML* (*Modell 2.3: $\beta = 0,236$; $p < 0,01$; $t = 3,188$ und Modell 2.4: $\beta = 0,236$; $p < 0,01$; $t = 3,179$*). Dabei sind jedoch nur zwei Gesamtmodelle der Δ *ML* signifikant, bei einem Erklärungsbeitrag von 7,9 % (*Modell 2.3*) und 8,2 % (*Modell 2.4*). Daher kann geschlussfolgert werden, dass ein höheres Transparenzangebot zu einem größeren Unterschied der *OL* zwischen *t1* und *t2* führt. Der Effekt fällt jedoch klein aus ($\beta = 0,157$). Für den Unterschied der *ML* ergibt sich ein ähnliches Bild, bei einem leicht größeren Effekt. Ein größeres Transparenzangebot führt demnach zu einer Steigung der wahrgenommenen *OL* und *ML* bei den Teilnehmer:innen.

Die durchschnittliche Verarbeitungszeit hat jedoch keinen signifikanten Einfluss und ebenfalls sind ihre Regressionskoeffizienten nahe dem Wert null. Die Annahme eines systematischen prädiktiven Einflusses der durchschnittlichen Verarbeitungszeit wird demnach nicht unterstützt. Die gesamten Ergebnisse der multiplen Regressionsanalysen je Legitimitätsdimension finden sich in den *Tabellen 12* bis *15* (siehe *Anhang P* bis *S*).

Da das Transparenzangebot als signifikanter Prädiktor mit leicht positivem Einfluss auf die Legitimitätsdifferenz identifiziert werden konnte, wurde ebenfalls eine stufenweise multiple lineare Regression isoliert innerhalb der VG (*n = 108*) durchgeführt. Diese sollte ein differenzierteres Bild der Verarbeitungszeit der einzelnen vorgelegten Dokumente ermöglichen. Dabei enthielt die erste Stufe wieder die Kontrollvariablen und die zweite Stufe die Verarbeitungszeitwerte je Informations-Kategorie. In den Ergebnissen konnte jedoch keinerlei Signifikanz der Variablen wie auch der Gesamt-

modelle festgestellt werden. Von einer näheren Betrachtung wurde entsprechend abgesehen.

4.5. Überprüfung der Hypothesen

Aufgrund der zuvor beschriebenen Erläuterung, dass ein Störeffekt durch den *Common Method Bias* als unwahrscheinlich eingestuft wurde und das zweistufige Experiment aufgrund der größeren Stichprobe und der höheren externen Validität als robuster angenommen wird, beziehen sich die Überprüfungen der Hypothesen *H1* bis *H3* vorrangig auf *Teil 1* des Experiments. Die Ergebnisse des dreistufigen Experiments (*Teil 2*) werden dennoch unterstützend bzw. einschränkend im Kontext der jeweiligen Hypothesen diskutiert. *Tabelle 6* am Ende des Kapitels fasst die nachfolgend beschriebene Überprüfung der Hypothesen zusammen.

Hypothese 1 (inkl. der Sub-Hypothesen)

Bei einer abschließenden Betrachtung für das zweistufige Experiment wurde *H1* samt der Sub-Hypothesen *H1a* und *H1c* widerlegt, da sich die wahrgenommene Legitimität für alle Konstrukte von *t1* auf *t2* bei geringer bis mittlerer Effektstärke in der KG signifikant verringert. Sub-Hypothese *H1b* (*ML*) muss aufgrund fehlender Signifikanz verworfen werden (siehe *Tabelle 3* in *Kapitel 4.2*).

Das dreistufige Experiment unterstützt diese Aussagen und zeigt ähnliche Ergebnisse. Demnach ist eine negative Entwicklung der wahrgenommenen Legitimität zu beobachten, welche bis auf die *ML* signifikante Werte aufweist. Lediglich die *PL* zeigt einen signifikanten Rückgang von *t2* auf *t3*, was einerseits auf einen Verzerrungseffekt zwischen *t1* und *t2* oder einer grundsätzlich volatileren Wahrnehmung der *PL* hinweisen könnte (siehe *Tabelle 5* in *Kapitel 4.3*).

Hypothese 2 (H2 bis H2c)

Im zweistufigen Experiment sinken in der VG die Konstrukte *OL*, *PL* und *KL*, während die *ML* steigt. Dabei muss *H2* sowie *H2a* verworfen werden, da die Ergebnisse der *OL* und *PL* keine signifikanten Werte aufweisen. *H2c* kann widerlegt werden, da die *KL* entgegen der Annahme signifikant sinkt. *H2b* zeigt jedoch eine signifikant positive Entwicklung der *ML* bei allerdings geringer Effektstärke, womit die Hypothese, dass ein hohes Transparenzangebot zu einer erhöhten *moralischen Legitimität* führt, vorläufig bestätigt werden kann (siehe *Tabelle 3* in *Kapitel 4.2*).

Das dreistufige Experiment unterstützt die Ergebnisse auch in diesem Fall und zeigt keine signifikanten Ergebnisse für die Konstrukte *OL* sowie *PL* sowie ein signifikant negatives Ergebnis für die *KL* und ein signifikant positives Ergebnis für die *ML*. Eine signifikante Veränderung von *t2* auf *t3* konnte hier nicht beobachtet werden (siehe *Tabelle 5* in *Kapitel 4.3*).

Hypothese 3 (inkl. der Sub-Hypothesen)

Für die dritte Hypothese kann im zweistufigen Verfahren eine teilweise weniger negative Veränderung der Legitimität von *t1* auf *t2* in der VG im Vergleich zur KG festgestellt werden. Aufgrund des weniger negativen und daher positiveren signifikanten Effekts für die Konstrukte *OL* und *PL* bei geringer bis mittlerer Effektstärke können *H3* sowie *H3a* vorläufig bestätigt werden. Da die *ML* sich in der VG stärker signifikant negativ verändert, kann *H3b* widerlegt werden. Ebenso zeigt die Veränderung der *KL* keine signifikanten Werte, *H3c* muss daher verworfen werden.

Im dreistufigen Experiment zeigen sich ähnliche Ergebnisse für *OL*, *PL* und *KL* bei einer mittleren Effektstärke und unterstützen damit die Hypothesenbewertungen *H3*, *H3a* und *H3c* aus *Teil 1*. Für die *ML* kann hier jedoch ebenfalls eine deutlich positivere Veränderung in der VG im Vergleich zu KG festgestellt werden, was demzufolge *H3b* unterstützen würde. Die Überprüfung von *H3b* fällt in diesem Modell demnach nicht eindeutig aus. Eine signifikante Veränderung der Mittelwertveränderungen von *t2* auf *t3* konnte auch hier nicht beobachtet werden (siehe *Tabelle 10* in *Anhang N*).

Hypothese 4 (inkl. der Subhypothesen)

Die multiplen linearen Regressionsanalysen der einzelnen Legitimitäts-Dimensionen zeigen keinen signifikanten Einfluss der durchschnittlichen Verarbeitungszeit und deren Interaktionseffekt mit dem Transparenzangebot für die Gesamtstichprobe auf. Ebenso konnten keine signifikanten Werte für die isolierte Stichprobe der VG in Bezug auf die durchschnittliche Bearbeitungszeit der unterschiedlichen Informationsarten und deren Interaktionseffekt mit dem Transparenzangebot festgestellt werden. Die Hypothesen *H4*, *H4a*, *H4b* und *H4c* müssen daher verworfen werden (siehe *Tabellen 12* bis *15* in *Anhang P* bis *S*).

5. Limitationen und weiterer Forschungsbedarf

Den Schlussfolgerungen dieser Arbeit sind gewisse Grenzen gesetzt. Für die vorliegenden Ergebnisse wird ihre Generalisierbarkeit als grundsätzliche Einschränkung identifiziert. Zu spezifizieren sind das eng gefasste Untersuchungsumfeld, die homogene Stichprobe und die Problematik der Erfassung der wahrgenommenen Legitimität. Außerdem bieten Limitationen im methodischen Aufbau der Arbeit Erweiterungsmöglichkeiten.

Untersuchungsumfeld und Stichprobe

Das Untersuchungsumfeld beschränkt sich hinsichtlich der Branche (Luftverkehr), der Geografie (Österreich) und des entsprechenden kulturellen Raums. Gesellschaftliche Normen und rechtliche Praktiken definieren daher den grundsätzlichen Korridor der Möglichkeiten. Es liegen bereits Erwartungen und ein allgemeines Verständnis von Transparenz und Legitimität über und von Unternehmen vor, welche sich für andere Branchen und geografischen Kontexte unterscheiden könnten. Die Einschränkungen des Untersuchungsumfeldes werden durch die spezifische Stichprobe noch einmal verstärkt. Dieser Sachverhalt wird von Humphreys und LaTour (2013, S. 773) speziell für die Wahrnehmung von Legitimität dargestellt und trifft demnach auch auf diese Arbeit zu. Daher könnte die Stichprobe in den gemessenen Parametern heterogener sein. Personen mit hohem

Tabelle 6: Übersicht der Hypothesenbeantwortungen (Quelle: Eigene Darstellung)

Hypothese	*a.V.*		*u.V.*		*vorläufig bestätigt*	verworfen	
						signifikant	*nicht signifikant*
H1	Transparenzangebot	(-)	OL	(+)		×	
H1a	Transparenzangebot	(-)	PL	(+)		×	
H1b	Transparenzangebot	(-)	ML	(+)			×
H1c	Transparenzangebot	(-)	KL	(+)		×	
H2	Transparenzangebot	(++)	OL	(+)			×
H2a	Transparenzangebot	(++)	PL	(+)			×
H2b	Transparenzangebot	(++)	ML	(+)	×		
H2c	Transparenzangebot	(++)	KL	(+)		×	
H3	Δ OL (T++)	positiver als	Δ OL	(T-)	×		
H3a	Δ PL (T++)	positiver als	Δ PL	(T-)	×		
H3b	Δ ML (T++)	positiver als	Δ ML	(T-)		*nicht eindeutig*	
H3c	Δ KL (T++)	positiver als	Δ KL	(T-)			×
H4	ø-Verarbeitungszeit	(++)	Δ OL	(-)			×
H41	ø-Verarbeitungszeit	(++)	Δ PL	(-)			×
H4b	ø-Verarbeitungszeit	(++)	Δ ML	(-)			×
H4c	ø-Verarbeitungszeit	(++)	Δ KL	(-)			×

- niedrig (a.V.); gesunken (u.V.)
+ erhöht
++ hoch
T Transparenzangebot

Bildungsniveau sind überrepräsentiert, da die überwiegende Mehrheit der Teilnehmer:innen Studierende waren und auch die Fachrichtung begrenzt sich hauptsächlich auf den Bereich der Wirtschaftswissenschaften. Künftige Forschungsarbeiten sollten die beschriebenen Phänomene daher mit einer heterogeneren Stichprobe untersuchen (Massey, 2001, S. 168).

Legitimitätserfassung

Organisationale Legitimität ist ein nicht beobachtbares und daher schwer erfassbares Konzept. Sie muss daher über Hilfs-Konstrukte, wie die verwendeten Likert-basierten Fragen, operationalisiert werden. Die indirekte Messung eines Konstrukts ist naturgemäß störanfällig. Bezogen auf die Teilnehmer:innen, sind die Interpretationen abhängig von den individuellen Urteilen, welche u.a. auf Einstellungen, Werten und Wahrnehmungen basieren (Suchman, 1995, S. 574). Auch wenn im vorliegenden Fall auf bereits existierende und entsprechend ausgereifte Fragebögen zurückgegriffen wurde, so kann nicht final ausgeschlossen werden, dass in dieser Arbeit eine Verzerrung der Ergebnisse durch entsprechende individuelle Faktoren der Teilnehmer:innen vorliegt. Dieses Argument wird noch verstärkt durch die Übersetzung der meisten Fragen aus dem Englischen sowie der Anpassung des Fragebogens durch die Aufnahme von handlungsorientierten Fragen als Teil der *pragmatischen Legitimität*.

Methodischer Aufbau

Der methodische Aufbau dieser Arbeit bildet die Möglichkeiten im Rahmen der experimentellen Erhebung von Daten im Kontext einer Master-Thesis ab. Diese sind jedoch mit Einschränkungen verbunden. Um die Auswirkungen der unterschiedlich klassifizierten Transparenzangebote genauer überprüfen zu können, wäre eine differenziertere Einteilung in weitere Experimentalgruppen sinnvoll. Auch könnte das quantitative Niveau der Transparenzangebote stärker variieren und einen möglichen Sättigungseffekt des Transparenzangebots in Bezug auf die wahrgenommene *organisationale Legitimität* näher überprüfen. Da unter den gegebenen Umständen jedoch das Risiko bestand, dass eine nicht ausreichende Stichprobengröße pro Gruppe zustande käme, wurde auf diese Variante verzichtet. Für zukünftige Forschungsarbeiten sollten daher die Informationstypen isoliert betrachtet und um weitere Experimentalgruppen, unterschiedlicher quantitativer Transparenz-Niveaus, ergänzt werden.

Es muss außerdem berücksichtigt werden, dass in beiden Experimentalgruppen die wahrgenommene *KL* sinkt,

die sich laut Kumar und Das (2007, S. 1443) nur sehr langsam verändert. Demnach könnte argumentiert werden, dass die Teilnehmer:innen *Air Vienna* in *t1* aufgrund mangelnder Informationslage in der Ausgangssituation einen Legitimationsvorschuss gewährt haben, welcher anschließend in *t2* von den Teilnehmer:innen wieder zurückgenommen wurde. Demnach hätte sich die tatsächliche Wahrnehmung der Teilnehmer:innen erst in *t2* eingestellt und die Ergebnisse des Experiments wären ein statistisches Artefakt, welches nur schwer interpretiert werden könnte. Da die Teilnehmer:innen allerdings keine Informationen über das Forschungsziel des Experiments erhielten und ihnen ebenfalls innerhalb kurzer Zeit viele unterschiedliche Fragen und Informationen in randomisierter Reihenfolge gezeigt wurden, kann zumindest nicht davon ausgegangen werden, dass der möglicherweise gewährte Legitimationsvorschuss vorsätzlich berücksichtigt wurde. In zukünftigen experimentellen Forschungen zu diesem Thema könnte daher eine umfassendere Beschreibung einer Ausgangssituation in Betracht gezogen werden.

Schließlich muss darauf hingewiesen werden, dass die Verarbeitung der Versuchsmaterialien stark von ihrem Charakter abhängt. Da die Materialien eigens für das Experiment erstellt wurden, kann nicht vollends kontrolliert werden, welchen Effekt diese auf die Wahrnehmung der gesamten Stichprobe haben, ohne andere mögliche Störeffekte auszulösen. Eine Möglichkeit wäre die Durchführung einer umfassenderen Vorab-Studie zur Weiterentwicklung der Versuchsmaterialien.

6. Diskussion

Hypothesen 1 und 2 (inkl. der Subhypothesen)

Die intuitive Hypothese, dass ein erhöhtes Transparenzangebot zu einer erhöhten wahrgenommenen *OL* samt Sub-Kategorien führt, wurde in dieser Arbeit auch aus der Literatur abgeleitet. Dennoch konnte die Annahme nur für die Veränderung der *ML* innerhalb der VG bestätigt werden. Für die *KL* beider Gruppen sowie für die *OL* und *PL* der KG kann sogar ein signifikant gegenteiliger Effekt, sprich eine Verringerung der wahrgenommenen Legitimität, festgestellt werden. Für die negativen Veränderungen der Hauptkategorie *OL* in der VG ist die Mittelwertdifferenz besonders gering und aufgrund der fehlenden Signifikanz nicht systematisch. Es kann also davon ausgegangen werden, dass diese auf einem gleichen Niveau bleibt. Ein ähnliches Bild zeigt sich für die nicht signifikant negativen Werte der *PL* innerhalb der VG und der *ML* innerhalb der KG.

Auch in der Literatur finden sich Argumentationen, die gegen eine positive Beziehung zwischen Transparenz und Legitimität sprechen. Nach De Fine Licht et al. (2014, S. 111) ist die Annahme, mehr Transparenz führe zu mehr Legitimität geradezu naiv und müsse wesentlich differenzierter betrachtet werden. So kann mehr Transparenz zwar bei Entscheidungsprozessen die Legitimität erhöhen, aber Offenheit nicht grundsätzlich als legitimitätsstiftend angenommen werden. Heimstädt (2017, S. 79) schlussfolgert, dass die Durchsetzung organisatorischer Transparenz letztlich ein Balanceakt zwischen Legitimität und Macht sowie sozialer Position ist. Horvath und Katuscakova (2016, S. 5625) stellen außerdem fest, dass die Auswertung von Umfragewerten der Europäischen Zentralbank (EZB) einen nichtlinearen Zusammenhang zwischen der von der EZB bereitgestellten Transparenz zum Vertrauen in diese aufzeigt. Ihre Ergebnisse legen nahe, dass die Steigerung des Vertrauens bei zunehmender Transparenz abnimmt. Dies unterstützt die Argumentation Ashforth und Gibbs (1990, S. 190), die davon ausgehen, dass Legitimierungsstrategien bei zu viel Anstrengung auch ins Gegenteil umschwenken und einen negativen Effekt auf die wahrgenommene Legitimität eines Unternehmens haben. Demnach führt Transparenz anfangs zu mehr und ab einem gewissen Punkt zu sinkendem Vertrauen der Bevölkerung. Technisch gesehen existiert damit ein optimales Level organisationaler Transparenz (Hermalin, 2014, S. 2). Dieser Zusammenhang wird in der Literatur auch als *„umgekehrte U-Hypothese“* beschrieben (Zhao, Benbasat & Cavusoglu, 2019). Weiter ist auch die bereits in den Limitationen angesprochene fehlgeleitete Signalwirkung zu erwähnen, die bei Inkonsistenz zu einem Legitimitätsabschlag führen kann (Massey, 2001, S. 168).

Weitere Autoren gehen außerdem noch differenzierter auf die unterschiedlichen Sub-Kategorien der Legitimität ein. Deephouse et al. (2017, S. 42) verknüpfen die *pragmatische* Legitimitätsebene mit der Unternehmensleistung. Demnach führen Herausforderungen der Leistung wie des finanziellen Unternehmensergebnisses zu Herausforderungen für die *pragmatische Legitimität*. Um ein glaubwürdiges Gesamtbild zu schaffen, wurden die Finanzergebnisse im Versuchsmaterial für die VG pandemiebedingt negativ mit positivem Ausblick dargestellt. Dieses Signal könnte speziell durch die Kleininvestor:innen-Rolle der Teilnehmer:innen zu einer Verringerung der *PL* geführt haben[4], bietet jedoch keine Erklärung für die KG. Möglicherweise führten hier die fehlenden Finanzinformationen dazu, dass aus Investor:innen-Rolle die Glaubwürdigkeit des Unternehmens sank und dementsprechend zu einem Legitimitätsabschlag führte (Bachmann & Ingenhoff, 2017, S. 79). Bezügliche der gestiegenen *ML* in der VG bieten die Befunde Milne und Patten (2002, S. 63) eine passende Erklärung. Nach den Autoren führen besonders sozial-ökologische Informationen zu einem positiven Effekt auf die wahrgenommene moralische Ebene der Legitimität. Die Ergebnisse der KG stützen dieses Argument, da hier ein sehr geringer nicht signifikanter Rückgang der Legitimität zu verzeichnen war. Demnach kann davon ausgegangen werden, dass es in der KG zu keiner systematischen Veränderung der *ML* kam, was auf die fehlenden sozial-ökologischen Informationen zurückführbar sein könnte (Coupland, 2005, S. 356). Die signifikante Verringerung der *kognitiven Legitimität* für VG und KG ist besonders überraschend. Aufgrund ihrer

[4] Wird dieser Annahme gefolgt, kann die einseitige Signifikanz der Veränderung der PL berücksichtigt werden, welche eine signifikante, leicht negative Entwicklung zwischen $t1$ und $t2$ aufzeigt.

sehr komplexen Verankerung im persönlichen Wertesystem kann davon ausgegangen werden, dass diese sich bei steigender Informationsmenge nur mäßig verändert (Kumar & Das, 2007, S. 1429). Die gegenteiligen Ergebnisse dieser Arbeit könnten darin begründet liegen, dass die Ausgangslage aus Sicht der Teilnehmer:innen nicht genügend Informationen enthielt, um eine abschließende Bewertung der *KL* vorzunehmen. Für dieses Argument spricht auch die unterdurchschnittliche Veränderung der „*Ich weiß nicht*"-Werte der *KL* zwischen *t1* und *t2* um nur ca. 30% in beiden Gruppen, welche auch absolut betrachtet mit zehn Zählungen in der VG und neun Zählungen in der KG ein geringes Ausmaß annehmen. Es zeigt sich, dass es eine Reihe an Erklärungen für Verringerung der Legitimitätswerte bzw. eine Steigerung der *ML* ergeben, die sich durch eine Vielzahl an Variablen erklären lassen könnten. Eine abschließende und pauschale Beurteilung der Wirkungsweise ist daher kaum möglich.

Hypothese 3 (inkl. der Subhypothesen)

Für *H1* und *H2* ist vor allem die Ausgangslage und ihr Effekt auf die Wahrnehmung der Legitimität in *t1* ausschlaggebend. Die zur Beantwortung von *H1* und *H2* herangezogenen abhängigen Mittelwertdifferenzen zwischen den Messzeitpunkten der Experimentalgruppen lassen daher nur begrenzt Aussagen über die Wirkungsweise des unterschiedlichen Transparenzangebots zu. Zur Beantwortung von *H3* wurde daher die Veränderung der Legitimität zwischen den Zeitpunkten und den Experimentalgruppen herangezogen, welche eine Aussage über die Wirkweise der Transparenzangebote zulässt.

Auch wenn die wahrgenommene Legitimität der Teilnehmer:innen für alle Dimensionen bis auf die *ML* der VG sinkt, so verringert sich die Legitimität der VG im Vergleich zur KG weniger stark negativ. Dabei sind die Differenzen der *OL* sowie *PL* signifikant und verändern sich entsprechend der Annahmen des Untersuchungsmodells. Die *ML* zeigt nur signifikante Werte bei den homogeneren Teilnehmer:innen des dreistufigen Experiments. Dies könnte sich durch die angesprochene positive Wirkung von sozial-ökologischen Informationen erklären lassen (Milne & Patten, 2002, S. 63). Im Rahmen des Projektes *Climate of Change*[5] gaben die befragten jungen Menschen (15–35 Jahre) den Klimawandel als größte aktuelle Herausforderung der Menschheit an (Südwind, 2021, S. 3). Nach Ferber (1977, S. 58) werden von Experimental-Teilnehmer:innen vor allem bezugsfähige Inhalte verarbeitet. In diesem Kontext kann argumentiert werden, dass aufgrund des jüngeren und homogeneren Durchschnittsalters der Teilnehmer:innen im dreistufigen Verfahren (Master-Studierende des Kurses *Organizational Behavior* der WU) eine gesteigerte Aufmerksamkeit auf den sozial-ökologisch relevanten Informationen lag. Da diese Informationen nur in der VG vorhanden waren, verringerte sich die *ML* dieser Logik folgend weniger negativ im Vergleich zur KG.

Die nicht signifikante Veränderung der *KL* in beiden Experimentalgruppen unterstützt die Argumentation Kumar und Das (2007, S. 1429). Demnach ändert sich die *KL* im Gruppenvergleich nicht systematisch abhängig von Menge oder Inhalt des Transparenzangebots und folgt der vorgeschlagenen Wirkungsweise der Autoren.

Hypothese 4 (inkl. der Subhypothesen)

Für die Überprüfung der H4 wurde bei einem signifikanten Gesamtmodell lediglich ein signifikant positiver Effekt der Transparenz auf die *ML* festgestellt. Das Modell lieferte jedoch nur einen überschaubaren Erklärungsbeitrag von 7,9 % (siehe *Tabelle 14* in *Anhang R*). Dieser Zusammenhang stützt die im vorigen Absatz postulierte Wirkweise des Transparenzangebots auf die *ML*. Der Einfluss der Verarbeitungszeit auf die wahrgenommene *organisationale Legitimität* und ihrer Sub-Kategorien konnte nicht festgestellt werden. Demnach muss dem in der Hypothesenentwicklung postulierten Zusammenhang widersprochen werden. Gerade das Vorhandensein der Informationen scheint der ausschlaggebende Faktor für die Verringerung des Legitimitätsabschlags zu sein. Demnach haben die Teilnehmer:innen die Signale als Ersatz für verdeckte Informationen empfunden. Es kann daher weiter angenommen werden, dass das Transparenzangebot von den Empfängern als glaubwürdig genug eingestuft wurde, um nicht an der Echtheit des Signals zu zweifeln (Connelly et al., 2011, S. 54).

7. Conclusio

Transparenz und Legitimität sind zwei schillernde Begriffe – so mag Transparenz zwar durchsichtig, aber auch verdeckt sein, während Legitimität so abstrakt definiert ist, dass eine trennscharfe Erfassung kaum möglich scheint (Deephouse et al., 2017, S. 27; Fox, 2007, S. 667–668). Dennoch sind beide Konzepte im organisationalen Kontext nicht wegzudenken und liefern wertvolle Erklärungen für das Handeln der Akteure innerhalb und außerhalb von Organisationen. Umso interessanter erscheint ihr Zusammenhang. Die Beantwortung der Frage nach dem Effekt von Transparenz auf Legitimität kann basierend auf den empirischen Ergebnissen dieser Arbeit jedoch nicht pauschal erfolgen, sondern muss differenziert betrachtet werden.

Die Wirkung von Transparenz in Form von unternehmensintern und -extern bereitgestellten Informationen auf die wahrgenommene *organisationale Legitimität* einer zentralen Anspruchsgruppe folgt zunächst nicht der intuitiven Erwartung, dass eine steigende Menge an Informationen auch zu einem Anstieg der individuell wahrgenommenen *organisationalen Legitimität* führe. Ganz im Gegenteil zeigt die signifikante Verringerung des Hauptkonstrukts der *organisationalen Legitimität* in beiden Experimentalgruppen (geringes sowie hohes Transparenzangebot) im zwei- sowie dreistufigen Experiment, dass für fast alle Legitimitäts-Dimensionen nach der Einführung weiterer Informationen ein negativer Effekt eintritt – getreu dem Aphorismus „*Reden*

[5] Europaweites von der Europäischen Union (EU) unterstütztes Projekt zur Unterstützung der Bewusstseinsentwicklung über aktuelle humanitäre und ökologische Krisen. In Österreich wird das Projekt von der Nichtregierungsorganisation *Südwind* umgesetzt (Südwind, 2021).

ist Silber, Schweigen ist Gold". Lediglich die *moralische Legitimität* der Versuchsgruppe (erhöhtes Transparenzangebot) steigt signifikant. Die Betrachtung des Vergleichs zwischen einem hohen und niedrigen Transparenzangebot liefert hier ergänzende Erkenntnisse. Demnach führt ein höheres Transparenzangebot zu einer weniger stark sinkenden *organisationalen*, *pragmatischen* und *moralischen*[6] *Legitimität*. Die *kognitive Legitimität* ändert sich hier nicht systematisch, was der erwarteten Wirkungsweise entspricht. Folglich kann zusammengefasst werden, dass ein höheres Angebot an Transparenz zwar nicht automatisch zu mehr Legitimität führt, ein erhöhtes Transparenzangebot sich auf die wahrgenommene Legitimität jedoch positiver auswirkt als ein niedriges Transparenzangebot. Dies könnte für Unternehmen implizieren, sich in ihrer Kommunikationsstrategie vor allem auf Informationen zu fokussieren, die mutmaßlich einen positiven Effekt auf ihre Legitimität ausüben. In diesem Kontext besonders relevant scheint die aktuelle Debatte zum sogenannten *Greenwashing*[7] von Unternehmen (Die Zeit, 2021). Gegen eine Berichterstattung positiver Nachrichten spricht erst einmal nichts. Jedoch sollte diese auf Fakten beruhen, um keinen Reputationsschaden zu erleiden (Naderer, Schmuck & Matthes, 2017, S. 110). Ebenso sollte eine einseitige und damit unausgewogene Kommunikationspolitik in diesem Kontext kritisch betrachtet werden.

Für die Wirkungsweise der transparenzschaffenden Signale zeigt sich, dass die Verarbeitungszeit keinen Einfluss auf die Legitimität hat. Das reine Vorhandensein des Signals scheint also auszureichen, um die wahrgenommene Legitimität in der Versuchsgruppe positiver zu beeinflussen als in der Kontrollgruppe. Es kann argumentiert werden, dass es bei der Informationsdarstellung primär um die Möglichkeit der schnellen Erfassung durch den Empfänger ankommt und somit für die möglichst effiziente Kommunikationspolitik von Unternehmen ein Minimalprinzip in Betracht gezogen werden sollte (Ware, 2019, S. 3–6).

Basierend auf den Auswertungen eignet sich Transparenzmanagement im Rahmen der Kommunikationsstrategie eines Unternehmens, um die wahrgenommene Legitimität zentraler Stakeholder zu beeinflussen. Hierbei wird vor allem die Legitimationsstrategie der *Kreation* durch die Erschaffung und Verbreitung von Wissen über das Unternehmen angesprochen. Im Rahmen der *Konformitätsstrategie* muss vor allem auf Signale reagiert werden, die externen Ursprung haben, um keine Einbußen hinsichtlich Glaubwürdigkeit, Reputation und Vertrauen hinnehmen zu müssen. Als übergreifende Implikation für die Praxis lässt sich daher an die Handlungsempfehlung von Mayrhofer und Meyer (2020, S. 155) anknüpfen, dass Transparenzbemühungen in Organisationen vor allem eine klare Transparenzstrategie benötigen, die nicht beabsichtigte Nebenwirkungen einbezieht. Dabei müssen Fakten und deren Verwendung im alltäglichen Handeln im Blick behalten werden.

[6] Eine Steigerung der *moralischen Legitimität* konnte nur für das dreistufige Experiment festgestellt werden. Im zweistufigen Experiment sinkt die *moralische Legitimität*, jedoch um einen nur sehr geringen Wert von 0,02. Eine mögliche Erklärung ist das zuvor angeführte gesteigerte sozial-ökologische Bewusstsein junger Menschen in Österreich.

[7] *Greenwashing* beschreibt positive CSR Kommunikation in Kombination mit schlechter CSR Leistung und die vorrangige Nutzung der CSR Aktivitäten als Werbemaßnahmen (He, Wang, Wang, Xie & Chen, 2022, S. 349; Wu, Zhang & Xie, 2020, S. 3095).

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Discussion of automotive trends and implications for German OEMs

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Abstract

The rapid change in the automotive industry, largely triggered by four disruptive trends – autonomous driving, connectivity, electrification, and shared mobility (ACES) – poses major challenges for incumbent players. This thesis aims to provide a comprehensive literature review of these four trends and to discuss implications for German original equipment manufacturers (OEMs). To do so we use the structure of Strengths-Weaknesses-Opportunities-Threats (SWOT) analysis and apply both qualitative and quantitative methods. Furthermore, we introduce new frameworks that shall support companies in make-or-buy decisions and competitor analyses. To this end, we present a new metric that provides information on the innovative capacity of OEMs – the ACES Index. We conclude the following: (1) German OEMs can use their financial power, brand popularity, and global presence to conquer new markets. (2) The organizational structures of German OEMs slow down their innovative power in identifying and developing disruptive trends, which is why they had to give up their leading position to new competitors. (3) The ACES Index has a decisive influence on the market capitalization of an automotive company, which is why German OEMs should integrate future-relevant technologies into their value chains by developing their own capabilities or establishing partnerships.

Keywords: Automotive trends; Autonomous driving; Electric vehicle; Shared mobility; German OEMs.

1. Introduction

The automotive industry is transforming at an immense pace due to disruptions from various fields. On the one hand, new technologies enable growing levels of automated driving and improved connectivity features, which increases safety (Fagnant & Kockelman, 2015), reduces emissions (Khondaker & Kattan, 2015; Zohdy & Rakha, 2016), and enables drivers and passengers to interact with their cars in entirely new ways (Bertoncello, Martens, Möller, & Schneiderbauer, 2021). On the other hand, the automotive industry plays a major role in the fight against climate change and must therefore drastically reduce its carbon dioxide (CO_2) emissions (European Parliament, 2019; Rogelj et al., 2016), leading to a shift from traditional internal combustion engine vehicles (ICEVs) to battery-powered electric vehicles (EVs) (Bernhart et al., 2019; Irle, 2021; Rietmann, Hügler, & Lieven, 2020). In addition, completely new mobility business models have emerged over the last decade, including on-demand ride services (Cramer & Krueger, 2016; Dudley, Banister, & Schwanen, 2017; Hensley, Padhi, & Salazar, 2017), car-sharing (Münzel, Boon, Frenken, & Vaskelainen, 2018; Zhou et al., 2020), or subscription-based full-service ownership options (Brenner, Seyger, Dressler, & Huth, 2018).

Incumbent automotive companies have noticed that a successful deployment of these four trends – autonomous driving, connectivity, electrification, and shared mobility, frequently referred to by the acronym *ACES* (Holland-Letz, Kässer, Kloss, & Müller, 2019) – will require massive efforts. In addition, they have to respond to macroeconomic challenges such as the rise of e-commerce, saturated core markets, and ever-increasing competition. Being successful in the future, thus not only requires the development of new products or technologies but rather a complete enterprise-wide transformation to a “new mobility” company. A good example of this was provided by Volkswagen AG (Volkswagen), which announced its innovation roadmap for the next few years with an elaborate media event – the "Power Day" (Volkswagen AG, 2021b).

It is important to note that all trends are still at an early point in their product life cycles (Bertoncello et al., 2021; Bloomberg, 2020b; Irle, 2021). However, since last year, which was largely marked by the impact of the global COVID-

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19 pandemic, future trends have been gaining momentum. This manifests itself in a huge growth in EV sales (Irle, 2021), increasing levels of digitization in different business sectors (Sinha, 2020), and major innovations in the service sector (Heinonen & Strandvik, 2021). As a consequence, automotive companies, also referred to as original equipment manufacturers (OEMs), that fail to take advantage of the four ACES trends and the associated profit opportunities will find it difficult to stay competitive. Although it is hard to imagine that today's successful and established companies will disappear, past experience shows that especially these companies face serious problems when markets change abruptly due to disruptive innovations (Christensen, 2013).

This particularly threatens the economies of countries like Germany, which are heavily dependent on the automotive industry, as it contributes massively to the gross domestic product (GDP) and provides employment for 830,000 people (Bundesministerium für Wirtschaft, 2020). One important reason for this is that Germany is home to some of the world's best-known OEMs, including Volkswagen, Daimler AG (Daimler), and Bayerische Motoren Werke AG (BMW) and many of their subsidiaries.[1] Therefore, it is of great economic interest to secure the future viability of these companies.

The objective of this thesis is twofold. Firstly, it aims to broaden the reader's understanding of the four ACES trends and, secondly, to discuss how these trends will affect German OEMs. Since this discussion encompasses multiple aspects, we approach it by defining a series of questions, which are:

(1) What unique assets do German OEMs possess that put them in an advantageous position when it comes to implementing new trends?
(2) How do their organizational structures influence the way they respond to disruptive trends?
(3) Which emerging markets and profit pools offer attractive business potential given their capabilities?
(4) How can make-or-buy decisions about disruptive technologies be answered in the modern business world?
(5) How can competitors be clustered and who poses the greatest threat?
(6) How well have German OEMs implemented ACES trends compared to their competitors?
(7) To what extent do investors value the efforts made by OEMs to establish a pioneering role in the implementation of ACES trends?

We answer these questions using current data from annual reports, database extracts, newspaper articles, and market studies and substantiate the findings through detailed literature analysis.

This work starts with a comprehensive literature review of the four ACES trends (Chapter 2), as most studies consider them separately (Bertoncello et al., 2021; Cramer & Krueger, 2016; Fagnant & Kockelman, 2015; Rietmann et al., 2020) even though a joint analysis is critical to exploit their full potential (Lempert, Preston, Charan, Fraade-Blanar, & Blumenthal, 2021). The objective of the chapter is to familiarise the reader with later required definitions (e.g. the different levels of autonomous driving) and with technical basics of the different technologies (e.g. the difference between ICEVs and EVs). Furthermore, the advantages and disadvantages of the technologies are discussed, as the literature comes to inconsistent and contradictory conclusions regarding their added values, potential threats, and limitations.

The results are presented in Chapter 4, following the structure of the well-known strategic management tool Strengths-Weaknesses-Opportunity-Threats (SWOT) analysis, examining both internal and external factors (Pickton & Wright, 1998). The analysis of internal factors involves the identification of critical monetary as well as non-monetary assets. To do so, we will investigate their annual reports, value their brand equities, and measure their footprints in the largest automotive markets. Furthermore, we will assess how the corporate structures of German OEMs differ from those of newcomers. In the next step, opportunities and threats are derived from the interactions of the firms with external entities, including governments and competitors as well as changing market landscapes. This part of the paper also introduces new frameworks to help companies evaluate complex problems such as competitor analyses or make-or-buy decisions.

2. Literature review

This chapter aims to provide a literature overview of the most important trends that currently shape the automotive industry. It's important to note, that the trends must not be considered exclusively. Instead, their combination builds an entirely new understanding of mobility – a shared autonomous vehicle using an electric engine. The joint view on ACES trends is also critical, as Lempert et al. (2021) note that the most significant social benefits arise from the interplay of electrification, autonomous driving, and connectivity.[2]

2.1. Autonomous driving

2.1.1. Different levels of autonomous driving

The Society of Automotive Engineers International (2018) defines five levels of vehicle automation, with level 1 being the most basic (driver assistance) and level 5 being the ultimately advanced (full driving automation), as follows: In level 1 the vehicle performs either the lateral (steering wheel) or longitudinal (speed and brake) motion control and leaves all other tasks to the driver. In level 2 (partial automation of driving), the vehicle can perform both lateral and longitudinal movement control. In level 3 (conditional

[1] In the following the term *German OEMs* refers to Germany's largest automotive companies Volkswagen, Daimler and BMW.

[2] Other cross-industry trends such as the rapidly growing e-commerce business, complex global supply chains, saturated markets, or regulations are not part of the literature review but are addressed in the results section.

driving automation) all dynamic tasks of driving are performed by an automated driving system, including motion control and environment monitoring. The driver still needs to be available for occasional control. In level 4 (high driving automation) all dynamic actions are performed by an autonomous driving system and the driver is not required to respond or intervene. Within level 4 all features are only applicable for certain roads and conditions such as dry highways. Finally, in level 5 the vehicle can perform all actions during any conditions on its own and in some cases leaves no intervention possibilities to the driver.

2.1.2. Positive effects and value proposition of autonomous driving

The positive effects of autonomous vehicles (AVs) are manifold. One of the most obvious and impactful consequences is arguably the increased safety. Most fatal accidents are attributed to the driver and are caused by activities such as drunk driving, fatigue, and distraction. According to the Federal Statistical Office, human errors account for almost 90 % of accidents in Germany (Deutsches Statistisches Bundesamt, 2018b). As a consequence, 2,724 people died and 328,000 were injured on German roads in 2020 in total (Deutsches Statistisches Bundesamt, 2021). Furthermore, making roads safer is a worldwide goal. Within its Sustainable Development Goals, the World Health Organization (WHO) set the target of halving the number of road deaths by 2020 (Goal 3.6) (WHO, 2016). AVs could thus support the WHO to realize its ambitions.

To quantify potential benefits resulting from higher safety and fewer accidents Fagnant and Kockelman (2015) model three scenarios based on the American market, with AV adaption rates of 10%, 50%, and 90%. The authors find that at the lowest adoption rate AVs could save 1,100 lives and avoid 211,000 crashes. Taking economic consequences (damages) as well as costs reflecting pain into account, Fagnant and Kockelman (2015) derive potential annual savings of USD 1,470 per vehicle. With higher penetration rates this number grows exponentially, as according to the authors, communication between AVs further lowers crash rates. With a 90% AV market share, the saved amount per vehicle could be USD 5,460. AVs would thereby avoid 21,700 road deaths and 4,220,000 accidents annually. On a country level (United States), this would mean annual savings of over USD 400 billion which again highlights the enormous impact that AVs could contribute.

Whether comparably high adoption rates are likely to be achieved depends strongly on the technology price and people's willingness to pay (Bansal & Kockelman, 2017). Using survey results of 2,167 Americans, Bansal and Kockelman (2017) conclude that in the most likely scenario with a 5% annual technology price decline and constant willingness to pay, the level 4 AV penetration rate will be 24.8% by 2045. In their most optimistic scenario with a 10% annual price decline and 10% willingness to pay increase the share would reach 87.2% in 2045, thus being close to the 90% market share scenario analyzed by Fagnant and Kockelman (2015). Fagnant and Kockelman (2015) expect that once the added price for AVs falls below USD 10,000 the technology becomes competitive and the additional benefits compensate for the higher price.

In addition to safety improvements, AVs also have the potential to reduce freeway congestion, fuel consumption, and air pollution by reducing bottlenecks and smoothing traffic flow, mainly enabled by vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication (Fagnant & Kockelman, 2015). This enables more efficient braking, accelerations, and lane choice decisions. The authors estimate that with 10% AV penetration, congestion could be reduced by 15% and fuel consumption by 13%, saving USD 1,400 per vehicle. In their 90% adoption rate scenario, highway congestion is expected to be reduced by 60% and fuel consumption by 23%, resulting in savings of USD 970 per vehicle. Hoogendoorn, van Arem, and Hoogendoom (2014) assume that AVs could reduce congestion even stronger. They argue that even without V2V and V2I equipment, congestion could be halved. Additionally, Shladover, Su, and Lu (2012) note that lane capacity could almost double when AVs apply cooperative adaptive cruise control, which is the system responsible for longitudinal automated vehicle control. Khondaker and Kattan (2015) report that advanced algorithms, optimized for intelligent acceleration and deceleration maneuvers could save 16% of fuel. Zohdy and Rakha (2016) propose an advanced version of cooperative adaptive cruise control, that could efficiently handle intersections including traffic signals, all-way stops, and roundabouts. According to the authors, their version could reduce delays by 90% and fuel consumption by 45%. Other fuel-saving benefits could arise from lighter design (due to enhanced safety) or less powerful engines (due to efficient accelerations) (Milakis, van Arem, & van Wee, 2017).

2.1.3. Negative consequences and current limitations

However, these positive effects could be canceled out by a significantly higher number of vehicle miles traveled (VMT), as more underserved people, including elderly or people with medical restrictions, would gain access to AV transportation services (Harper, Hendrickson, Mangones, & Samaras, 2016). The authors find that AVs could provide great new opportunities to this group and enable them the same travel options as normal drivers. This could result in a 14% VMT increase (295 billion miles in the United States) for the entire population. On top of that, travel times could be used more efficiently and make cars an attractive alternative to rail or air travel (Yap, Correia, & van Arem, 2016). Taking all effects into account, (Fagnant & Kockelman, 2015) conclude that AVs could lead to a VMT increase of 26% (90% adoption rate scenario). Correia and van Arem (2016) conclude that AVs increase VMT by 17%, using the model of a European mid-sized city.

Additionally, several barriers to implementation still exist, which is why development remains below expectations and currently only level 2 technology is available on the market (Bloomberg, 2020b). One reason for this is that costs are

considerably high so that AVs only appeal to a small proportion of potential buyers (Fagnant & Kockelman, 2015). On top of that AVs could become the target of cyberattacks (Petit & Shladover, 2015). Petit and Shladover (2015) warn that those threats with the highest probability of success (blinding the camera and GPS spoofing) can be achieved with little effort while having threatening consequences.

Cyberattacks, technical difficulties as well as mistrust among the population set high standards for the approval of AVs. Kalra and Paddock (2016) note that it could take billions of kilometers under normal road test conditions to prove the safety of AVs. They therefore call for innovative testing methods. Finally, the big questions about AV liability remain unresolved. Commissions need to clarify which parties bear ultimate responsibility and answer how algorithms should determine who is to be protected in the event of unavoidable accidents (amongst others Fleetwood, 2017).

2.2. Connectivity

2.2.1. Different levels of connectivity in connected cars (CVs) and scope

Similar to AVs, there are different degrees of connectivity within vehicles. Bertoncello et al. (2021) define a framework that distinguishes between five levels: Level 1 vehicles provide basic vehicle monitoring functions, while level 2 vehicles provide additional connectivity to the driver's digital ecosystem (Bertoncello et al., 2021). Level 3 technology additionally enables predictive and intelligent functions, including features such as personalized infotainment or advertising for all vehicle occupants. In level 4 vehicles, passengers have the option to engage in multimodal dialogues with the vehicle or proactively receive intelligent recommendations. Finally, in level 5, the vehicle acts as a virtual chauffeur and fulfills all passengers' needs with the help of Artificial Intelligence (Bertoncello et al., 2021). According to the authors, by 2030, the proportion of CVs will increase to 95% (560 million with level 1 or 2 capabilities, 120 million with level 3, and 160 million with level 4 or 5 capabilities). They also state that the massive expansion of the connectivity ecosystem will lead to further integration of players from other industries such as telecommunications, streaming services, and infrastructure providers.

To define the scope of vehicle connectivity, it additionally needs to be noted that there exist several overlaps with autonomous driving technology. Talebpour and Mahmassani (2016) for example state that connectivity features are the key enabler of autonomous driving. They argue that they enable AVs smoother and safer driving, as they do not only have to rely on sensor data but can rather use the information provided by other vehicles and infrastructure (V2V and V2I). These technologies, however, have already been discussed in Chapter 2.1 and will therefore not be part of this chapter.

2.2.2. Benefits and monetary potential from CVs

Lempert et al. (2021) report that the impact of CVs on increased social welfare including health, access, equity, and environmental benefits will depend not only on technological improvements but also on favorable policies. They conclude that only a combination of both will lead to improvements in all areas. In addition, Lempert et al. (2021) model two further scenarios, one with more optimistic policy assumptions but less optimistic technology assumptions and one vice versa. Both scenarios lead to environmental benefits, while only the former also offers health and access benefits (Lempert et al., 2021). In contrast, the latter will lead to a deterioration in health, access, and equity for most people which underscores the critical role of policy in ensuring a successful CV adoption (Lempert et al., 2021). Another positive impact on the environment could result from lower fuel consumption due to optimized route planning, taking into account both vehicle characteristics and traffic data (Miao, Liu, Zhu, & Chen, 2018). According to the authors, their new approach could reduce fuel consumption by up to 15%.

Besides social and environmental benefits, CVs have a huge monetary potential for OEMs, resulting from both additional revenue streams and reduced costs (Bertoncello et al., 2021). Bertoncello et al. (2021) identify nine use case clusters that could potentially deliver up to USD 400 billion of additional value. On the cost side, this includes topics such as research and development (R&D) optimization or vehicle health monitoring (Bertoncello et al., 2021). The authors state that depending on the connectivity level this could lead to savings of USD 100 (level 1 and 2) up to USD 210 (level 4 and 5) per vehicle. The revenue potential is even higher and includes use cases such as on-demand hardware/software, mobility insurance, and seamless in-car experience (Bertoncello et al., 2021). The additional revenue per vehicle is expected to be between USD 130 (level 1 and 2) and USD 610 (level 4 and 5) per vehicle according to the authors. Bertoncello et al. (2021) note that this potential will not monetize on its own. Instead, OEMs need to leverage customer feedback, build strong in-house expertise, and improve time-to-market. Athanasopoulou, de Reuver, Nikou, and Bouwman (2019) confirm that OEMs should use the increasing importance of vehicle connectivity to adapt their business models and successfully transform from product to service providers.

2.2.3. Technical base

To leverage the described potential, CVs must be able to collect, process, and transfer huge amounts of data accurately and within a very short time. For this purpose, the concept of the Internet of Things is well suited, as it encapsulates several essential functions, including the sensors, software, and internet connection. It additionally enables the interconnection between a vast number of physical objects (Rayes & Salam, 2017). The emergence of the fifth generation of broadband mobile networks will provide a further technology boost by offering enhanced capabilities such as increased bandwidth, best-in-class security, low latency, and very high reliability (Papathanassiou & Khoryaev, 2017). However, according to Ai, Peng, and Zhang (2018), conventional cloud computing is of limited suitability due to the high latency and high mobility of vehicles. They therefore propose the use of

edge cloud computing, a technology where computation and data storage take place closer to the point of need (Ai et al., 2018).

2.3. Electrification

2.3.1. Background, technology, and current market

The impact of greenhouse gases on global warming has been widely discussed and there is a broad consensus that drastic reductions are needed to curb the effects (e.g. Schneider, 1989). As a result, the Paris Climate Agreement was agreed in December 2015, involving 195 nations, with the goal of keeping global warming well below two degrees above pre-industrial levels (Rogelj et al., 2016). To comply with this agreement, the European Parliament (2019) has committed to reducing CO_2 emissions from the transport sector by 60% until 2050 compared to 1990. Consequently, the automotive industry has a large and important role to play, as it accounts for 72% of transport emissions (European Parliament, 2019). An important step is to successfully drive the transformation from ICEVs to EVs, as the latter promise to produce less emissions, when using electricity from renewable resources (European Parliament, 2019). The need for EVs is further strengthened by the limited fossil energy resources (Shafiee & Topal, 2009). According to the authors, oil and gas reserves could run out as early as the 2040s.

In addition to pure EVs, there are also hybrid solutions that use both an internal combustion engine and an electric engine, supplied by a battery. They are called hybrid electric vehicles (Arslan, Yildiz, & Ekin Karaşan, 2014). A special variant of hybrid vehicles with extended ranges are plug-in hybrid electric vehicles (PHEVs), which can be recharged at the charging station in addition to pure recuperation (Arslan et al., 2014).[3] The components used in EVs are very different from those used in traditional ICEVs. One of the core technologies and differentiators in EVs are batteries. In recent years, the lithium-ion battery has emerged as a the technology leader due to its high specific power, high energy density, high specific energy, and low weight (Mahmoudzadeh Andwari, Pesiridis, Rajoo, Martinez-Botas, & Esfahanian, 2017; Tie & Tan, 2013). Another important component is the electric engine, which has the advantage of higher torque (especially at low speeds), more efficient conversion of electrical to mechanical energy, and the ability to recover energy during braking compared to an internal combustion engine (Mahmoudzadeh Andwari et al., 2017). Other components include the battery management system, which monitors and safely operates the battery, and the power electronics, which act as an intermediary between the battery and the engine (Mahmoudzadeh Andwari et al., 2017). To date, however, the technology has several disadvantages compared to ICEVs including costs, mileage, fueling/charging time, and service infrastructure (Kapustin & Grushevenko, 2020).

[3] In the scope of this thesis, PHEVs will be also considered as EVs, following Rietmann et al. (2020). They argue that pure EVs are steadily gaining PHEV's market shares and PHEV customers will switch to pure EVs.

Figure 1 depicts the global EV sales and market shares since 2011. It is evident that the growth in EV sales is significantly outpacing that of the total automotive market as shown by the increasing market penetration, which was over 4% of total sales in 2020. It is also clearly visible that the major share of EV sales comes from China and Europe. 2020 was the first year that Europe became the number one in EV sales, as many member countries doubled or even tripled their sales (Irle, 2021). As a consequence, one out of 10 cars sold in 2020 in Europe was equipped with a battery, according to the author. Other markets such as Japan that once were first movers in the e- mobility market have continuously declined within the last years and also the United States show only moderate growth (Irle, 2021).

2.3.2. EV emission reduction potential and influencing factors

The CO_2 saving potential of EVs is immense, as Teixeira and Sodré (2018) show that the emissions of an EV fleet can be 10 to 26 times lower than those of an ICEV fleet. Whether this potential can be realized on a global scale and whether EVs can thus contribute to lower CO_2 emissions worldwide depends on two main factors: The market share of EVs and the energy mix used for recharging (Rietmann et al., 2020). In order to predict the future market share, Rietmann et al. (2020) use a logistic growth model for 26 countries on five continents, which they base on actual sales data from 2010 to 2018. They conclude that the global market share of EVs will be 42.5% by 2035, albeit with strong differences between the examined countries. While countries such as Norway or Sweden are expected to reach a 50% market penetration in the 2020s, China or the United States will take longer than 2035 (Rietmann et al., 2020). The authors' second finding confirms the hypothesis of Canals Casals, Martinez-Laserna, Amante García, and Nieto (2016), who argue that the significant discrepancies in the energy mix between countries pose an additional challenge to a successful and sustainable EV implementation.

The results of Rietmann et al. (2020) underline that in all examined countries (except India and Hong Kong) EVs will lead to a significant CO_2 reduction. Rietmann et al. (2020) estimate that compared to an "ICEV only world" EVs will be able to reduce CO_2 emissions by 17.2% in 2035. However according to the authors emissions will still be 11.8% higher than in 2018, so further improvements are required. Gómez Vilchez and Jochem (2020) confirm these results and expect that total greenhouse gas emissions will be between 13% and 32% higher in 2030.

According to Rietmann et al. (2020) the biggest CO_2 saving contributions will come from countries like Sweden or Norway that combine a high EV market share with a renewable energy mix. They will consequently be able to reduce CO_2 emissions by over 60%. Other countries such as Germany or the United Kingdom will have to improve their energy mixes in order to benefit from the increase in EV sales (Rietmann et al., 2020). The authors see the greatest room for improvement in China and India. According to their sce-

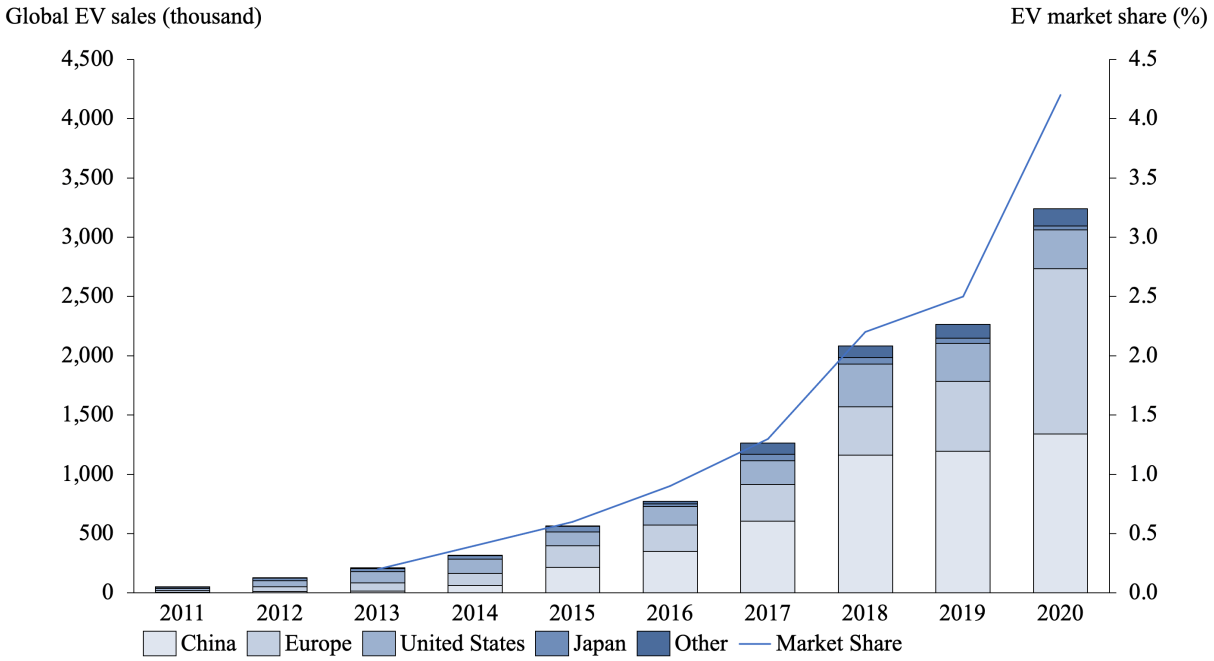

Figure 1: Worldwide EV market development 2011-2020.

Source: Adapted from Irle (2021)

nario, emissions will increase by 54% and 130% respectively compared to 2018, despite moderate increases in EV market shares due to the poor energy mix.

2.3.3. EV challenges – Manufacturing & scrapping, rare resources, and grid stability

As discussed before, EVs can make their contribution to emission reduction if they use renewable energy for operation. However, for comparison with ICEVs, both the manufacturing and the scrapping process (the vehicle cycle) need to be taken into account (Gómez Vilchez & Jochem, 2020). The authors conclude that these emissions will account for a significant share in 2030, representing one-third of an EV's lifetime emissions. As with the energy mix for operations, China and India occupy the last places in terms of manufacturing and scrapping emissions, which need to be improved in order to reduce greenhouse gas emissions (Gómez Vilchez & Jochem, 2020). Hao, Qiao, Liu, and Zhao (2017) therefore call to rethink the production and scrapping process, as they show that optimized recycling could reduce emissions by 34%.

Another criticism of EVs is their high consumption of scarce resources. Noori, Gardner, and Tatari (2015) note that one EV consumes over 3 million liters (>800,000 gallons) of water during its lifetime, which is almost six times higher than the consumption of an ICEV and is mainly due to upstream electricity generation and battery production. The latter also requires the use of rare earth elements, which yields several issues (Ali, 2014). Ali (2014) is especially concerned about the effects on the environment as well as on the safety, health, and society of workers.

According to Kapustin and Grushevenko (2020), the widespread adoption of EVs will lead to an 11% to 20% increase in global electricity consumption by 2040, even though the authors assume a significantly lower EV share (12% to 28%) than the studies discussed before. This and additional peak times, especially in the morning when people come to work and charge their cars and in the evening when people return home, create a major challenge for a stable energy grid (Kapustin & Grushevenko, 2020). Furthermore, Kapustin and Grushevenko (2020) argue that renewable energy sources are not suited to handle peak loads. Dharmakeerthi, Mithulananthan, and Saha (2014) come to a similar conclusion and urge the development of new load model predictions to accurately predict the energy demand changes from EVs. To counteract undesired grid instabilities and ensure a stable supply, one option could be to expand conventional fuel generation (Kapustin & Grushevenko, 2020). However, according to the authors, the more favorable solution would be to install energy storage combined with renewable energy feed.

2.4. Shared mobility

2.4.1. The concept of the sharing economy

Even though people have shared things for centuries, the concept of sharing has gained significant attention within the last decade driven by the emergence of digital platforms (Zervas, Proserpio, & Byers, 2017). Those platforms can reach a giant user base and facilitate transactions and thus enabled the creation of the "sharing economy". In academia there exist several definitions for this term. Sundararajan (2016,

p. 23) defines the sharing economy as "an economic system with the following five characteristics: largely market based, high impact capital, crowd-based networks, blurring lines between the personal and professional, and blurring lines between fully employed and casual labor." The different aspects included in this definition provide a comprehensive description of the ride-hailing business model discussed in Chapter 2.4.2. Lessig (2008, p. 143) characterizes the sharing economy as "collaborative consumption made by the activities of sharing, exchanging, and rental of resources without owning the goods", which neatly describes the concept of carsharing discussed in Chapter 2.4.3.

Like Airbnb, where owners can lend their homes to registered users, various forms of carsharing enable more efficient use of cars. There is a huge leverage for different business models to increase the efficiency of car usage, as Dudley et al. (2017) note that vehicles sit idle at least 90% of the time. This section aims to present the two most prominent sharing models in the mobility sector and to discuss their up and downsides.

2.4.2. Ride-hailing – Market development, value proposition, and limitations

One of the most prominent forms of sharing cars is ride-hailing (also called ride sourcing or ride sharing). It allows travelers to request a ride which is then matched to a nearby driver via a platform (Rayle, Dai, Chan, Cervero, & Shaheen, 2016). Typical providers are Uber Technologies, Inc. (Uber), Lyft, Inc. (Lyft) or Didi Chuxing Technology Co. (Didi). The largest ride-hailing markets, China (USD 24 billion) and the United States (USD 23 billion), are dominated by single players (Grosse-Ophoff, Hausler, Heineke, & Möller, 2017). The authors note that in contrast, the third-largest market Europe (<USD 6 billion) is more fragmented due to country and city-specific regulations. In combination with considerable VMT growth rates (150% until 2017) the ride-hailing market seems to be an attractive investment opportunity (Hensley et al., 2017). Holland-Letz et al. (2019) confirm this hypothesis. They report that between 2010 and 2019 over USD 56 billion were invested into ride-hailing companies, making it the largest new mobility investment category.

Cramer and Krueger (2016) who compare the usage of Uber and traditional taxis in five major American cities come to the result that Uber drivers have a 30% higher utilization rate measured by time and even a 50% higher utilization rate measured by miles. Similar to AVs this also helps to reduce congestion and emissions. Cramer and Krueger (2016) see a more efficient matching technology, a larger scale of Uber drivers, inefficient regulations for taxis, and finally Uber's more flexible working model as the main reasons for this advantage. Dudley et al. (2017) add that Uber rides are more transparent and convenient for travelers as the calculation of fares, the route planning, and the final payment are all done within the app. Hensley et al. (2017) expect that the occurrence of purpose-built vehicles (vehicles optimized for passenger experience and designed for different use cases) will provide a further push for ride-hailing companies. An even stronger impact could result if AVs find their position in the carsharing market. Shared AVs would significantly reduce costs for passengers and thus encourage more customers to switch to ride-hailing services. As a consequence private vehicle ownership could be reduced by 90% Boesch, Ciari, and Axhausen (2016); Fagnant and Kockelman (2014).

In addition to these positive aspects, there are some problems associated with ride-hailing that make further expansion difficult or even call into question the argument that ride-hailing makes travel more sustainable. For example, Hensley et al. (2017) note that ridesharing services are not applicable for people in rural areas. Furthermore, the authors argue that it is only cost-effective to forego a car and rely on ride-hailing for those people who travel 3,500 miles or less, which affects only 5% to 10% in America. As a consequence, only 1% to 3% of total VMT in major American cities are conducted with ride-hailing services (Bliss, 2019). Another aspect that complicates expansion for ride-hailing companies are conflicts with legislative systems as well as their drivers, who fight for better conditions and permanent employment (Dudley et al., 2017). This conflict endured for several years until in March 2021, the British Supreme Court decided that Uber drivers in Great Britain had to be considered as "workers" (Satariano, 2021). As a consequence, Uber must pay its 70,000 drivers the minimum wage as well as holiday allowance and provide access to a pension plan (Satariano, 2021). Moreover, Bliss (2019) notes that ride-hailing companies, namely Uber and Lyft increase VMT and traffic congestion. Henao and Marshall (2019) come to similar conclusions, finding that ride-hailing increases VMT by 83.5%.

A solution to the congestion problem could be achieved through on-demand ride pooling (Ke, Yang, & Zheng, 2020). With this model, not only one person but several people with a similar destination can be transported. On-demand ride pooling is also offered by Uber, Lyft or Didi and on top of that by Moia GmbH (Moia), a subsidiary of Volkswagen. Ke et al. (2020) demonstrate that if companies optimize the matching window (the time passengers are willing to wait for a vehicle), ride-pooling services are able to reduce congestion for both passengers and private car users.

2.4.3. Carsharing – Different models and their effects on vehicle ownership

Similar to ride-hailing, there has also been a clear development in carsharing in terms of availability and user numbers. Zhou et al. (2020) estimate that carsharing services are available in more than 30 countries and serve over five million users worldwide. Münzel et al. (2018) distinguish between four business models: cooperative, business-to-consumer (B2C) (roundtrip and one-way), and peer-to-peer (P2P) carsharing. According to Münzel et al. (2018) cooperative carsharing is mainly practiced in small towns and involves mainly small fleets. Its initial idea was to offer a more environmentally friendly and sustainable way of getting around (Münzel et al., 2018). Later, and with the help of advanced technology (as with other sharing economy business models), B2C carsharing providers such as Car2go

GmbH entered the market (Münzel et al., 2018). Within B2C carsharing the authors further differentiate between round-trip models (also called station-based carsharing), where users have to return the car at a certain point, and one-way models (free-floating carsharing), where users can park the car any-where within the grid. Illgen and Höck (2019) see the latter as the most promising, as it is the most suitable for most use cases. Finally, the P2P carsharing model allows users to share their cars with each other via a platform, which according to Münzel et al. (2018) is the best solution for very large cities. Münzel et al. (2018) find that fleet sizes in this model are the largest. As the presented models serve different purposes, Münzel et al. (2018) conclude that all different models can co-exist as they have only a few overlaps.

Similar to ride-hailing the desired effect of carsharing is a reduced vehicle ownership and less congestion (Zhou et al., 2020). In academia, controversial results are reported and discussed. While several early studies (e.g. Costain, Ardron, & Habib, 2012) confirm that the availability of carsharing services leads to less vehicle ownership, Zhou et al. (2020) neglect that effect, finding only a minor relationship between carsharing availability and reduced vehicle ownership. They argue that earlier studies mainly examined people who already used carsharing services and therefore contained a bias problem. Participants in these early studies were also found to be more environmentally conscious and therefore more willing to give up owning a car (Costain et al., 2012).

Instead of looking at the impact of car sharing as a single model, it is worth examining the impact of the different carsharing options. Using data from DriveNow GmbH & Co. KG (for free-floating) and Flinkster GmbH (for station-based carsharing), Giesel and Nobis (2016) show that only the latter leads to a significant reduction in car ownership (15% versus 7% reduction). A study by the German carsharing agency Bundesverband Carsharing (2020) comes to similar conclusions. They also confirm that only the less widespread station-based carsharing can significantly reduce car ownership.

3. Methodology

To broaden the understanding of how current trends in the automotive industry influence German OEMs and to evaluate possible strategies, we apply the mixed methods approach (Denscombe, 2008). This approach differs from purely quantitative or qualitative studies, as it combines the two and thus obtains benefits from both (Denscombe, 2008). On top of that Collins, Onwuegbuzie, and Sutton (2006) note that the mixed methods approach increases data accuracy and supports the creation of a more holistic view. This is of particular importance for the topic of this thesis, as the analysis includes several internal and external dimensions. Furthermore, the interactions of German OEMs with stakeholders as well as sudden industry changes further complicate the situation, which is why a holistic view is indispensable.

The general structure of Chapter 4 is based on a SWOT analysis, which is considered as one of the most respected and used tools in strategic management (Glaister & Falshaw, 1999; Panagiotou & Van Wijnen, 2005).[4] It includes both internal (a firm's strengths and weaknesses) as well as external factors (outside opportunities and threats) that are depicted in a basic 2x2 matrix (Pickton & Wright, 1998). The simplicity of the SWOT matrix, as well as its focus on core issues, is considered to be one of its major advantages (Pickton & Wright, 1998).

Pickton and Wright (1998) note that, as in other analyses, the assessment of strengths and weaknesses is only relative to the competition. The same applies to opportunities and threats – they result only from the actions and inactions of the analyzed parties and those of their competitors (Pickton & Wright, 1998). In the scope of this thesis, the analysis of the external factors will be complemented by concrete strategy recommendations. This is intended to counter one of the biggest criticisms of SWOT analyses, namely that they do not specify implementation strategies (Helms & Nixon, 2010).

It is important to note that both internal dimensions can be mapped to both external ones. This is described by Weihrich (1982) and counteracts the misleading perception that strengths always result in opportunities and weaknesses in threats. Instead, companies can also recognize their weaknesses and turn them into opportunities (Weaknesses x Opportunities) or vice versa (Strengths x Threats) (Weihrich, 1982).[5] Figure 2 visualizes a SWOT analysis for German OEMs with internal factors in the first and external factors in the second row. The shown dimensions are discussed in Chapter 4.

As intended in the mixed methods approach, the different subchapters will have different focuses and apply different methods, although they follow a similar structure. Each section aims to shed light on a current topic by formulating hypotheses based on current data and testing them with an extensive literature review. The latter will also be used to generate new frameworks that shall support German OEMs in their decision-making. For this purpose, various approaches from the literature are combined and adapted to current issues in the automotive industry.

To ensure that the data sets are as current and accurate as possible, we use the annual reports of the examined companies and additionally draw on market and business segment analyses by expert companies (Bloomberg, Reuters) or renowned external consulting firms (McKinsey & Company, Boston Consulting Group). Additionally, external databases and test results are used to enable industry-wide comparisons (EV Database, ADAC). On top of that, we employ newspaper articles to reflect current events (Die Zeit, Wirtschaftswoche).

This paper concludes with a quantitative assessment of the current implementation of ACES trends by German OEMs

[4] Although the origin of the SWOT analysis remains unknown it is likely to date back to the 1960s and 1970s (Helms & Nixon, 2010).

[5] Examples for the different combinations are discussed in Chapter 4.

Strengths	Weaknesses
1. Profitable business and large financial reserves 2. Localized R&D departments, local production, and global sales 3. Valuable brands 4. Long-established industry expertise and supplier relationships	1. Rigid organizational structures optimized for the "old automotive world" 2. Lacking investments into new technologies 3. Backlog in software technology 4. Missing e-mobility infrastructure 5. Outdated customer relationship
Opportunities	**Threats**
1. Increasing mobility requirements and emission-free vehicles 2. Emerging purpose-built vehicles market 3. Increased R&D expenditures, process improvements and partnerships 4. German government as stake holder 5. Increased upstream integration potential 6. Downstream integration, servitization, and direct-to-consumer sales	1. Regulations and missing intellectual property rights in China 2. Environmental regulations in Europe and Germany 3. Shrinking traditional profit pools 4. The competitive landscape of German OEMs 5. Indirect competitors (substitutors) and their business models 6. Direct/potential competitors and their technological advances

Figure 2: SWOT analysis for German OEMs.

Source: Own analysis

and a selected group of competitors. To the best of our knowledge, it is the first study to conduct a quantitative and holistic analysis of all trends. To do so, we divide each trend into several subcategories and rate the performance of the investigated OEMs in each subcategory using an ordinal scale from zero (0) to five (5), with 5 being the best score. Applying the arithmetic mean of the subcategories, we can assess how well an OEM has implemented each trend. In the next step, we define the ACES Index as the arithmetic mean of the scores of the four trends for each OEM. Finally, we use an ordinary least squares (OLS) regression to investigate whether a company's ACES index influences its market capitalization. If this is the case, it would support the objective of this paper, which is to highlight the importance of ACES trend implementation for German OEMs.

The three companies under consideration in this thesis are Volkswagen, Daimler, and BMW. Volkswagen is Germany's largest and the world's second largest OEM, delivering over 9.3 million units in 2020 (11 million in 2019) (Volkswagen AG, 2021a). The group consists of 12 brands ranging from the low to medium price segment (Skoda, Seat and Volkswagen) to the ultra-high price segment (Bentley, Lamborghini and Bugatti) (Volkswagen AG, 2021a). In between, the sporty and high-quality brands Audi and Porsche position themselves (Volkswagen AG, 2021a). Volkswagen is also active in the commercial vehicle segment (MAN and Scania), which is however not considered in this paper. Its size enables huge investments into new technologies. Consequently, Volkswagen increased the budget for its tech-transformation to EUR 73 billion until 2025 focusing particularly on electromobility (EUR 35 billion) and digitization (EUR 27 billion) (Volkswagen AG, 2020b).

Daimler is Germany's second largest OEM, delivering 2.8 million units in 2020 (3.3 million in 2019) (Daimler AG, 2021a). It consists of the three business units Mercedes-Benz Cars & Vans, Daimler Trucks & Buses, and Daimler Mobility (Daimler AG, 2021a). Again, the focus of this paper lies on the passenger vehicles, including the umbrella brand Mercedes-Benz which is complemented by Mercedes-EQ (electromobility), Mercedes-AMG (car tuning), Mercedes-Maybach (ultra-luxury) and Smart (urban mini cars) (Daimler AG, 2021a). Similar to Volkswagen, Daimler is planning to invest EUR 70 billion in electromobility and digitization in the next 5 years, especially in the car segment (Daimler AG, 2020b).

BMW delivered 2.3 million units in 2020 (2.5 million in 2019) (BMW AG, 2021). It is the only German OEM that consists only of premium brands (BMW, Mini and Rolls-Royce). It has been one of the pioneers in the area of EVs and car-sharing services since it has introduced the i3 in 2013 (BMW

AG, 2021). Since then, however, their strategy has been less aggressive than that of the other OEMs. Instead of fully electrified model series, BMW plans to offer customers a choice between combustion, hybrid or electric engine for every series (BMW AG, 2021).

4. Results

4.1. Strengths

For decades, the German automotive industry has been the flagship for German engineering and quality, thrilling customers all over the world. There is no other country that has a comparable density of OEMs and where the automotive sector contributes more to GDP (Saberi, 2018). For a long time, this has helped them maintain their competitive position and become global leaders. In this chapter, several critical assets and their associated advantages are presented.

4.1.1. Profitable business and large financial reserves

One of the main strengths of German OEMs is their financial stability and their sustainable growth. Between 2010 and 2019 German OEMs managed to almost double their revenues.[6] Although their operating margins did not keep pace with this growth, they remained roughly constant. Even in the last three years, when the global markets became increasingly saturated (see Chapter 4.1.2) and as a consequence of the COVID-19 crisis began to shrink, German OEMs were able to achieve significantly positive operative earnings, mainly thanks to their successful ICEV business. Between 2018 and 2020, Daimler and BMW could achieve a total operating profit of EUR 20 billion each and Volkswagen of even EUR 40 billion (BMW AG, 2020, 2021; Daimler AG, 2020a, 2021a; Volkswagen AG, 2020a, 2021a).

Due to years of successful business activity, the three German OEMs have generated retained earnings of over EUR 200 billion by the end of 2019 (see Figure 3).[7] Since 2019 their retained earnings have increased at a compounded annual growth rate (CAGR) of around 10% and thus even exceeded the CAGR of revenues. Retained earnings are of great importance for companies as they not only provide a safety cushion but also have a significant positive impact on expected stock returns (Ball, Gerakos, Linnainmaa, & Nikolaev, 2020). This is due to the fact that they contain information on all past earnings which has a much greater influence in predicting future stock prices than current earnings (Ball et al., 2020). Therefore, investors pay a premium for shares in companies with high retained earnings (Ball et al., 2020). This suggests that German OEMs could cope with less profitable years without losing their attractiveness for investors. By reducing the focus on achieving high current earnings, German OEMs can invest massively in R&D for ACES trends and compensate for initial losses when entering new markets.

Figure 3 shows that R&D margins (the ratio of R&D spending to revenues) are at a high level and have increased to around 6% in 2019, which even exceeds Tesla, Inc.'s (Tesla) R&D margin (5.5%) (Macrotrends, 2021c). This suggests that German OEMs are increasingly investing in future trends, which is of great importance due to their enormous competitive importance (see discussion in Chapter 2). Increasing R&D activities also have a positive impact on a variety of metrics. This manifests itself in the positive influence of R&D expenses on subsequent sales (especially when they exceed the threshold of 3% of revenues) (Morbey, 1988), improvement in market share (Ettlie, 1998), and an increase in enterprise value (Ehie & Olibe, 2010).

A further balance sheet analysis in combination with literature research reveals another advantage of German OEMs. Van Binsbergen, Graham, and Yang (2010) outline that a company's balance sheet and asset composition affect the cost of debt. They state that firms with high asset collateral and high book-to-market values face lower costs of debt. Both apply to German OEMs (BMW AG, 2021; Daimler AG, 2021a; Volkswagen AG, 2021a) and, as they are highly leveraged (Damm, 2020), plays hugely in their favor, allowing them to borrow money on favorable terms. Compared to new ventures, German OEMs furthermore do not require expensive funding. In addition, the three companies have significant liquid assets, which they could use in case of financial distress. BMW leads this category with liquid assets of around EUR 19 billion, which earns them the second-best rating among investors worldwide (Schürman, 2020).

In addition to the sales of new vehicles, the aftermarket business is another important source of revenue for German OEMs. A strong position in this market is crucial for smoothing the cyclical vehicle sales, as maintenance and services are largely independent of the economic situation. On top of that, the margins within the aftermarket business are considerably high. Brandt and Springer (2015) report that the after-sales business accounts for around 50% of total profits at some car manufacturers.

4.1.2. Localized R&D departments, local production, and global sales

Another strength of German OEMs is their global presence on both supply and demand side. All three companies have local production plants, localized R&D departments, and a global supply chain network. Daimler reports of more than 30 production plants on four continents (Daimler AG, 2020a), BMW a similar number (BMW AG, 2020). For Volkswagen, this number is even higher with 124 production plants worldwide (Volkswagen AG, 2020a). BMW has R&D departments in twelve countries (BMW AG, 2020) and Daimler in 15 (Daimler AG, 2020a), a considerable amount of which in Asia.

Bhattacharya, Hemerling, and Waltermann (2009) find several advantages in localized R&D departments in rapidly developing economies. Firstly, companies are able to lower labor costs by up to 60% and on top of that gain access to

[6] Find detailed information on discussed Key-Performance-Indicators (KPIs) and sources in Appendix 1-3.

[7] Data for 2019 is used to avoid bias from the influences of the COVID-19 crisis. Information for 2020 can be found in Appendix 1-3.

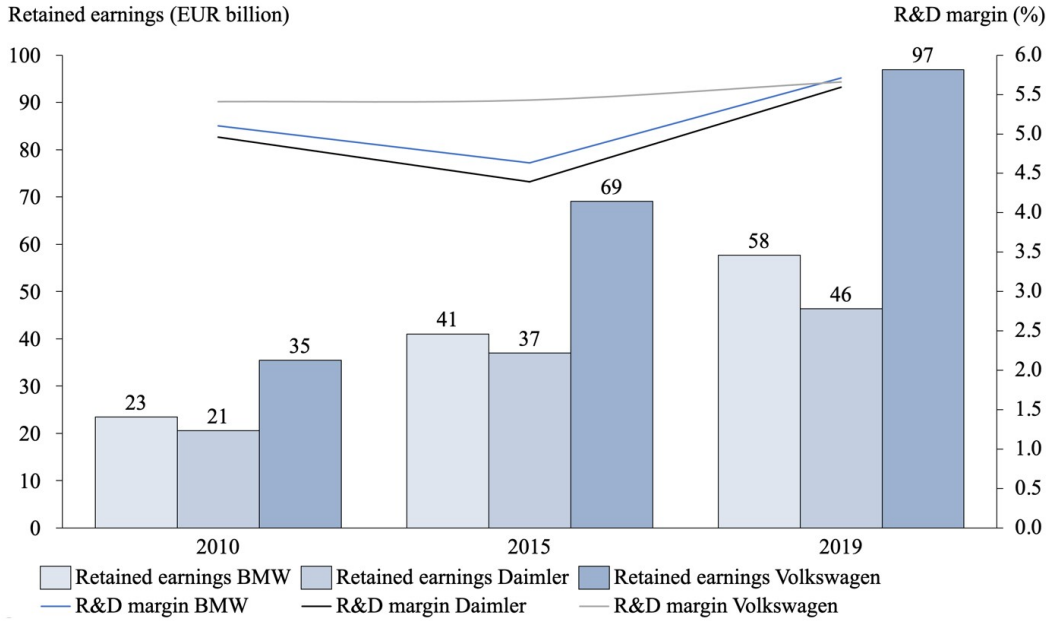

Figure 3: Retained earnings and R&D margins of German OEMs 2010-2019.

Source: See Appendix 1-3

a large pool of local talents (Bhattacharya et al., 2009). According to the authors, another aspect is that these markets become increasingly important due to their fast growth rates. The authors argue that the best way to enter these markets is to develop products or services that are specifically tailored to the needs of consumers in the respective regions. This can be better achieved when they are designed by locals (Bhattacharya et al., 2009). Finally, they argue that in established R&D clusters (places where firms co-locate with direct competitors) companies will benefit from partnerships and exchange of knowledge. Alcácer and Zhao (2012) confirm this hypothesis. They find evidence that in clusters innovations are quickly internalized and are more likely to involve cooperation across locations. Additionally, Alcácer and Zhao (2012) note state that strong networks help firms to keep control over local innovation and mitigate the risk of knowledge outflow.

An OEM's success in a market depends heavily on the economic conditions, as GDP development and passenger vehicle sales are highly correlated (European Automobile Manufacturers Association, 2018). For their advantage, downturns rarely hit economies with the same magnitude and at the same time, as the example of China shows. Even during the world financial crisis in 2008 and 2009 (GDP growth rate +9%) or during the COVID-19 crisis in 2020 (GDP growth rate +2%) (Macrotrends, 2021a) its economy was able to grow. Consequently, OEMs can stabilize their businesses, offering diversified product portfolios and being globally active, as the example of China shows.

German OEMs are active in almost all markets worldwide (BMW AG, 2021; Daimler AG, 2021a; Volkswagen AG, 2021a) with the highest volumes in Europe, China, and the United States, which are also the largest automotive markets measured in units sold (Verband der Automobilindustrie, 2020). The development of their three core markets in terms of passenger vehicles sold, market growth rates, and market shares of German OEMs between 2010 and 2019 are presented below (Figure 4 to Figure 6).[8]

Figure 4 shows how German OEMs developed and strengthened their positions in China. Daimler and BMW were able to almost triple their market shares, which is even more remarkable considering that the market itself grew by over 60% during this period. Volkswagen started from a higher level but also managed to grow its share by almost five percentage points. For Volkswagen, China has become the largest market (4.2 million units sold in 2019) (Volkswagen AG, 2021a). This was true even back in 2015 when they already sold around 15% more in China than in their home market Western Europe (Volkswagen AG, 2016).

An important decision that led to the strong growth in China was to develop models that are specifically tailored to the market's requirements, such as the Mercedes Benz GLA and GLC long version or the BMW 3 series long version. This hypothesis is supported by the literature. Calantone, Daekwan, Schmidt, and Cavusgil (2006) find evidence that active product adaption in foreign markets increases export performance. They further state that companies are more active with product adaptions when exports depend heavily on the target market and when the target market is very different

[8]Data for 2019 is used to avoid bias from the influences of the COVID-19 crisis. The detailed numbers as well as the sources can be found in Appendix 4-6.

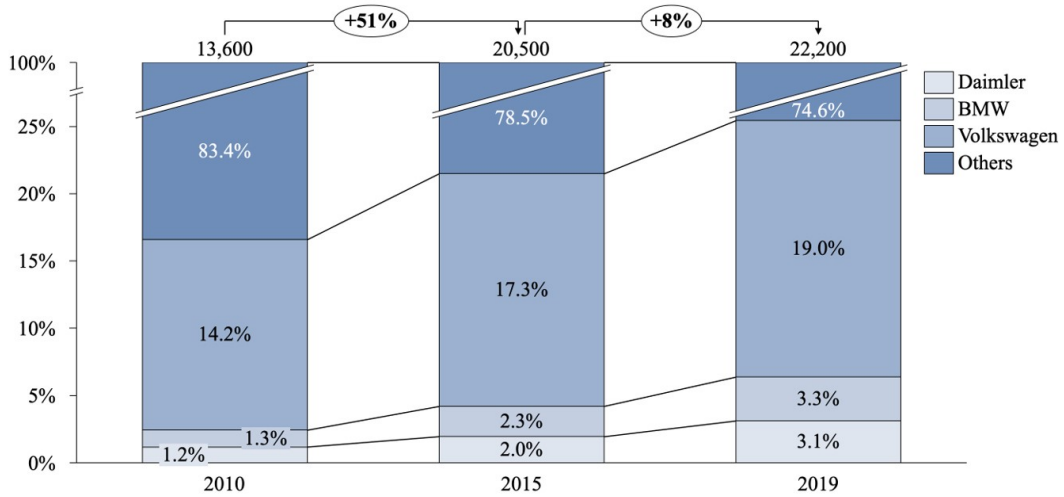

Figure 4: Market share development of German OEMs in China.

Source: See Appendix 4

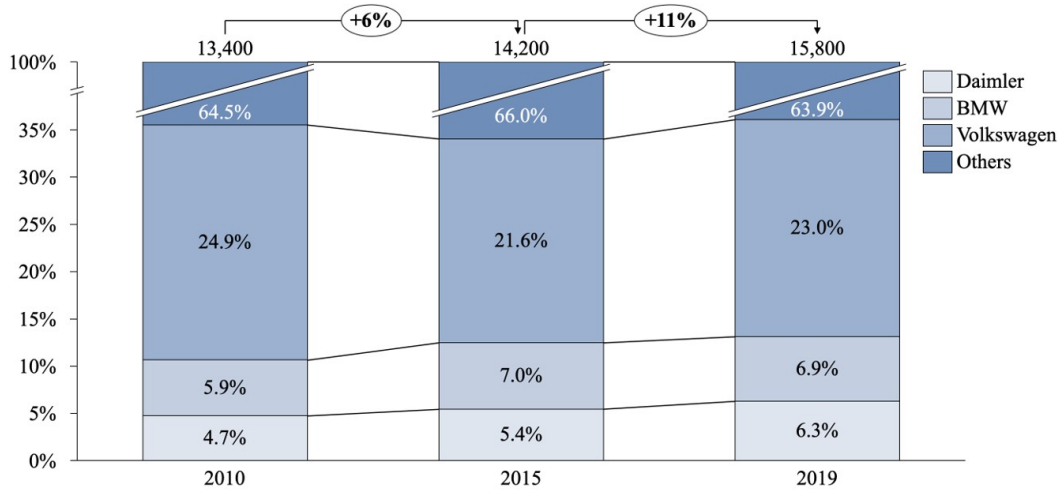

Figure 5: Market share development of German OEMs in Europe.

Source: See Appendix 5

from the home market. Both facts apply to China.

Compared to China, the European market showed only modest but nevertheless sustainable growth between (+6% between 2010 and 2015; +11% between 2015 and 2019). Again, Daimler as well as BMW could expand their market shares. For them Western Europe is the market with the highest volumes. In 2019 they sold almost 50% more units than in China (BMW AG, 2021; Daimler AG, 2021a). Volkswagen saw a slight decline of about 2 percentage points in Europe. This is not surprising, however, as this compensates for the massive growth in China.

In the United States all companies have a combined market share of less than 8% since the American market is dominated by American and Asian companies (Demandt, 2019). Nevertheless, German OEMs were able to benefit from the massive growth of over 50% between 2010 and 2015, as they were able to keep their market shares constant or, in the case of Volkswagen, even expand it.

4.1.3. Valuable brands

One of German car manufacturers' most critical assets are their brands. The marketing consultancy Interbrand (2019) found in its latest global report that two out of the three most valuable car brands are German - namely Mercedes Benz (USD 49.27 billion brand value) and BMW (USD 39,76 billion). Accordingly, the brand accounts for more than half of their group's market capitalization (Companies Market Cap, 2021; Interbrand, 2019). These high brand valuations even exceed that of the world's most valuable car manufacturer Tesla (USD 12,79 billion) by far (Companies Market Cap, 2021; Interbrand, 2019).

A strong brand is critical for several reasons. Firstly,

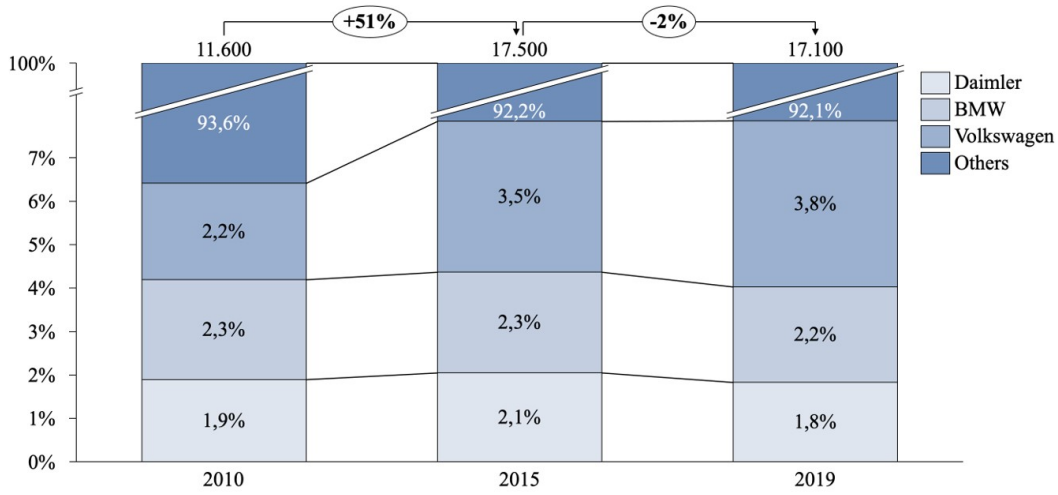

Figure 6: Market share development of German OEMs in the United States.

Source: See Appendix 6

Madden (2006) using the concept of the Fama-French model (Fama & French, 1992), by creating portfolios consisting only of high brand equity firms, finds that strong brands generate higher returns than their benchmarks and do so with lower variance. Other studies find significant relationships between brand values and market-to-book ratios (Kerin & Sethuraman, 1998) or profitability measures (e.g. return on investment) (Yeung & Ramasamy, 2008). Stahl, Heitmann, Lehmann, and Neslin (2012) study the influence of several components, associated to brand equity on the customer lifetime value. The customer lifetime value is defined as "the present value of the future cash flows attributed to the customer relationship" (Farris, Bendle, Pfeifer, & Rebstein, 2006, p. 143) and can be composed to customer acquisition, retention, and profit margin. Stahl et al. (2012) find that knowledge of a brand positively influences all three customer lifetime value components, whereas brand differentiation only positively influences profitability but negatively influences customer acquisition and retention.

Conforming results can be observed in the automotive sector, as retention rates for mass market cars tend to be higher than for more differentiated luxury market cars (J.D. Power, 2020). Still German OEMs achieve good results, with the brands BMW and Mercedes Benz ranking second and third within the luxury segment. The asset *brand* is also becoming increasingly important in China. The results of Guan, Gao, Wang, Zipser, and Shen (2019) show that the share of respondents that would buy the same brand again increased from 12% in 2017 to 31% in 2019. With 41% this share is particularly high for high-end cars, which is also the segment where German OEMs mainly compete.

Besides that, there is evidence that companies with strong brands are more attractive to young job seekers and therefore can acquire talents more easily (Myrden & Kelloway, 2015). Surveys concerning the attractiveness of employers among German graduates confirm this hypothesis: among students in both economic and engineering related fields, car companies rank at the very top (Arbeitgeber Ranking, 2020).

4.1.4. Long-established industry expertise and supplier relationships

German OEMs are globally known to deliver high quality including design, reliability, and safety. This is not only likely to positively influence brand perception as discussed before but is also a fundamental driver for several financial dimensions. For example, Phillips, Chang, and Buzzell (1983) find a positive effect of product quality on a firm's return on investment and Aaker and Jacobson (1994) a positive effect on stock return. Cho and Pucik (2005) also confirm a positive correlation between quality and the dimensions growth performance, profitability performance, and value performance.

Another positive effect of long-time industry expertise is a well-established supplier network. Volkswagen for example has 40,000 suppliers world-wide (Volkswagen AG, 2020a). BMW has around 12,000 and purchases two-thirds of its components from companies outside of Germany (BMW AG, 2020). The characteristics in car manufacturing – the assembly of thousands of small components (most of which are purchased from different suppliers) – allows their procurement departments an aggressive bargaining position and the ability to cut prices (Tyborski, 2020).

The literature also emphasizes non-financial advantages of established OEM-supplier relations. Kotabe, Martin, and Domoto (2003) find that higher-level technology transfers increase as relationships between OEMs and suppliers endure, for both the American and the Japanese market. As a consequence, the performance of suppliers increases, which is beneficial for the buyers as well. On top of that Dyer (1996) finds that co-specific investments (e.g. Daimler's investment in a strategic partnership with the Chinese battery cells manufacturer Farasis Energy (Ganzhou) Co., Ltd. (Farasis) (Daimler AG, 2020d)) have a positive effect on the return on assets for

car manufacturers.

German OEMs also have a strong position in the field of future technologies. Bernhart et al. (2019) find that they are the technology leaders in the area of EVs, ranking before China and Korea. This is even more remarkable as Asian countries have significantly stronger expertise in battery cell production. Germany's technological advantage is also reflected in current sales figures. In 2020, Germany took second place in EV sales for the first time (398,000 units), overtaking the United States (328,000 units) and France (194,000 units) (Irle, 2021). Only the Chinese market was able to sell more EVs (1.34 million). As shown in Chapter 4.2.1 German OEMs can also benefit from this due to their strong position in China (Irle, 2021).

4.2. Weaknesses

The market capitalizations of German OEMs are low compared to most industry newcomers, suggesting that investors tend to believe in the long-term success of others companies (Companies Market Cap, 2021).[9] This is clearly illustrated by the valuation of Tesla, which is worth twice as much as the three German OEMs combined (Companies Market Cap, 2021). The situation is similar for Nio Inc. (Nio), whose market capitalization is almost equal to BMW's, although its sales volume in 2020 was only about 2% of BMW's (BMW AG, 2021) Companies Market Cap (2021); Nio Inc. (2021). Like Tesla, they benefit from a completely new way of thinking (replaceable battery, autopilot, and other connectivity features (see Chapter 4.4.6)). A comparable logic applies to competitors in the shared mobility sector. Uber's valuation reaches that of Daimler (Companies Market Cap, 2021; Macrotrends, 2021d) and Didi is catching up as they seek an initial public offering of around USD 60 billion (Bloomberg, 2021). This section will discuss which attributes of German OEMs make investors believe in other competitors.

4.2.1. Rigid organizational structure optimized for the "old mobility world"

The competitors mentioned above owe their high valuations mainly to their successful implementation of ACES trends (Tesla and Nio mainly in the area of electrification and connectivity, Uber and Didi mainly in shared mobility). Most likely, German OEMs were also aware of these trends but did not implement them, even though they had considerable cash reserves and large R&D departments that could have leveraged their innovative power (see Chapter 4.1.1). It is therefore logical to assume that fundamental problems lie in their organizational structures. In the following section, we will discuss three approaches.[10]

Henderson and Clark (1990) see one explanation in the difficulties of established actors to cope with architectural innovations, which they describe as the "reconfiguration of an established system to link together existing components in a new way" (Henderson & Clark, 1990, p.12). They argue that firms are optimized for component-level innovation and that their organizational divisions reflect the components of their products, which is advantageous as long as their underlying relationships do not change fundamentally. If they do, however, these changes are not as obvious as disruptive ones and therefore pose the threat of being detected too late (Henderson & Clark, 1990). This can lead organizations to wrongly assume to have a good understanding of the new technology. Even if companies recognize architectural innovations, they still need to build new knowledge and skills and find acceptance for them, which is again time and cost intensive (Henderson & Clark, 1990). On the opposite side, new players can start their businesses optimized for the new architecture (Henderson & Clark, 1990). An example of architectural innovation inside the automotive industry can be seen in the exponentially growing connectivity between components which lead to a new arrangement of the system, increased complexity, and reduced flexibility. Consequently, companies are forced to change the architectural design and adapt interdepartmental communication (Henderson & Clark, 1990).

Another approach is to analyze the effects of incremental and disruptive innovations on companies and link them to their organizational structures. There is strong evidence in the literature that the former tend to favor incumbent firms that have accumulated many years of experience in the field, whereas the latter tend to harm them and benefit new market entrants (Clark, 1985; Tushman & Anderson, 1986). Clark (1985) makes the connection to the organizational structure of a company by stating that once a company has chosen a certain path, subsequent decisions are based on it and chosen before alternatives. Consequently, companies build very specific knowledge that allows them to stay successful as long as disruptive technologies do not occur (Clark, 1985). If they do, however, most of their experience and knowledge become obsolete and established players run the risk of being replaced, the author argues. As the automotive industry is hit by several disruptive trends and German OEMs have spent decades incrementally improving established techniques such as the combustion engine, they failed to develop knowledge in battery technology or software that will be central for future mobility concepts.

An obvious solution could be to employ new talents, especially in IT-related areas. However, this is challenging, as due to their large sizes, cost-saving projects, and strict firing policies German OEMs have only limited employment capacities (Specht, 2019). Consequently, German OEMs barely hired additional staff (Appendix 1-3), whereas Tesla almost quadrupled their employees between 2015 and 2019 (Macrotrends, 2021b). Strack et al. (2019) note that competition for new digital talent has become increasingly international, with two-thirds of digital experts willing to move to another country for a job. This increases competition considerably so that German OEMs now must compete with companies like Amazon.com, Inc., Google LLC (Google), or Apple Inc. (Apple), which are known for attracting digital talent.

[9] All information is based on stock prices from April 15, 2021

[10] Discussion from Christensen (2013)

Christensen (2013) contributes a third theory by introducing the concept of value networks. A value network describes the position of a company in the value chain as well as the way it solves problems, reacts to customer demands, responds to competition, or maximizes profits (Christensen, 2013; Dosi, 1982). A firm's position in this value network is critical because it determines the markets in which the firm operates and how it evaluates new technologies. Based on these evaluations, managers decide how they allocate resources (Christensen & Rosenbloom, 1994, 1995). Christensen (2013) considers this as a decisive cause for the failure of incumbent companies since the allocation decisions are based on the economics of existing value networks and are therefore mainly in favor of incremental innovations. Disruptive technologies, however, create different value networks and require a different resource allocation.

Christensen (2013) argues that value networks have a strong influence on organizational structures and even on cultures within companies. On top of that, value networks determine how companies measure value (Christensen, 2013; Dosi, 1982). This becomes clear when comparing the unique selling propositions of German OEMs with those of new competitors such as Tesla or mobility providers like Uber. German OEMs have long prided themselves on their unique driver experience, strong performance, and high quality but failed to see that customers were demanding additional features. Tesla, on the other hand, has focused early on EV range extension, autonomous driving features, or over-the-air updates to improve the overall ownership experience. Mobility providers like Uber deliver convenient on-demand rides, make costs more controllable, and protect their customers from unwanted activities like maintenance.

Figures 7 and 8 compare two illustrative value networks for German OEMs. The first one shows the situation and markets that these companies used to address in the past. The latter shows a potential value network for a future mobility provider. It illustrates that companies are embedded in those networks, as their products are integrated into components within other products (Marples, 1961). The examples shown vary greatly as downstream market players force OEMs to deliver new products with very different characteristics, as shown here in the example of the powertrain. It also shows that purchasing decisions focus on other attributes (right side of boxes) and that components are delivered by other suppliers (left side of the box).

As demonstrated in this case, the new value network is completely changing the market landscape. Consequently, OEMs are forced to find their positions, develop new capabilities, and work together with new suppliers that can deliver the required parts and components.

Value networks not only specify the required product characteristics but are also responsible for the specific cost structures (Christensen, 2013). As a result, disruptive innovations can appear unprofitable when viewed through the lens of the old value network and therefore will not gain financial support from the management (Christensen, 2013). A comparison of the cost structure and resulting profitability between current ICEVs and EVs illustrates this. Baik, Hensley, Hertzke, and Knupfer (2019) show that the costs of the latter would currently be around 50% (EUR 12,000) higher if they had the same characteristics as ICEVs. As discussed earlier, however, future EVs will address different requirements. Therefore, manufacturers can simplify the design, optimize them for urban mobility, and reduce content. Combining these steps enables a cost reduction of EUR 5,700 to EUR 7,100 (Baik et al., 2019). The introduction of new business models such as battery leasing or fleet sales will further reduce costs so that their final costs will be only 20% higher (Baik et al., 2019). The authors further argue that, as the technology matures, costs will continue to decrease so that EVs will break even with ICEVs in 2025. This example shows that future mobility will form completely new value networks. This is another explanation why German OEMs have long left the field to new competitors. Based on the profit structures of the old value networks, managers apparently made the right decisions when they decided to continue ICEV production or to outsource software development. However, as disruptive technologies advanced, these decisions were doomed to fail.

Christensen (2013) finally argues that applying the economics of the technological S-curve will not help incumbent players when disruptive technologies occur. The technological S-curve represents the influence of time or engineering effort (horizontal axis) on the performance of certain product attributes (vertical axis) (Christensen, 2013). The theory holds that in the early stages of a new technology, progress is relatively slow, followed by a rapid development as it gains momentum until the technology finally matures (Sahal, 1981). Christensen (2013) argues that incumbent players are experts in identifying the point of inflection of S-curves and come up with successor technologies at the right time. However, as discussed before, disruptive technologies define new value networks which assess product attributes of performance (vertical axis) differently. Therefore, the new technological S-curve is placed in a different coordinate system (Christensen, 2013). As a consequence, all actions taken to sustain innovation by incumbent players (increased R&D investments, research consortia, technology scanning, etc.) will not address the new value network, as the new network demands fundamentally different attributes (Christensen, 2013). In the following subchapters, we examine a number of negative consequences that are most likely to result from organizational structures and related problems.

4.2.2. Lacking investments into new technologies

As depicted in Figure 8 future mobility concepts will serve other customer needs and therefore require other components and technologies. German OEMs cannot indefinitely benefit from their experience and advantages in the internal combustion engine technology, since stronger CO_2 regulations, consumer preferences of a clean technology and their own desire to build a sustainable company force them to shift their businesses. In addition, the development of various technologies needed to implement the four ACES

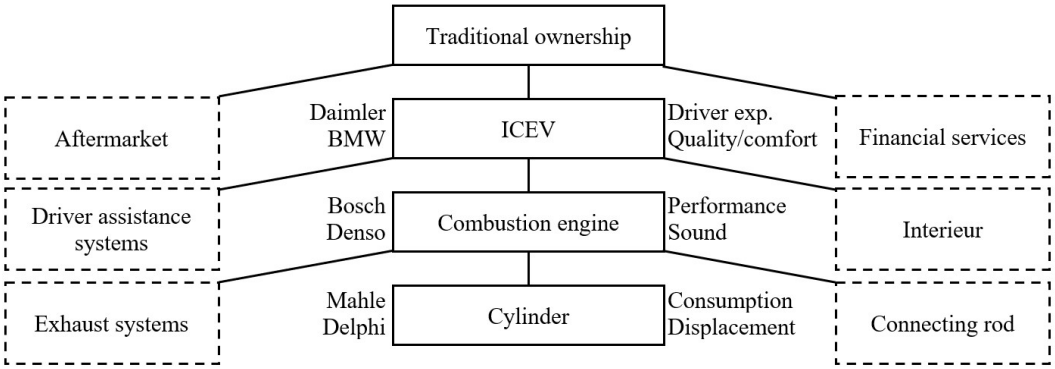

Figure 7: Value network for the "old automotive world".

Source: Own analysis adapted from Christensen (2013, p.35)

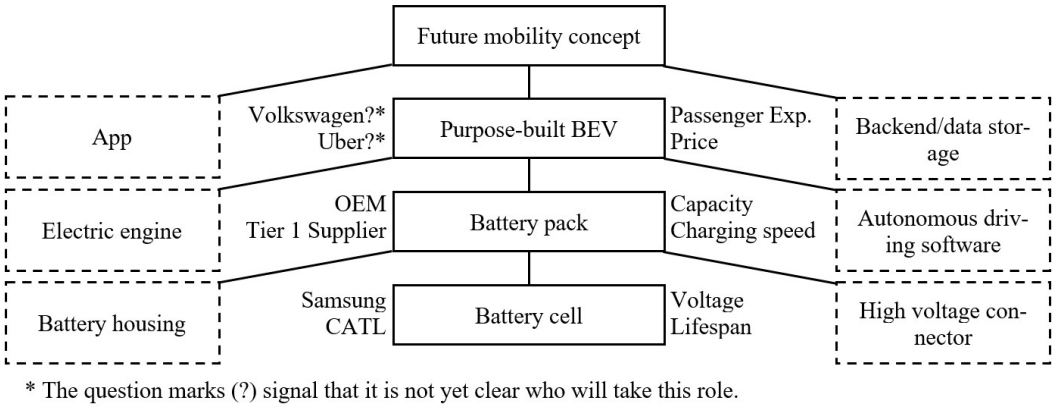

Figure 8: Value network for the “new mobility world”.

Source: Own analysis adapted from Christensen (2013, p.35)

trends is taking place in regions other than Germany or Europe. Holland-Letz et al. (2019) demonstrate that over a third (USD 84.5 billion) of overall investments into the mobility sector since 2010 has gone to companies in the United States. The European Union on the other side only accounts for USD 10.7 billion, ranking far behind China (USD 50.6 billion), United Kingdom (USD 34.1 billion) and Israel (USD 18.5 billion) (Holland-Letz et al., 2019). Holland-Letz et al. (2019) also find that investments have become larger, which indicates that the competition for ACES technologies is becoming more competitive and that technologies start to mature. Thus, it is becoming increasingly difficult for German OEMs to take a pioneering role in these trends, and they run the risk of having to purchase knowledge at a high price in the future. Another interesting finding is that 90% of the investments come from companies outside the automotive sector such as the Japanese SoftBank that invested USD 30 billion into new mobility trends (Holland-Letz et al., 2019). This data shows that the automotive market is becoming increasingly competitive with investments favoring technology players outside of Europe.

4.2.3. Backlog in software technology

Software, computing power, and advanced sensors will likely replace the engine as the technology core of future vehicles (Kaleta, 2021). According to this, the OEMs that best manage the transition from hardware to software will dominate the market in the future. However, German OEMs still struggle with this change and lag behind their competitors. This is also known at the management level, however, solutions are not in sight (Kaleta, 2021; Lambert, 2020). Volkswagen’s Chief Executive Officer (CEO) Herbert Diess stated that Tesla’s superior software competencies would give him “headache” and that it would be a “long way” to catch up (Krogh, 2020). Daimler’s CEO Ola Källenius also embraced the crucial meaning of software which he calls “the brain” of a car (Kaleta, 2021). However, experts criticize that his efforts to regain control on that “brain” are not extensive enough. They argue that Daimler’s innovations, such as subscription models or software updates, are not different from technologies that Tesla has already been offering for years (Kaleta, 2021).

As discussed in Chapter 2.1 one of the most prominent uses of software in future vehicles will be the function of

the autopilot and later full autonomous driving. Bernhart, Hasenberg, Winterhoff, and Fazel (2016) assume that by 2030 shared AVs will gain around 40% of total global profits in the automotive market. To drive this development, German OEMs mainly rely on test fleet data, whereas Tesla uses the data generated by its entire customer fleet (Lambert, 2020). This means a serious disadvantage for German OEMs because, as the author argues, the Tesla fleet functions similarly to a neuronal network in this process. Like other neuronal networks it improves with the amount of data points collected. Tesla's customers already benefit from it, as Tesla provides its customers with a software update every two weeks (Lambert, 2020).

One reason for this backlog could be that German OEMs have long outsourced software development, possibly because they underestimated its competitive importance and value (see Chapter 4.2.1), as the example of Volkswagen demonstrates. Their current share of in-house software development is below 10% (Volkswagen AG, 2019a). They use 70 control units with operating systems from over 200 suppliers, some of them redundantly (Volkswagen AG, 2019a). This not only reduces their value creation share but also increases complexity drastically. As the lines of codes are often not separated from the hardware devices an update requires a complete replacement of the component in the worst case (Hohensee, Hajek, Reimann, & Seiwert, 2021). For many experts it was therefore no surprise that Volkswagen reported several problems during the final development phase of the ID.3 – the car they want to use to start the race to catch up with Tesla (Wimmelbücker, 2020). As a result, the first tranche of models shipped had several software shortcomings that needed to be fixed at a repair shop (Wimmelbücker, 2020).

4.2.4. Missing e-mobility infrastructure

Furthermore, the provision of charging stations has long been a problem in Germany (Thio, 2019). German OEMs have not found a competitive answer and have left the market to the utility companies, which today operate 80% of charging stations in Germany (Bundesverband der Energie- und Wasserwirtschaft, 2020). This has had two negative consequences. First, as Skippon and Garwood (2011) report, charging infrastructure is one of the main pain points for customers when deciding whether to buy an EV or an ICEV. As a result of a poor infrastructure, sales fell short of opportunities and the field for developing the EV market was left to competitors in other countries. Second, German OEMs missed out on a potential new revenue stream. As will be shown later, revenue streams in the automotive industry will change drastically, requiring OEMs to find new revenue opportunities. One possibility could be the charging station segment but as is apparent in the German market, other competitors are better positioned.

4.2.5. Outdated customer relationship

Another category that shows elementary disadvantages compared to new competitors is German OEMs' understanding of customer relationship. They (as most other incumbent players) mainly use the traditional sales via independent retailers (Ilg, 2019): potential customers go to a store, talk to salesmen, book a test drive and eventually buy a car. However, as in most other industries, there is an increasing trend towards online shopping, which is expected to grow from 0.5% today to as much as 17% in the United States by 2030, and to even higher figures in China and Europe (Lellouche, Grover, Blue, Walus, & Barrack, 2020). Moreover, Srivastava, Lellouche, Seners, and Vigani (2018) find that around 5% of customers would buy a car online without ever seeing or test-driving it. Although the number of online car purchases may still be low, online channels already play an important role in the purchase decision. Lellouche et al. (2020) report that 75% to 85% of the customers already base their buying decisions on internet research today. As a consequence, the average number of dealership visits per purchase have dropped from 4 to 1.4 (Srivastava et al., 2018).

As a further consequence of the current distribution model of established OEMs, there are few, if any, touch points with customers. Those that exist, however, are often painful. A Cox Automotive (2019) study shows that customers on average spend 50 hours with vehicle services during a vehicle's lifetime. This experience is particularly inconvenient compared to other products in the consumer-tech sector and poses a great risk of pushing young people towards alternative mobility concepts. In contrast, due to the business models of companies like Uber or Didi there is a continuous interaction with their customers, allowing them to collect user data on a regular basis.

4.3. Opportunities

4.3.1. Increasing mobility requirements and emission-free vehicles

From the strengths and weaknesses discussed above, several opportunities can be derived. One of the probably most important opportunities is that vehicle sales are expected to continue growing with an annual rate of 1.9% to 2.4% by 41 million units between 2015 and 2030 (Grosse-Ophoff et al., 2017). One reason for this growth is increasing urbanization. Studies estimate that the number of people living in cities will grow by 1 billion between 2018 and 2030 (Deutsches Statistisches Bundesamt, 2018a). Another reason are macroeconomic trends, such as a growing middle class (European Commission, 2017a). It is estimated that by 2030 the global middle class will reach 5.3 billion people, resulting in expenses of USD 64 trillion (European Commission, 2017b).

This growth is expected to mainly come from Asian countries (European Commission, 2017b) – markets where German OEMs are already well established. As discussed in Chapter 4.1.2 all three players were able to increase their footprint in China significantly within the last decade. Their joint share grew from below 17% in 2010 to over 25% in 2019, whilst the total market grew by over 60%. It can be assumed that this trend continues as increasing wealth is likely to have a positive impact on car sales that will further boost

volumes in the Chinese automotive market. Weber, Krings, Seyfferth, Güthner, and Neuhausen (2019) estimate that the total number of cars in China will increase from 227 million to 339 million between 2020 and 2030, which corresponds to a CAGR of 4.1%.

Asian markets and the Chinese market, in particular, will furthermore provide a strong push to the aftermarket business, which is, as outlined in 4.1.1, a considerable income source for German OEMs. In China for example the growth of the aftermarket until 2030 is expected to be twice as high as that of traditional car sales (8% CAGR vs. 4% CAGR), which again underlines its importance (Kempf, Heid, & Hattrup-Silberberg, 2018).

To meet fleet emission standards German OEMs will need to increase their EV shares significantly. They thereby benefit from the combination of two of their vital strengths as well as governmental decisions. Firstly, German OEM are technology leaders within the development of EVs (Bernhart et al., 2019). Secondly, they have a strong footprint in the European as well as the Chinese market, which are the regions with the fastest-growing EV markets (Bernhart et al., 2019; Irle, 2021).

4.3.2. Emerging purpose-built vehicles market

As future mobility concepts like ridesharing gain importance, there will be a shift from driver to passenger ride experience. As a result, OEMs will have to put a higher focus on designing vehicles that maximize passenger ride experience (purpose-built vehicles) and consequently create this market (Bernhart, Hasenberg, Karlberg, & Winterhoff, 2018). This opportunity must be seized seriously, as this market will be of great importance. Bernhart et al. (2018) estimate that the market for purpose-built vehicles will reach a size of around 2.5 million sold units per annum in 2025 and that it will continue to grow to as many as 5 million annually sold units in 2030. This growth is again primarily driven by China, accounting for 60% of the volume (Bernhart et al., 2018). On top of the economic importance of this market, the authors consider it an important foundation for a successful position in the market for autonomous driving. They argue that the design and functionalities of a purpose-built vehicle will be very similar to those of a shared AV. They expect that once the technology for autonomous driving is sufficient, OEMs only need to replace the driver with software algorithms.

One way to get a foot in this market is demonstrated by Volkswagen, which signed a fleet management contract for 100,000 vehicles (two-thirds of which Volkswagen vehicles) with Didi (Shah & Shirouzu, 2018). In addition, the agreement provides for joint design and development and allows Volkswagen to access passenger data (Shah & Shirouzu, 2018). Daimler has taken a similar step, building a joint venture with the Chinese Geely Holding (Daimler AG, 2019). Together they plan to develop a purpose-built electric version of the smart.

Bernhart et al. (2018) propose three possible development scenarios for purpose-built vehicles. The first option is to design the new vehicles based on existing models. Grosse-Ophoff et al. (2017) highlight that reduced specifications like less powerful engines and simpler interiors will lower costs by 15%. Moreover, they find that distribution costs can be reduced by 80%, as purpose-built vehicles will be sold in larger bulks. In total, costs for purpose-built vehicles will be 25% less (Bernhart et al., 2018). According to Bernhart et al. (2018) this scenario would however not exploit the entire saving potential and thus would lead to a higher break-even point than the other options. They suggest that OEMs could alternatively start the design from scratch using traditional product development concepts. They consider this approach particularly favorable for non-traditional OEMs that can produce at lower costs. The third option is to come up with a new out-of-the-box design, investing a lot in research and design and build the vehicles in low-cost countries in Asia. This could lead to a 50% lower price compared to today's models.

Options 1 and 3 probably offer the greatest potential for German OEMs. In the former scenario, they would benefit from their strong design competence and market position in the quality segment. In the latter, they could use their strong financial situation and ability to make large R&D expenditures to develop new concepts (see Chapter 4.1.1). In addition, they could use their global production capacities, which enable low costs (compare Chapter 4.1.2 and 4.1.4). As the examples of Daimler and Volkswagen show, a promising approach to market entry can be the establishment of joint ventures with Chinese players.

Bernhart et al. (2018) stress that purpose-built vehicles will require a completely different design architecture. According to the authors, these vehicles will be optimized for certain use cases and passengers will have the opportunity to order transportation services according to their current needs. A vehicle ordered for leisure activities will therefore be very different from the one used for business rides. Figure 9 demonstrates three possible variants, including the categories "Productive", "Relaxing", and "Fun". Bernhart et al. (2018) emphasize that all components need to be adaptive to serve the current desires of the customers. During the design phase, OEMs moreover can relieve pain points (lack of air conditioning control or avoidance of unwanted conversations with the driver) from current models. Due to changing customer concerns Bernhart et al. (2018) estimate that the product lifetime of purpose-built vehicles will be reduced to three to five years. OEMs can make use of that by using a modular architecture, that allows switching individual modules.

Finding the optimal point in time to enter a new market is a topic that has been widely discussed in academia. As a result, a shift from first mover advantage to first mover disadvantage research could be observed (Lieberman & Montgomery, 1998), with many scholars studying the effects of entry order (among others Lambkin, 1988). It is argued that while first movers enter a plain field with few competitors, the market lacks structure and therefore bears high risk to follow a wrong path (e.g. Aldrich & Fiol, 1994). However, firms should not hesitate too long, as that would increase the threat

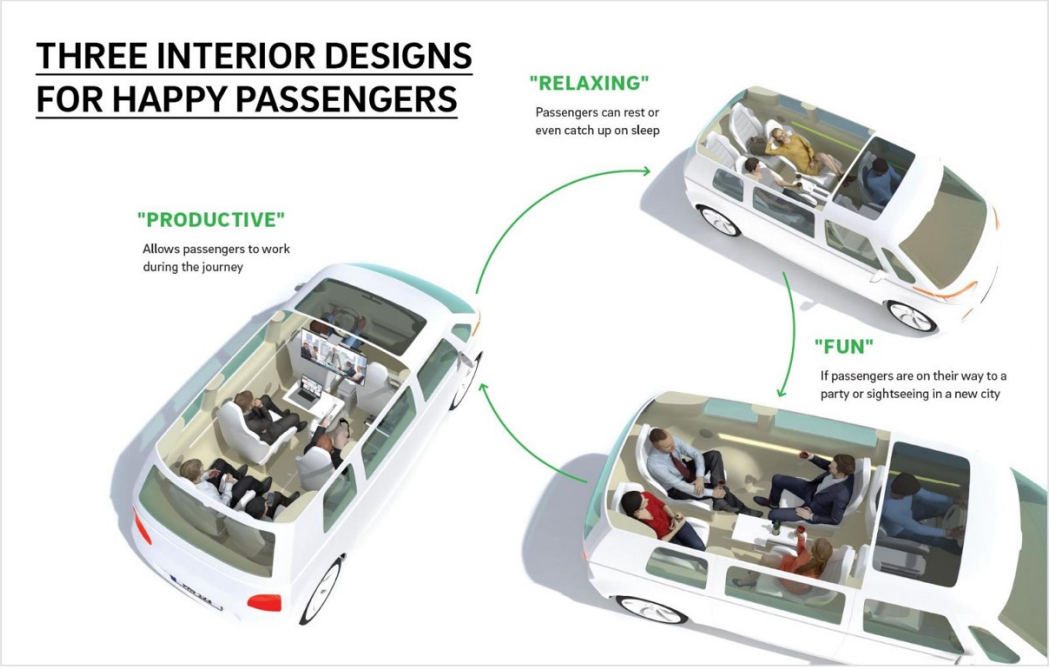

Figure 9: Three use case scenarios for purpose-built vehicles.

Source: Bernhart et al. (2018, p. 10)

to leave the market to their competition (Suarez & Utterback, 1995). The authors show that firms entering an industry before a dominant design emerges will have higher chances of being successful. Their explanation is that those firms will have more time to experiment with new products and that their competitors often fail to catch up. Suarez, Grodal, and Gotsopoulos (2015) combine these results and state that the optimal time to enter an industry is between the emergence of a dominant category and the emergence of a dominant design (see Figure 10). This is also the point in time where a dominant category has emerged, and an increasing number of players figures out a design.

There is evidence that the category of purpose-built vehicles is exactly in that window. As the data of expected growth presented above suggests, the market for purpose-built vehicles has emerged and is gaining momentum, however without an established design yet. Due to their strong financial resources, German OEMs have more time for "experiments" (Suarez & Utterback, 1995), which gives them a critical advantage in nascent markets (Rindova & Kotha, 2001). Rindova and Kotha (2001) also state that a strong identity is crucial for success in nascent markets and that in contrast to established players newcomers often lack it. With significant R&D expenses made by German OEMs (see Figure 3) they seem to be well prepared to play a dominant role in the market for purpose-built vehicles, which is still at an early stage.

4.3.3. Increased R&D expenditures, process improvements, and partnerships

To meet the challenges associated with ACES trends and become the mobility provider of the future, OEMs will need to invest heavily in these new trends. Holland-Letz et al. (2019) report that these investments must amount to at least USD 70 billion by the end of the decade in order to remain competitive. Although this sum represents a major challenge – even for wealthy German OEMs – recent reports show that they are actively addressing it: In addition to the already mentioned investments in e-mobility and digitization, Volkswagen announced at its first "Power Day" to build six gigafactories with a capacity of 240 gigawatt hours by 2030. They also want to expand the European fast-charging network by working with partners to quintuple the number of charging points (Volkswagen AG, 2021b). They have recognized their weaknesses and are now addressing them. Furthermore, Daimler announced investments of about EUR 70 billion (Daimler AG, 2020b), BMW followed with about EUR 30 billion of investments into future trends (Zwick, 2020).

Another area where established OEMs will profit from innovation is in process automation and outsourcing of white-collar jobs (Joas, Reiner, Deinlein, & Oertel, 2018). The authors conclude that these improvements will be higher than in previous decades and should lead to savings of up to 30%. Further cost reduction potential for OEMs beyond current limits can be achieved through the use of Artificial Intelligence throughout the value chain (Joas et al., 2018). The authors demonstrate that its use would enable a profitability potential increase of 15% to 20% per vehicle. Artificial

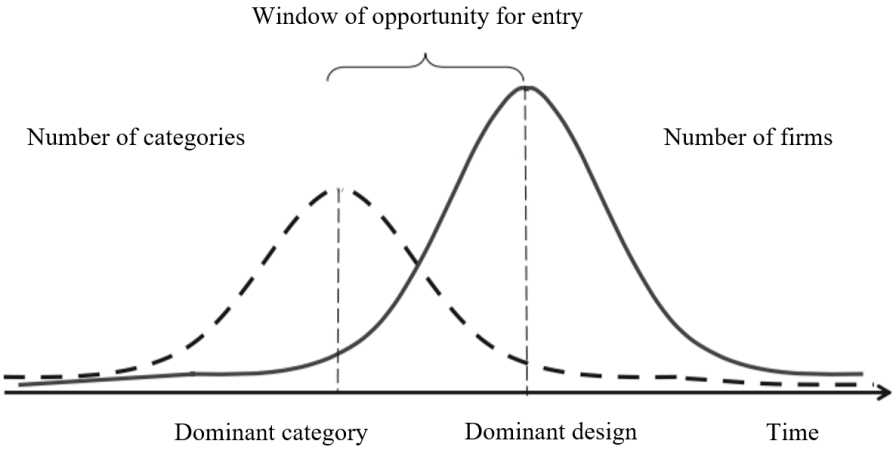

Figure 10: Dominant category and dominant design during the industry lifecycle.

Source: Suarez et al. (2015, p. 441)

Intelligence could for example improve purchase incentives by significantly reducing rebates and vehicle times on stock (Joas et al., 2018).

New technologies or business models are often accompanied by start-up problems or initial losses. This is also true for carsharing services or a comprehensive expansion of a charging station infrastructure (Fockenbrock, Fasse, & Hubik, 2019). However, through partnerships, it is possible to reduce these negative initial effects, use economies of scale and benefit from knowledge transfer and shared risks. One example is the joint-venture Ionity GmbH (Ionity) of Daimler, Volkswagen, BMW, and Ford Motor Company (Ford) (European Commission, 2017a). Under the project name EUROPE Action, Ionity will build 340 Ultra-Charging stations (up to 350 kilowatt) in 13 EU member countries by the end of 2021 (European Commission, 2017a). They thereby mainly focus on highway locations. The average distance between the stations will be 120 kilometers (European Commission, 2017a). According to Jochem, Brendel, Reuter-Oppermann, Fichtner, and Nickel (2015), highways are the best location for charging stations for two reasons. Firstly, the volume of passing cars is high which increases demand and secondly, customers will be willing to pay more than for inner-city charging stations, making the business profitable by 2030 (Jochem et al., 2015).

4.3.4. German government as stake holder

The automotive industry is of great importance to Germany. In 2019, the industry generated revenues of EUR 436 billion (of which more than three-quarters came from OEMs), employed 830,000 people, and made Germany the world's export champion, as 75% of units were shipped abroad. (Bundesministerium für Wirtschaft, 2020). As a consequence, politics have a strong incentive in promoting and stabilizing the industry. They therefore work closely together with the German Association of the Automotive Industry (Verband Deutscher Autombilindustrie (VDA)). Past incidents illustrate how strong the influence of the VDA on German politics is. In 2015 VDA's president Matthias Wissmann was able to prevent stricter exhaust gas tests for diesel cars (S. Becker & Traufetter, 2017). In 2012 the VDA was heavily involved in the introduction of energy labels that assess CO_2 emissions, with the result that heavy German passenger cars with rather poor levels still achieved good rankings (Maisch, 2013).

Besides high involvement in political decisions, the automotive industry could also count on financial support during crises. To incentivize car purchases after the financial crisis in 2009, the government contributed EUR 2,500 for the exchange of an old car for a new one (Seiwert, 2010). As a consequence of the COVID-19 pandemic, the industry was supported with EUR 3 billion (Delhaes, 2020). The government is also strengthening Germany's position in the future mobility market and supporting OEMs in meeting the challenges associated with ACES trends. An example therefore is the EUR 382 million investment into R&D for e-mobility (Bernhart et al., 2019). These investments, measured as a share of GDP, exceed the investments of the Chinese or American governments in the automotive industry by a factor of 10 (Bernhart et al., 2019). On top of that the German government supports the purchase of EVs with up to EUR 9,000 (Delhaes, 2020). This measurement lead to a tripling of new registrations for EVs in Germany during 2020 (Irle, 2021). However, the advancement of EV technology is no exception in the field of innovation. According to the latest Bloomberg report on the innovation power of various nations, Germany is in first place (Jamrisko & Lu, 2020).

In addition to the German government, the European Commission also promotes innovation. One example is the funding of the charging station provider Ionity, which was supported with around EUR 40 million or 20% of the total project costs (European Commission, 2017a). Currently, however, significantly higher investment sums are in discussion. As Balser, Bauchmüller, and Meta (2020) report, the Eu-

ropean Commission is currently considering subsidies in the area of mobility funding of up to EUR 100 billion, of which up to EUR 60 billion would be used for the development of future powertrain technologies. In addition, a double-digit billion amount is to be invested in the expansion of the charging infrastructure (Balser et al., 2020).

4.3.5. Increased upstream integration potential

Within a rapidly changing value network, new components gain importance. This chapter will discuss how German OEMs can benefit from these changes; threats will be discussed in 4.4.3.

Figure 11 demonstrates how profit pools will change over time according to Andersen et al. (2018). While the industry will be able to increase profits by 2.9% annually up to USD 380 billion in 2035, it becomes also clear that this profit will belong to the players that are able to successfully realize the income streams from emerging profit pools. Figure 11 underlines that. Traditional profits will only slightly increase until 2025 and then start to decline, while in the meantime emerging profit pools gain momentum.

The very right column shows how the profit pools will be composed in 2035. Around half of the emerging pools (USD 75 billion) will belong to companies that successfully improve their autonomous driving, electrification, and connectivity capabilities. This again highlights the major strategic importance of these trends and the compelling need to acquire the relevant skills. However, many OEMs still source the required components or software solutions from suppliers (e.g. Volkswagen AG, 2019). They should therefore re-evaluate make-or-buy decisions and consequently build new capabilities or enter partnerships for critical technologies.

While early make-or-buy frameworks focused primarily on the cost or time-saving potential (Williamson, 1981), today's increasingly complex environments require a more holistic approach. To this end, it is worthwhile to start with a discussion of the factors that put companies in a (dis)advantageous competitive position. From this, a modern framework can be derived in a second step. One way to do this is to conduct an internal analysis of a company's capabilities, and to assess its resources, which is referred to as the resource-based view (e.g. Barney, 1991). Barney (1991) states that those firms with valuable, rare, inimitable, and not substitutable resources have a sustained competitive advantage over their competitors. However, Dyer and Singh (1998) note that this approach falls short, as many of a company's critical resources go beyond the company's boundaries and to a significant extent are sourced from suppliers. They argue that the success of a company therefore depends not only on the unique resources of a company but also on the relationships with companies that are integrated into the value chain.

As a consequence, Mudambi and Tallman (2010) recommend that companies should reformulate the problem from a make-or-buy to a make-or-ally decision. According to the authors, entering an alliance would allow companies to retain a certain degree of control over the production process without fully internalizing it. Companies could thus also protect and collect knowledge and benefit from the experience of the alliance partners (Mudambi & Tallman, 2010). Furthermore, this approach counters Dyer and Singh's (1998) criticism by considering the company's closer ties to suppliers (alliance partners).

Powell Mantel, Tatikonda, and Liao (2006) see dependence on suppliers (strategic vulnerability) as one of the most important determinants for make-or-buy decisions. They argue that when strategic vulnerability is high, which is the case when there are few suppliers in the market and costs are high, companies tend to produce in-house and vice versa. Additionally, Powell Mantel et al. (2006) note that companies prefer keeping production in-house when a product or technology is high in core competency. This is the case for products that help companies maintain a competitive advantage in the market (Powell Mantel et al., 2006).

Combining the different frameworks, it can be stated that the make-or-buy (make-or-ally) decisions depend on both the availability of resources (Barney, 1991) as well as their competitive relevance (Powell Mantel et al., 2006). Companies need to identify critical technologies (low availability and high competitive relevance) but also determine whether they are able to compete with suppliers. If they are not, however, which is especially the case with technologies that have already reached a certain level of maturity, they should use partnerships to benefit from the partner's experience and still participate in the value creation (Mudambi & Tallman, 2010). A comparison between autonomous driving and electromobility components illustrates this. As shown in Figure 11, both technologies should be integrated into the value chain due to their competitive relevance. However, implementation should differ, as the technologies are at different stages of maturity and thus the competitive opportunities of German OEMs vary (Bloomberg, 2020a; Eddy, Pfeiffer, & van de Staaij, 2019; Fleetwood, 2017).

Although autonomous driving algorithms and software are making steady progress, unresolved issues slow down their implementation (Fleetwood, 2017; Kalra & Paddock, 2016). As a result, OEMs are still far from offering level 5 vehicles and will not be able to do so on a broad basis within the next years (Bloomberg, 2020b). Consequently, the pressure to deliver a holistic solution is not as immediate. This gives OEMs time to build capabilities and develop the software internally, partner selectively, or acquire promising ventures. Holland-Letz et al. (2019) confirm that incumbent OEMs do most of the development of critical technologies in-house, being responsible for only 10% of the investments but 85% of the relevant patents. More importantly, 58% of all patents in the field of autonomous driving since 2010 have come from Germany, half of them from OEMs (German Department and Trade Mark Office, 2019b). In 2019, three of the four companies with the most patents were German, two of which were OEMs (German Department and Trade Mark Office, 2019a). As shown before Volkswagen has also recognized its shortcomings in the area of software and has therefore founded

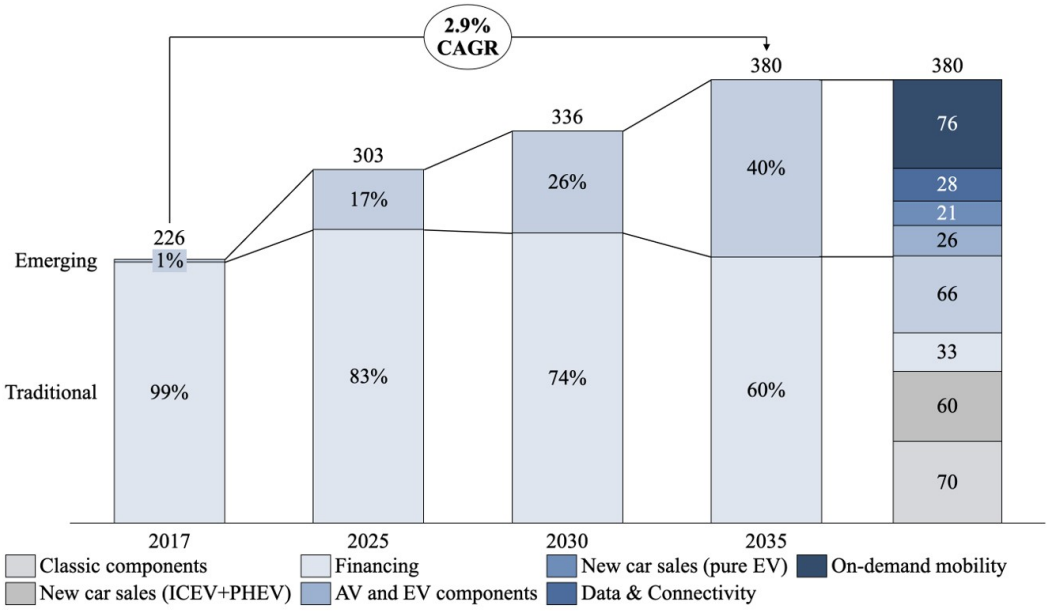

Figure 11: Traditional and emerging automotive profit pools 2017-2035.

Source: Adapted from Andersen et al. (2018)

the subsidiary Car.Software Organization, which will employ up to 5,000 people in the future (Volkswagen AG, 2019a). They aim to increase the company's share of software development from currently 10% to at least 60% (Volkswagen AG, 2019a).

As outlined above, German OEMs have also joined forces in autonomous driving technology development, as the cooperation between Daimler and BMW shows. They are jointly developing level 4 vehicles involving 1,200 employees (Bloomberg, 2020b). Daimler also cooperates with German Tier 1 supplier Robert Bosch GmbH (Bosch) on the development of level 5 vehicles (Bloomberg, 2020b). Another salient example of increased upstream integration is the joint acquisition of HERE, a provider of high-resolution maps, which was acquired by Audi, BMW and Mercedes (Bernhart et al., 2016).

In contrast to providers of comprehensive software solutions for autonomous driving, there is already a huge supplier base for battery cells with decades of experience (Eddy et al., 2019). Moreover, the knowledge required for successful battery cell production does not correspond to the core competencies of incumbent OEMs (Eddy et al., 2019). An example of this is Daimler's failed attempt to establish its own battery cell production under the name Li-Tec (Sorge, 2015). However, German OEMs must find a solution to participate in the profits, because the European battery cell market will have a volume of EUR 90 billion per year in 2040 and thus represents a major opportunity (Eddy et al., 2019).

One promising approach is to collaborate or set up joint ventures with battery cell experts such as Samsung SDI, Contemporary Amperex Technology Co. Limited (CATL), or LG Group. Eddy et al. (2019) emphasize the importance of this cooperation taking place close to the OEMs' locations. They see this as a fundamental building block for the long-term success of these companies. German OEMs have already implemented this: BMW has entered into a strategic partnership with CATL, which will produce battery cells in Erfurt (BMW AG, 2019), and Daimler with Farasis, which will produce in Bitterfeld-Wolfen and create 2,000 jobs (Daimler AG, 2020d). Another example is the joint venture between Volkswagen and Northvolt AB, which will provide 16 Gigawatt hours of capacity from 2024 on (Volkswagen AG, 2019b).

4.3.6. Downstream integration, servitization, and direct-to-consumer sales

Since the 1990s, there has been a clear trend of manufacturing companies moving downstream as they have realized that the service business is more lucrative (Wise & Baumgartner, 1999). The authors see the origin of this concept in the economic development in the second half of the last century: Firstly, due to the strong economic upswing since the 1960s and the increasing wealth of the population, more and more people could afford exclusive products. Secondly, after the growth slowed towards the end of the century, the high number of past purchases as well as the long product lifetimes had resulted in a huge base of products that required additional services (Wise & Baumgartner, 1999). Producing companies were thus able to compensate for lower sales figures with additional services such as maintenance, which increased the share of services in GDP from 16% to 40% (Wise & Baumgartner, 1999).

The trend described above is also known as *servitization* and was first described by Vandermerwe and Rada (1988) as the change of modern companies "offering more comprehen-

sive market packages or bundles of customer-oriented combinations of goods, services, support, self-service, and knowledge" (Vandermerwe & Rada, 1988, p. 314). Servitization, however, not only offers companies an attractive additional source of revenue but also leads to some positive interactions with the product itself (Kastalli & Van Looy, 2013). Kastalli and Van Looy (2013) find that an increase in product sales leads to an increase in service sales, with EUR 1.00 generating an additional EUR 0.86 ($p<0.001$). Even more interestingly and less obviously, the authors confirm this effect vice versa, as they report that an additional EUR 1.00 in services sales leads to an increase in product sales of EUR 1.53 ($p<0.001$). Finally, Kastalli and Van Looy (2013) confirm that customer centricity, which is often only considered as an important component of the services business positively influences product sales ($p<0.05$).

E. Fang, Steenkamp, and Palmatier (2008) note, however, that positive effects from service sales do not monetize from the beginning but require a critical mass before the positive effect pays off. They determine that until service sales reach a share of 20% of total sales, the effect on the firm value is even negative but from that point reaches exponential growth. The dependance of the firm value on service ratio can thus be described as a U-curve (E. Fang et al., 2008). These findings suggest that companies should not only reap the low-hanging fruits but should see the service business as a major profit opportunity and invest heavily to scale it. German OEMs are in a good position to do so, given their strong financial background and their strong presence in the largest automotive/mobility markets. This, however, requires them to internalize these services. We will discuss some alternatives in the following.

A major opportunity for German OEMs lies in the Car-as-a-Service (CaaS) market, although it is currently mainly served by fleet management companies such as Sixt SE (Brenner et al., 2018). The CaaS model aims at a more flexible, subscription-based mobility solution with a full-service concept and therefore serves as a good example of servitization within the automotive sector. In order to enter the market, German OEMs could leverage their existing capabilities from their financial services subsidiaries and adapt them to more advanced customer requirements (Brenner et al., 2018). This could include extended warranty services, insurance, home delivery, and many more. In addition to the fact that German OEMs would be tapping into a previously unexploited market, this market is also developing attractively. Brenner et al. (2018) expect the CaaS market in Europe to grow at an annual rate of 5% to EUR 86 billion by 2025, when it will comprise 15 million units. Brenner et al. (2018) also do not see alternative mobility models such as carsharing or ride-hailing as a threat to the CaaS market. Instead, the authors assume that a changing perception of car ownership will further boost the CaaS model.

As shown in Figure 11, by 2035 on-demand mobility will be the biggest profit pool in the automotive/mobility sector (USD 76 billion). German OEMs positioned themselves in the car sharing sector early on and made their ambitions clear after the merger of BMW and Daimler under the brand Share Now, Europe's leading platform (Share Now, 2021). Volkswagen is also active in the ride pooling market under the brand Moia and plans to scale up significantly (Germis, 2019). In addition, it will be crucial for German OEMs to participate in the massive potential of the ride-hailing market through equal cooperation, as is currently being demonstrated by Volkswagen and Uber (Uber Technologies Inc., 2020).

Another important downstream profit pool is the European used car market, which has an annual turnover of EUR 600 billion (Busvine, 2021). A prominent example that illustrates the attractiveness of this market is the successful initial public offering of the German used car dealer Auto1.com GmbH (Auto1), which reached a valuation of around EUR 12 billion (Busvine, 2021). The company operates both an online B2B marketplace (AUTO1.com) and an online direct-to-consumer platform (Autohero) (Busvine, 2021). The latter achieved significant growth (+75%) in the last quarter of 2020 and exhibits high margins, which is why Auto1 will use the new capital to further develop the brand (Busvine, 2021). However, the number of sales is still small, especially compared to the new car sales of German OEMs. Consequently, German OEMs could tap into an enormous new profit pool if they managed to remarket a portion of their sold vehicles after their first life cycle.

The case of Auto1 and Autohero, in particular, demonstrates the power of the direct-to-consumer online distribution channel which is used by an increasing number of companies to boost their sales and increase their margins (Cao & Li, 2015; Duch-Brown, Grzybowski, & Romahn, 2017; Gao & Su, 2017). German OEMs could also take advantage of this and embark on a multi-channel sales strategy. By doing so, they would counteract one of their biggest weaknesses (missing customer relationship) and could create an end-to-end customer journey with multiple touchpoints. Online retail, however, offers several further advantages: Duch-Brown et al. (2017) state that direct online sales not only take significant shares from traditional channels but also significantly increase the overall turnover. Additionally, the authors argue that firms can transfer relevant product information to potential customers more efficiently and increase product differentiation using a superior website interface.

German OEMs could also use the buy online pick up in stores model proposed by Gao and Su (2017) and thus reach a new customer segment seeking information and convenience. This approach could also be a good fit for them, as delivering cars is costly and time-consuming for dealers, while picking them up is an experience for many buyers. An additional argument in favor of building an online retail channel is that Zhuang, Popkowski Leszcyc, and Lin (2018) report that, contrary to popular belief, the price dispersion of online products is higher, allowing for better price discrimination. The authors argue that this is particularly the case in e-marketplaces where customers have a high level of trust in the supplier, which can be assumed in this case, given the brand strength of German OEMs. Furthermore, Zhuang et al.

(2018) make clear that even without direct online sales, the online presence of manufacturers is crucial for obtaining information, which is also in line with the results of Lellouche et al. (2020), who report that 75% to 85% of customers base their purchase decision on internet research.

4.4. Threats

4.4.1. Regulations and missing intellectual property rights in China

As discussed in Chapter 4.1.2 German OEMs rely heavily on the Chinese market due to its strong growth and high margins. In strong contrast to these promising factors, however, the Chinese market also harbors many risks and dangers, especially due to the influence of the communist party and the associated low degree of freedom. China ranks only 103rd in the Economic Freedom Score, performing particularly poorly in the areas of intellectual property rights, government integrity, and investment/financial freedom (The Heritage Foundation, 2020). The first two pose a particular threat to German OEMs, as will be discussed in the following.

For foreign companies, such as German OEMs, weak intellectual property rights have two negative consequences: Firstly, foreign firms are often forced to establish partnerships or joint ventures with domestic players, which the latter use to absorb knowledge (Collinson & Liu, 2019). Weak intellectual property rights increase the difficulty for foreign firms to obtain the core of innovation in such partnerships. Therefore, according to Zhao and Anand (2009), they do not want to share critical information with their Chinese partners. This makes a trustworthy and successful collaboration almost impossible. Secondly, there is evidence that China's handling of intellectual property rights harms innovation (Brander, Cui, & Vertinski, 2017). As the main reason, the authors bring into play that weak intellectual property rights destroy the creation of incentives. They argue that innovation stalls if innovators are not rewarded for their achievements. L. Fang, Lerner, and Wu (2017) confirm this hypothesis. The results of their study show that companies in cities with higher intellectual property rights protection are more innovative.

On top of that, the Chinese government is often accused to favor local players, especially those in high-tech industries (Denyer, 2014; Sutherland, 2003). An example therefore is the rise of Nio which was financed with USD 1 billion by a municipal government in China (Bloomberg, 2020a). After this financing round Nio's stock price exploded (Bloomberg, 2020a). Now that the government owns shares, its interest in Nio's success has increased further, making the company a serious competitor to the established players (of which also Tesla is one). In the case of German OEMs, the strong influence of the government can be very dangerous because it not only supports local players but also makes lives difficult for foreign competitors, as the current example of Tesla shows. Tesla was accused of using spy software for military purposes (Zhai & Kubota, 2021). As a consequence, the government banned its vehicles for military or other state-owned companies (Zhai & Kubota, 2021).

4.4.2. Environmental regulations in Europe and Germany

To meet the European Union's CO_2 targets, German OEMs have adjusted their fleet mix and plan to increase the share of EVs significantly by up to 70% of total sales (Seiwert, 2019, 2021). For a long time, the European Green Deal regulation foresaw a CO_2 reduction of 40% until 2030 compared to 1990 (Götze, 2020). However, since a new legislative decision in December 2020, this target has increased to 55% (Götze, 2020). In addition, the author notes that there will be fewer penalty exceptions that OEMs currently benefit from. These additional requirements could hit German OEMs hard, as Volkswagen, for example, is responsible for 2% of worldwide CO_2 emissions (Seiwert, 2019). Experts such as the CEO of Bosch Volkmar Denner warn of the consequences of the new regulations, as he believes they will spell the end of ICEVs and the mass loss of jobs that will come with them (Seiwert, 2019).

Volkswagen, unlike BMW and Daimler, did not achieve the required fleet consumption in 2020 (Reuters, 2021). However, they benefited from the currently rather soft regulations and therefore had to pay a fine of just over EUR 100 million for exceeding the average fleet consumption by 0.5 grams per 100 kilometers (Reuters, 2021). Experts, however, assume that the fine could have been in the billions if the law was interpreted more strictly (Reuters, 2021). This illustrates the high penalties German OEMs could face in the next few years and underlines the disruptive power of regulations in the automotive sector. German OEMs are in a disadvantageous position compared to companies like Tesla or Nio, which have a pure EV portfolio or Volvo Car Corporation (Volvo) with significantly better fleet consumption (Freitag, 2020). These companies can sell their CO_2 credits to companies with worse fleet emissions and thereby achieve billions of euros in revenues as the example of Tesla and Fiat Chrysler demonstrates (Freitag, 2020).

Other regulations take place at the national level. One example is the current debate on the introduction of a speed limit on German motorways. Survey results show that the proportion of German citizens in favor of a speed limit has risen significantly since 2014 and in 2020 has overtaken the proportion of those against for the first time since 1993 (ADAC, 2020). Malorny (2020) sees a possible speed limit as a major threat for German OEMs. He argues that there is a strong correlation between a car's ability to reach speeds of 250 kilometers per hour and its perceived quality. In his opinion, consumers worldwide are convinced that German OEMs offer the highest quality cars due to the combination of an unrestricted speed limit and the fewest accidents per kilometer. He is concerned that a speed limit would damage the perceived premium quality of German OEMs and reduce their pricing power.

4.4.3. Shrinking traditional profit pools

The share of German OEMs' classic profit pools – vehicle sales and the aftermarket business –within the automotive/mobility market will shrink (Andersen et al., 2018). In this chapter, we look at the data shown in Figure 11 from

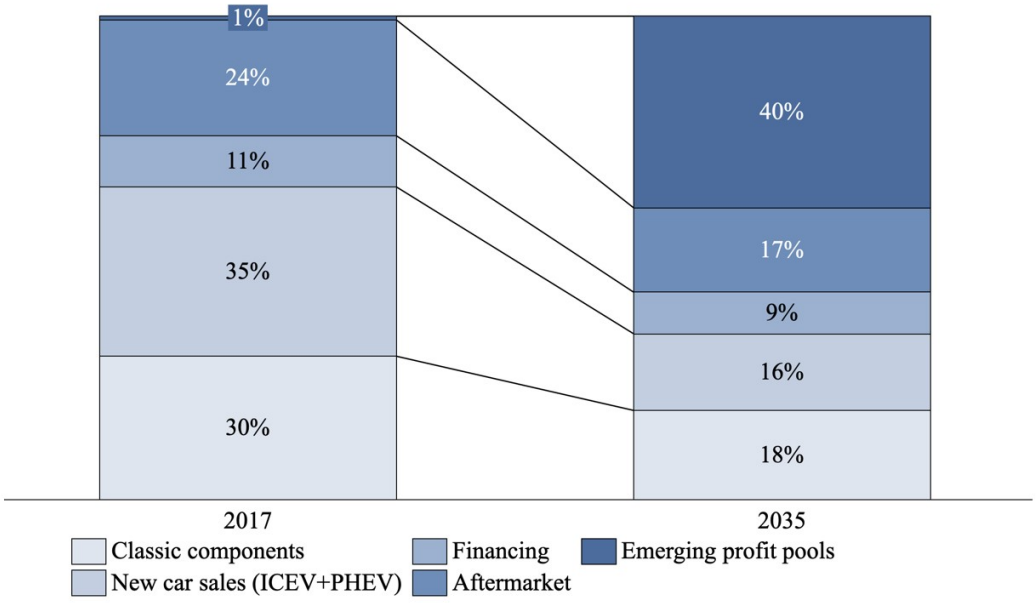

Figure 12: Automotive profit pools in 2017 and 2035.

Source: Adapted from Andersen et al. (2018)

a different perspective. Assuming that German OEMs will find it difficult to successfully exploit the new trends, their future appears uncertain, and they run the risk of losing importance and becoming low-margin hardware players. Figure 12 shows that by 2035, about 40% of traditional profit pools will be displaced by emerging ones. This hits sales of new cars with conventional combustion engines particularly hard and reduces their profit share by more than half to just 16%. The aftermarket and component business, which are also profitable for carmakers and dealers, will be similarly affected.

As discussed earlier, higher costs for the EV powertrain will change the economics in production. Weber et al. (2019) argue that premium OEMs should not compensate for this effect by lowering the cost of other components but instead raise prices. However, this risks shrinking sales in the competitive EV market (Weber et al., 2019). Furthermore, the authors discuss two scenarios based on an increase in the EV share. In their baseline scenario, they argue that the profit margins of incumbent OEMs will fall below 2% by 2030 due to increased costs and limited price increase opportunities as EV sales gain momentum after 2024/25. However, if OEMs manage to further reduce costs and increase customer perceived value and willingness to pay, they could break even at pre-COVID margins in 2025 (Weber et al., 2019).

Governmental decisions, especially those in Europe in China (Chapter 4.4.1 and 4.4.2) will further accelerate the decline in ICEV sales. In addition, the market growth caused by increasing urbanization (discussed in Chapter 4.3.1), is slowed down by shared mobility business models. Grosse-Ophoff et al. (2017) expect this effect to amount to 13 million fewer units sold per year and to be composed of two opposing forces: Due to sharing solutions, around 23 million fewer vehicles will be needed, however, since shared cars are used more frequently and thus wear and tear increases, 10 million more vehicles will be needed (Grosse-Ophoff et al., 2017).

In addition, ACES trends will seriously affect the aftermarket in several categories (Kempf et al., 2018). The authors expect that around 40% of profits (EUR 100 billion) will be redistributed as a result of disruptive trends. One reason for this is the technological progress in new vehicles. While an ICEV powertrain may have over 1,000 components, that of an EV contains only a few hundred (Küpper, Kuhlmann, Tominga, Arora, & Schlageter, 2020). This significantly reduces the susceptibility to faults and possible repair shop visits with the need for spare parts. In addition, networked components will be able to detect failures more quickly so that they can be replaced earlier and with less damage (Küpper et al., 2020). With the advent of automated driving technology, vehicles will be involved in significantly fewer accidents, which in turn will reduce the need for new components (Fagnant & Kockelman, 2015). In addition, further development of ACES trends will increase product complexity, which will require additional workforce qualification.

Another trend is the changing customer relationship. Kempf et al. (2018) predict that those who are able to best analyze the Big Data generated by their customers will succeed. Jäck and Sizov (2020) support this hypothesis. They conclude that future successful players in the automotive aftermarket business will use advanced analytics to better predict market baskets or calculate the probability of certain events. Another point Kempf et al. (2018) mention is that the increasing digitization of distribution channels reduces information asymmetry, making it even more difficult for market

players to generate profits through traditional business.

Taking the discussed trends together, it is apparent that reduced ICEV sales volumes and falling profit margins are making it difficult for German OEMs to retain their leading position and thus to finance further significant R&D spending. Moreover, it seems rather unlikely that German OEMs have the necessary capabilities to establish their successful position in the aftermarket business. It seems more probable that newcomers who use Big Data effectively and those who take a better, customer-centric approach will shape the market. Even if German OEMs can survive in the aftermarket, its margins will most likely be lower and the positive smoothening effect will diminish.

4.4.4. The competitive landscape of German OEMs

German OEMs face increasing competition from different areas. The use of Bergen and Peteraf's (2002) framework allows for broader coverage of competition as besides direct competitors it also takes into account potential and indirect competitors (substitutors). This step is essential as Eisenhardt and Bourgeois (1989) warn that managers in high-speed environments like the automotive industry are tempted to focus too much on direct competition and risk overlooking competition from emerging sectors. They argue that competitor research in different sectors is significantly more complex, time consuming, and expensive and that managers dispose of a limited number of resources (time and budget), resulting in flawed allocations. An example of this is the struggle between incumbent OEMs who focused on beating the direct competition by developing better ICEVs but failed to recognize the entry of companies specializing in EVs, software, or advanced mobility solutions.

Figure 13 depicts the current situation of the automotive market from the perspective of a German OEMs, using Bergen and Peteraf's (2002) framework. The framework is based on the generally accepted simultaneous consideration of supply and demand side (e.g. Day, 1981). In order to build the framework, Bergen and Peteraf (2002) borrow from Chen (1996) using the dimensions market commodity (demand) and resource similarity (supply). According to Bergen and Peteraf (2002), market commodity is "the degree to which a given competitor overlaps with the focal firm in terms of customer needs served" (Bergen & Peteraf, 2002, p. 160) and resource similarity "the extent to which a given competitor possesses strategic endowments comparable, in terms of type, to those of the focal firm" (Bergen & Peteraf, 2002, p. 161). As the automotive market evolves at an ever-fast speed and clusters in the automotive market seem to be larger and more overlapping than in the traditional framework, arrows symbol the cluster's movements and extensions.

The application of this framework enables several observations. Firstly, it becomes apparent that established and large firms such as Toyota Motor Corporation (Toyota) or General Motors Corporation (General Motors), which can benefit massively from economies of scale due to their enormous sizes, represent direct competition for German OEMs. Their large sizes can be particularly beneficial in the group-wide standardization of operating systems, battery cell development, or the development of algorithms for autonomous driving, as the R&D costs can be allocated to a higher number of units. Secondly, the group of potential competitors and the group of direct competitors are converging, as the established OEMs have understood that they need to address other customer needs such as zero-emission travelling to remain competitive. Thus, they are addressing customer needs that previously only newcomers like Tesla could solve, which increases overlaps in market commodity. As a result, German OEMs will find themselves in a significantly larger direct competitor pool in the future. A similar, albeit less pronounced, convergence can be observed in the cluster of indirect competitors since OEMs are increasingly entering the service market (see Chapter 4.3.6). Additionally, growing interactions between mobility service providers and OEMs can be expected (see Chapter 4.4.5).

4.4.5. Indirect competitors (substitutors) and their business models

For decades there were hardly any penetrations into the automotive market due to high entry barriers and German OEMs have successfully defended their position within. According to Peteraf and Bergen (2003), indirect competitors or substitutors often pose the greatest threat as they are not recognized as such. Indirect competitors are those that serve similar customer needs but use different resources. In the case of an OEM, they can come from two different regions. First are mobility service providers such as Uber or Didi. Second are software companies such as Google or Nvidia Corporation (Nvidia). Both will be discussed in more detail.

Compared to OEMs mobility providers possess few assets, sell services instead of goods and often and employ their staff (drivers) on a self-employed basis. As discussed previously they however serve similar customer's needs – the need to get from A to B safely, fast, and cost efficiently. It can be argued that today the majority of people prefer owning cars but as the understanding of mobility and ownership further change, the boundaries continue to blur (Weber et al., 2019). The results of Weber et al. (2019) underline that. The authors report that around 74% of surveyed consumers opt for the most convenient mobility solution. Additionally, they note that over 40% of consumers in urban areas would give up their cars and that over 50% would pay up to USD 250 for unlimited free ride services. This seems reasonable as Andersen et al. (2018) report that by 2030 for 30% of Europe's population it will be less expensive to use shared mobility services compared to possessing a car. Bernhart et al. (2016) expect that mobility service providers will be at the "fat end" of the value chain, as they will make use of the direct customer interaction and maximize revenues and profits. On the other side, OEMs will lose influence and are threatened to be downgraded to pure device manufacturers that need to obey the specifications and requirements of mobility service providers.

Bernhart et al. (2016) portray three possible scenarios

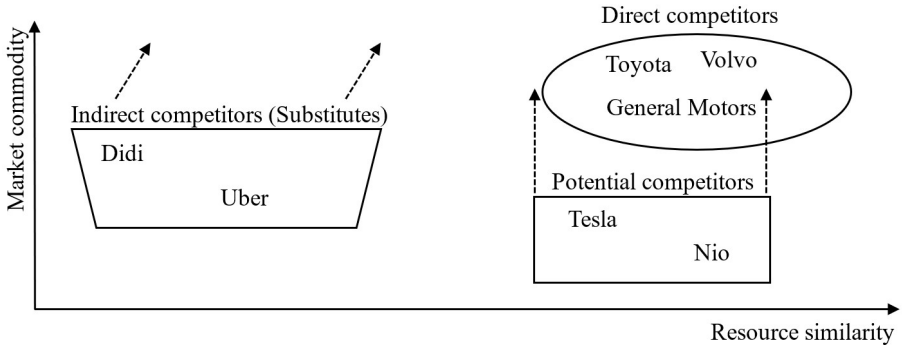

Figure 13: Competitive landscape of German OEMs.

Source: Adapted from Bergen and Peteraf (2002, p. 160)

for OEMs. There is only one, however, in which German OEMs can continue to profitably exploit their status position, based on the interplay of quality and brand. Alternatively, they could end up as contract manufacturers and would have to comply with the specifications of the mobility service providers (Bernhart et al., 2016). Even worse for them would be the third scenario, in which they would be white-label manufacturers and leave the complete branding to the mobility service providers (Bernhart et al., 2016). This is a crucial threat especially for German OEMs, as the brand is one of their most valuable assets (see Chapter 4.1.3).

As discussed in Chapter 4.3.6 German OEMs can also choose to enter the mobility services market. While this opens a new promising profit pool, Bernhart et al. (2016) note that OEMs face significantly higher internal costs. If they fail to adapt these and consequently will not reach the required profitability margins, they are in danger to lose the market to competitors.

In addition, the massive emergence of new competition from software specialists like Google, Nvidia, or in a broader sense Apple must be considered. Although they currently do not offer holistic mobility solutions, this could change quickly. According to recent rumors, Apple is looking for a hardware partner for its automotive business (Hohensee et al., 2021). Apple has also poached senior managers and engineers from Tesla and Ford for its car project called "Titan" (Hohensee et al., 2021). Furthermore, according to the authors, Apple's iPhone manufacturer Foxconn Technology Group has started to build a car factory in China. Another point that can be seen as evidence of the increasing influence of software companies in the automotive sector is the valuation of new competitors such as Tesla. According to Klebnikov (2020), Tesla is not priced as an automotive but rather as a fast-scaling software company. Entering the automotive market could pay off for Apple, as it could significantly expand its ecosystem and gather new customers and data. Experts believe that a third of Apple's worldwide customers would be interested in an Apple car (Hohensee et al., 2021). Given 1.5 billion Apple devices currently in use their market share would be enormous.

Besides the opportunity of providing holistic vehicle solutions, software specialists also focus on operating systems as the examples of Google and Nvidia demonstrate. Nvidia's CEO Jen-Hsun Huang expects that in the future OEMs will not earn money from vehicle sales but mainly from functionalities and services provided by software (Hohensee et al., 2021). Google Waymo's boss takes a similar position. Disguised as a "partnership", he wants to convince carmakers to produce cars while Waymo provides the "driver" (Hohensee et al., 2021). In return, this would mean the degradation of car manufacturers to pure hardware providers if they fail to produce the operating systems internally. Although this scenario sounds alarming, carmakers such as Volvo and Ford have decided to rely on Google's solution "Android Auto" in the future (Hohensee et al., 2021).

German OEMs, on the other hand, are focusing on independent development (Hohensee et al., 2021). However, this is associated with enormous costs and their comparatively low valuations make it difficult to raise additional money. In addition, the authors argue, it is more difficult for Daimler and BMW to allocate development costs due to their small sizes.

4.4.6. Direct/potential competitors and their technological advances

According to Bergen and Peteraf (2002) and Chen (1996), the greatest competitive threat comes from potential competitors, those that have high resource similarity and low market similarity. In the case of German OEMs, these are companies such as Tesla or Nio. Tesla has been relying on ACES technologies for some time and was therefore particularly attractive to tech-savvy and affluent consumers. However, established players have also recognized the importance of ACES trends, so that the clusters are consequently moving towards each other. In addition to new potential competitors, this section also analyses the established players, as the enormously fast development of the industry and the new applications of ACES technologies sometimes blur the boundaries between the two. Consequently, today's incumbent players have the potential to become tomorrow's innovators. This section is divided into three parts: First, we

assess several OEMs in terms of their future capabilities to exploit the four ACES trends. To do so we introduce the ACES Index, which we define as the arithmetic mean of the scores that the considered OEMs achieve in the four dimensions *autonomous driving, connectivity, electrification,* and *shared mobility*. The score of each dimension results from several subcategories. Second, a prediction of future leadership is derived based on the three dimensions *size, ACES Index*, and *market capitalization*. Finally, we analyze whether the ACES Index is a good predictor for future success. Table 1 shows the results of the analysis of ACES capabilities for a selected group of OEMs. In addition to the German ones, Asia's and world's largest OEM Toyota, one of America's largest OEMs General Motors, and one of Europe's innovative players Volvo as well as the two newcomers Tesla and Nio are considered.

In each sub-category, a company can achieve scores from zero (0) to five (5), with 5 being the best score.[11] The scoring is based on an ordinal scale.[12]

The *autonomous driving* dimension consists of three subcategories (strategy/ambition, patents, and field testing). The results show that German OEMs are well positioned in the area of research due to partnerships or, as in the case of Volkswagen, hold strong stakes in autonomous driving technology companies. Daimler engages in research projects with Tier-1 supplier Bosch where they test vehicles with level 4 and 5 capabilities (Bloomberg, 2020b). BMW even plans the roll-out of the iNext in 2021, which will offer level 3 technology (Bloomberg, 2020b). German OEMs also hold several autonomous driving technology patents. Volkswagen leads this category with 1,101 patents, which is almost double that of second-placed General Motors and BMW ranks third (Bardt, 2019). However, compared to their competitors, with the exception of BMW, German OEMs conduct few field tests, which puts them in a position at the end of the line (Bloomberg, 2020b). Daimler for example only operates a test fleet consisting of twelve vehicles, Volkswagen collaborates with Argo AI LLC, using around 100 vehicles (Bloomberg, 2020b). Another problem for German OEMs could be their lack of sense of urgency. While Tesla is channeling almost all of its expenditures into the development of autonomous driving technology (Bloomberg, 2020b), BMW and Daimler have announced the end of their collaboration due to necessary cost savings (Daimler AG, 2020c). In this category, it is also noticeable that, in addition to the newcomers Tesla and Nio, the American OEM General Motors scores positively. Its good performance is largely based on the purchase of the American self-driving car company Cruise LLC in 2016 (Bloomberg, 2020b).

The *connectivity* dimension consists of three subcategories (connectivity/app services, infotainment, and user experience). As stated before a competitive position in this area is crucial, since many industry experts assume that future profits will mainly come from additional software services and functionalities (Hohensee et al., 2021). BMW and Daimler achieve very good results in this area (first and third place respectively) and can compete with Tesla and Nio. This is mainly due to their excellent app services (Mercedes me and BMW Connected), as well as due to large and high-resolution screens (Bender, Peuckert, & Waasen, 2020). Volkswagen, on the other hand, only takes sixth place. This is mainly due to less comprehensive app services and, in some cases, not fully intuitive usability (Bender et al., 2020). It needs to be noted here, however, that premium brands (BMW, Daimler, or Tesla) charge high fees for their services, which makes comparability difficult (Bender et al., 2020). As a result, Toyota's and General Motor's performances are at the bottom of the field. They offer only rudimentary app services and, in the case of Toyota, mediocre screen quality (Bender et al., 2020).

The *electrification* dimension consists of five subcategories (choice/availability, Center of Automotive Management (CAM) innovation power index, range, price per kWh, and charging speed). German OEMs perform in the midfield, leaving Toyota and General Motors far behind, as the latter currently do not offer pure EVs in significant numbers. Volkswagen even manages to win the subcategory "price per kWh" with their newly introduced ID.4. On top of that Volkswagen has a considerably high CAM innovation power index, which is almost as high as Tesla's and three times higher than that of third-placed General Motor's (Center of Automotive Management, 2021). In total, however, the backlog of German OEMs to Tesla and Nio is large. Apart from the Volkswagen example mentioned, the German OEMs must admit defeat to Tesla and Nio in every category. According to Eddy et al. (2019), the supply chain risk is another major threat for European players, as they currently possess little knowledge. With increasing demand, those that have integrated major parts of the value chain would further benefit.

Within the *shared mobility* dimension, the only subcategory "sharing services" assesses current and planned platforms for carsharing, ride sharing, and full-service leasing services. This is the only category where all German OEMs achieve good results, especially compared to new competitors who have announced sharing services but do not provide holistic solutions yet. All German OEMs have their own free-floating services and offer a solution for private carsharing ("Mercedes me") or ride-hailing services (Volkswagen Moia) (Daimler AG, 2021b; Germis, 2019). Whether internalized sharing services will give German OEMs a competitive advantage in the future however still remains unsure, as they still report negative figures (J. Becker, 2019). Similar is true for General Motor's service platform "Maven" which was shut down in 2020.

This section concludes with two analyses that shall test the influence of a company's ACES Index on its future success in a rapidly evolving market. In a first step, the examined companies are therefore clustered into one out four categories based on their ACES Indices as well as their current

[11] See Appendix 7-15 for the results and sources from subcategories.

[12] A score of 5 can only be accomplished when a company dominates all aspects from a category.

Table 1: ACES Indices for German OEMs and competitors.

	Autonomous driving	Connectivity	Electrification	Shared mobility	ACES Index	Rank
Daimler	2.0	3.8	2.4	3.5	2.9	6
BMW	3.2	4.0	2.4	3.0	3.2	5
Volkswagen	3.3	2.7	3.8	3.5	3.3	3
Tesla	4.5	4.0	4.6	1.5	3.7	1
Toyota	2.8	1.8	1.5	3.0	2.2	8
General Motors	3.7	2.3	2.2	2.0	2.5	7
Volvo	2.8	3.0	3.2	3.5	3.2	4
Nio	4.0	3.8	4.3	2.0	3.5	2

Source: Own analysis, see Appendix 7-15 for detailed results from subcategories and sources

market sizes (units sold in 2020).[13] For better comparability, we apply the logarithmic function of sales volumes, as sales numbers differ greatly (Nio. 43,000 units vs. Toyota 9.53 million units), following Fama and French (1992). The resulting four dimensions are *industry stars* (large size, high ACES Index), *aggressive innovators* (small size, high ACES Index) *incumbent players* (large size, low ACES Index) *and hardware niche players* (small size, low ACES Index). The emerging framework is reminiscent of the Boston Consulting Group's Matrix, which includes the dimensions of market growth and market share (Hambrick, MacMillan, & Day, 1982). Moreover, both frameworks include the market capitalization of the examined companies. Figure 14 depicts the resulting quadrants and the position that the examined companies take within. The areas of the circles represent the companies' market capitalizations.

As expected, the newcomers Tesla and Nio are placed within the "aggressive innovators" and the German OEMs as well as their large direct competitors within the "incumbent players" quadrant. Volvo is at the edge of being an "aggressive innovator" and a "hardware niche player". Probably the most noticeable result is that there is currently no company in the target quadrant "industry stars". Either they do not have the necessary size, or they do not have the necessary technological capabilities. The arising question is, which company will succeed in penetrating this quadrant. This could be answered by looking at the area of the bubbles, as these provide information about investors' expectations of future turnover/sales figures. The size of Tesla's bubble (market capitalization) is particularly noticeable, which leads to the assumption that Tesla will be able to significantly increase its sales figures and thus move along the horizontal axis towards the "industry star" quadrant. The same could be true for Nio, as its bubble is almost the same size as that of the established players, although it is much smaller in terms of sales volume. Investors expect significant growth here as well, so Nio could follow Tesla's movement and become an "industry star".

[13]Please find detailed information on sales volumes, market capitalizations, and sources in Appendix 16.

Given the results from Chapter 4.4.3, which showed that the automotive market growth is slowed down by the emergence of several trends, that would mean, by implication, that Tesla and Nio would be massively stealing market shares from incumbent companies. Consequently, incumbent OEMs could be pushed in the direction of "hardware niche players" if they fail to regain their technological leadership position. In the "hardware niche players" quadrant competition is particularly fierce. This is reflected in the current wave of consolidation that is affecting some of these competitors as the example of the Stellantis Group, which merged the Fiat Chrysler Group and the French PSA Group, shows (Piovaccari, 2021).

The purpose of the third analysis is to determine how well the ACES Index is suited to predict the future success of a company. A common indicator for the latter is the market capitalization, as it indicates expected future cash flows. Again, as company sizes differ significantly, we compensate for that by dividing the market capitalizations by the number of vehicle sales and thus obtain the valuation per vehicle. This is a similar metric to what Fisher (1984) introduced as the price-to-sales ratio. Without that adjustment, newcomers with low volumes would be underrated and incumbent players with high volumes overrated.

Table 2 depicts the results from a series of OLS regressions (n=8). First, it can be seen that the ACES Index serves as a good predictor of the market capitalization per vehicle (t-statistic = 2.341) and is able to explain around 48% of the model's variance. The high beta value of 950,328,98 again underlines the potential leverage of the ACES Index: If a company is able to increase its ACES Index by 0.1 points it could increase the valuation per vehicle by USD 95,328, according to the analysis. Second, controlling for all independent variables separately shows that only the variables *autonomous driving* and *electrification* have a significant positive impact on the market capitalization (t-statistic = 2.851 and 3.068 respectively). They are also able to explain a higher part of the variance compared to the ACES Index (R^2= 0.575 and 0.611 respectively). On top of that even their lower 95% confidence interval is significantly positive (88,574.12 and

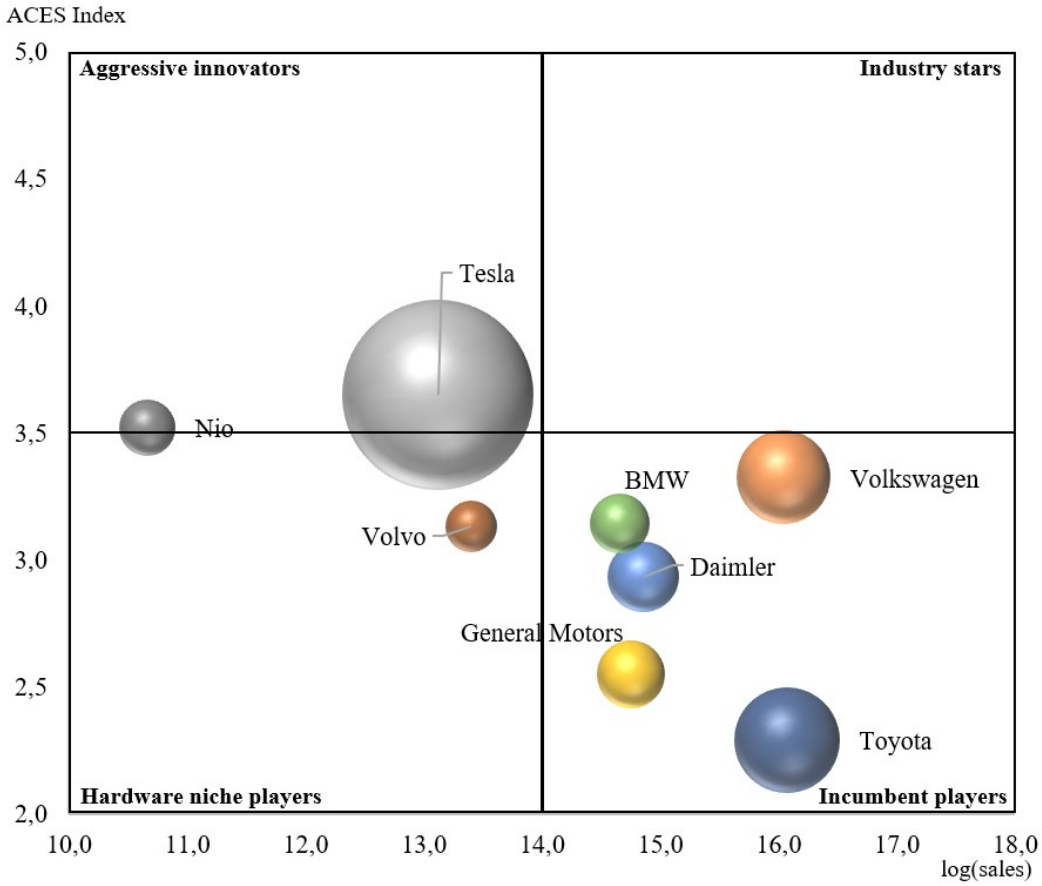

Figure 14: OEM clusters based on the ACES Index and size.

Source: Own analysis

Table 2: OLS regression analysis on ACES trends and market capitalization per vehicle.

Predictor	*Beta*	*t-statistic*	*p-value*	*Lower 95%*	*Upper 95%*	R^2
ACES Index	950,328.98	2.341	0.058	-42,787.78	1,943,445.75	0.477
Autonomous driving	624,616.68	2.851	0.029	88,574.12	1,160,659.25	0.575
Connectivity	402,792.90	1.549	0.172	-233,502.62	1,039,088.43	0.286
Electrification	455,548.88	3.068	0.022	92,189.45	818,908.30	0.611
Shared mobility	-609,492.44	-2.913	0.027	-1,121,458.54	-97,526.34	0.586

Source: Own analysis

Table 3: Correlation analysis of different trend indices.

	Autonomous driving	Connectivity	Electrification	Shared mobility
Autonomous driving	1.00			
Connectivity	0.19	1.00		
Electrification	0.67	0.54	1.00	
Shared mobility	-0.86	-0.22	-0.42	1.00

Source: Own analysis

92,189.45 respectively), which again illustrates that it is most likely that a high index positively influences the market capitalization per vehicle. Besides that, the two variables are highly correlated (r = 0.67) meaning that companies which perform well in one of the categories do so in the other as well (see Table 3).

The independent variable *connectivity* does not have a significant influence on the market capitalization per vehicle (*t*-statistic = 1.549). Its correlation to *autonomous driving* (r = 0.19) and *electrification* (r = 0.54) is again positive, however weaker than that of *autonomous driving* and *electrification*. Even more surprisingly *shared mobility* has a significant negative impact on the market capitalization per vehicle (*t*-statistic = -2.913). This effect is driven by the poor performance of the newcomer companies Tesla and Nio (those with the highest market capitalization per vehicle) and could also be a sign that investors do not value the offer of shared mobility services provided by OEMs. Controlling for correlation with the other variables confirms that hypothesis, as they show a strong negative correlation with *shared mobility* (see Table 3).

5. Conclusion

As initially targeted the present work contributes to providing a literature overview on the four trends that currently shape the automotive industry: Autonomous driving, connectivity, electrification, and shared mobility. While these trends often exist separately from each other today (carsharing models using ICEVs or privately used EVs), their interaction has the potential to introduce a new age of mobility – a carsharing concept with autonomous vehicles using electric engines and offering seamless connectivity features to their passengers. These vehicles not only generate attractive new profit pools for OEMs but also have the potential to increase social welfare by avoiding accidents, reducing emissions, and providing access to mobility for a wider population. On the other hand, there are still unresolved problems, such as the sustainable coverage of the electricity demand of EVs, the accountability of AVs, or the fair employment of staff in ride-hailing companies. Policymakers need to find answers to these questions in order to exploit the full potential that these vehicles could offer.

The discussion of the implications for German OEMs followed the structure of a SWOT analysis to answer the seven questions formulated in the introduction. To answer the first question, which related to the unique assets of German OEMs, we took a closer look at the companies' annual reports. We found evidence for profitable operations, significant retained earnings, and a strong presence in the largest automotive markets Europe, United States, and China. This allows them to invest heavily in new technologies, offset cyclical market downturns and benefit from local talent, which we were able to confirm through an analysis of R&D expenses and operating margins. In addition, German OEMs profit from their strong supplier relationships and powerful brands, which both have a positive impact on several KPIs. Secondly, we investigated how the corporate structures of German OEMs influence the implementation of disruptive trends. We therefore discussed three explanatory approaches from academia and finally compared the value networks of German OEMs to those of potential future mobility providers. We noticed that these networks differ significantly, as do the attributes that influence the perceived attractiveness of the components and technologies involved. As a consequence, incumbent companies have difficulties to classify the added values of disruptive technologies as they evaluate them with attributes that were exclusively applicable to predecessor technologies (Christensen, 2013). Therefore, incumbent players often fail to adopt disruptive technologies at an early stage, which has long been evident in the lack of EV development as well as outsourcing of software solutions. To answer the third question about attractive future business opportunities, we analyzed both emerging markets and untapped profit pools along the value chain. We found that an attractive opportunity for German OEMs lies in the market for purpose-built vehicles, which is still at an early stage of development and can thus be shaped in their favor. They could benefit from their R&D and design expertise, production locations in low-wage countries, and partnerships with ridesharing companies. In addition, downstream opportunities arise, including the CaaS market, the used car market as well as direct-to-consumer sales channels. We also noticed that new components are gaining importance due to the emergence of the four ACES trends, requiring German OEMs to carefully consider which ones to integrate into the value chain. To support decision-making, we propose a framework that encompasses the dimensions of resource availability, competitive relevance, and maturity of a technology. In short, the answer to the fourth question regarding make-or-buy decisions for disruptive technologies is, that those technologies with low availability and high competitive relevance should be integrated into the value chain. To answer the fifth and sixth questions, which relate to both competitor analysis and the implementation of ACES trends, a two-step approach was required. First, we distinguished between direct competitors (e.g. General Motors), indirect competitors (e.g. Uber), and potential competitors (e.g. Tesla). As the latter pose the greatest threat to German OEMs (Bergen & Peteraf, 2002; Chen, 1996) we conducted an analysis of the ACES capabilities of some major automotive players (including the three German OEMs). Therefore, we introduced a new metric, the ACES Index, which measures the capabilities of companies in the different trends. German OEMs achieved midfield positions in this ranking with Volkswagen in third (behind Tesla and Nio), BMW in fifth, and Daimler in sixth place. We then clustered the investigated companies into four segments according to their market sizes and ACES Indices. All German OEMs were identified as "incumbent players" and Tesla and Nio as "aggressive innovators". None of the companies was identified as "industry star" as this would require a high ACES Index in addition to a large size. The final analysis addressed the question of whether investors value a strong implementation of the

ACES trends (a high ACES Index). We therefore performed an OLS regression and confirmed a significant positive impact of the ACES Index on a company's market capitalization per vehicle. When we controlled for the different parameters separately, the strongest positive influence came from autonomous driving and electrification ($p<0.05$). In contrast, connectivity showed no significant and shared mobility even a negative significant influence on market capitalization per vehicle ($p<0.05$). Investors thus seem to value technology leadership in electrification and autonomous driving but prefer that OEMs leave the development of sharing services to specialized companies.

Finally, it should be noted that the managers of German OEMs, albeit not as first movers, have understood the importance of disruptive trends and are on the way to transforming their companies. Recent announcements clearly indicate that they genuinely aim to embrace the ACES trends and embark on further transformation paths. To achieve this, they can use their capital reserves, profitable operations, and brand popularity. In addition, they are backed by the German government, which, on the other hand, demands a clear commitment to sustainable mobility and thus supports the development of innovative solutions. They also need to create more agile corporate structures and develop the necessary capabilities to produce mission-critical technologies such as autonomous driving and electrification internally or in partnerships. For better competitive intelligence, we recommend the use of the ACES Index.

6. Limitations and outlook

In addition to the interesting insights provided by this work, we would like to point out potential limitations resulting from methodological weaknesses in the data sets and within the analyses. First, we based our research on secondary data and therefore had to accept the associated problems, such as uncertain quality, lack of personalization, and in some cases, incomplete data samples. In addition, we had to use some non-scientific sources, as this was the only way to ensure the timeliness of the data. However, we relied exclusively on sources from reputable institutes and publishers. Secondly, due to the limited scope of this thesis the competitor consideration set was small ($n=8$). Furthermore, the ACES Index framework presented is only an approximation for the innovative strength and implementation capabilities of OEMs, makes no claim to be exhaustive, and may be biased due to partly subjective assessments. Similarly, the make-or-buy framework presented is intended as a starting point for decision-making and should be considered as a qualitative assessment opportunity. Finally, it should be noted that we could not include all possible future automotive trends in the analysis, which is why we decided to exclude hydrogen fuel cell technology from the discussion. The reason for this was that most OEMs have committed themselves to battery cell technology.

As initially targeted, this thesis contributes to the existing literature as well as practice by discussing several implications that future automotive trends will have on German OEMs. It must be acknowledged, though, that the scope of the topic is too large to be discussed in this paper alone and that some limitations exist. However, future research could draw on our findings. Firstly, the structure and dimensions of the SWOT analysis could be transferred to other OEMs. Secondly, the ACES Index framework could be enriched by adding more competitors and dimensions within the different categories. Finally, our make-or-buy decision framework could be applied more broadly to other technologies. Furthermore, it could be extended to include a quantification method of added value. In this way, researchers could address some of the weaknesses identified and shed further light on this interesting area of research.

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Chances and challenges for the members of the Fairtrade-supply chain: a case study of Chile and Switzerland

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Abstract

Conventional international trade has become discredited because of emerging conflicts on fairness on producers' economic, social & ecological situation. Aiming to provide alternatives, the Fairtrade-certification was amongst the first that incorporated solidarity within the worldwide economy. Within a few decades the certification managed to exceed its pure labelling activities and implemented a whole supply chain, representative for debates about due diligence in international supply chains. While such a partnership is vital for more fairness in supply chains, it poses challenges to its agents. This paper, based on a case study of Swiss and Chilean companies, aims to explore the complexity for members in such a Fairtrade-supply chain. To this effect, it sheds light on the social and economic chances and challenges both for producers and merchandisers participating in the Fairtrade-system. The study gives evidence that this supply chain is a cooperation on eye-level which can provide an alternative to conventional free trade. Further, it shows that motivation and cultural background play a decisive role in the chances and challenges of Fairtrade-members. Ultimately, it proves that Fairtrade can be a partner for rising legal requirements in the course of due diligence laws.

Keywords: CSR; Case study; Fairtrade; Supply chain; Due diligence.

1. Introduction

1.1. Relevance

> *"For at least another hundred years we must pretend to ourselves and to every one that fair is foul and foul is fair; for foul is useful and fair is not. Avarice and usury and precaution must be our gods for a little longer still. For only they can lead us out of the tunnel of economic necessity into daylight"* (Keynes, 1931, p. 372).

For a long time, Keynes's call for selfish economic interests has been followed by large-scale enterprises all over the world at the expense of people who are at the mercy of those companies (Suzianti, Atthousi, Pratama, & Hasyati, 2018; Tiffen, 2019). Until now, especially small-scale producers of the primary sector, the oldest economic sector, are being put at the lowest level of the pay scale (Audebrand & Pauchant, Juli 2009; Mookerjee, 2019). However, Keynes's 100-years-prophecy was interpreted differently when in the 1950s and 1960s criticism on conventional free trade and labor conditions in international supply chains emerged and the Fair-Trade movement found its roots (Emons, Fulda, Klengel, & Schietinger, 2021; Loske, 2017; Low & Davenport, 2005; Nicholls & Opal, 2005). Consequently, some companies began to include the concept of 'fairness' as an economic value into their internal business strategy and made the "fair useful" (Becchetti & Huybrechts, 2008, p. 747). Thus, in 1988 out of the cooperation between a Dutch NGO called *Max Havelaar* and a Mexican cooperative, the first coffee emerged with the certificate *Fairtrade*[1] (Lukas, 2015; Proqualitas Sostenibilidad). Since the late 1980s, FT-certified

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[1] For the ease of reading the phrase 'Fairtrade' is from here on abbreviated as 'FT'. However, it is to be pointed out that there is a difference between

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products have become more than just an extension to the product range of specialty stores: On the one hand, FT broadened its range in the course of mainstreaming, i.e., that FT-products were offered in supermarkets where they can compete directly with common, traditional brands (Cater, Collins, & Beal, 2017; Davies, Doherty, & Knox, 2010). On the other hand, in the last decades the certification implemented a whole supply chain which is representative for current debates about raising standards in international supply chains (Emons et al., 2021; Lukas, 2015). Existing research acknowledges the mainstreaming-activity of FT (Cater et al., 2017; Grant & Palakshappa, 2018; Moore, 2004; Ruggeri, Orsi, & Corsi, 2018). However, it does not necessarily include the recent development of FT as a feasible alternative to the predominant economic model and conventional supply chains (Grant & Palakshappa, 2018; Lukas, 2015).

1.2. Research gap and research question

Relevant literature has already shed light on various aspects of FT, e.g., its history, its mission or on the typologies of companies that are most likely to engage in such a trading partnership (Bezençon & Blili, 2009; Cater et al., 2017; Low & Davenport, 2005). Although these approaches make a valuable contribution to the understanding of FT and are undoubtedly important in raising awareness of the topic in the scientific field, they do not meet the recent developments of FT. The literature still lacks well-founded research on the fact that, by now, FT has exceeded its pure certification activities and established a whole supply chain (Lukas, 2015). However, little is known on the chances and challenges associated with actors' willingness to engage in such a FT-supply chain (Bezençon & Blili, 2009; Cater et al., 2017; Lukas, 2015). Moreover, following the remarks of Cater et al. (2017) there is a general lack of country-specific research on the FT-sector, especially applicable for the Latin-American region (Lernoud & Willer, 2018; Raynolds, 2012).

The underlying empirical research of qualitative nature aims to close these gaps. Looking at the big picture, it adds valuable insight to the research on FT from a supply chain-perspective by focusing on the everyday social and economic reality certified producers and merchandisers are confronted with. Going more into detail, it aims to identify converging or conflicting interests between the FT-members. Finally, this study emphasizes FT's capability to support companies in rising legal requirements in the context of due diligence laws.

The above-mentioned relevance and the research gaps lead then to the following question: How can the chances and challenges for members of a FT-supply chain be described? Thereby, the research gap that calls for more country-specific research in Latin America is addressed by the analysis of a FT-partnership between Chile and Switzerland.

'Fair Trade' and *Fairtrade*: whereas 'Fair Trade' or 'fairly traded' refers to the trading partnership per se, *Fairtrade* corresponds to the organizations, brands and products related to the official Fairtrade International organization (Parvathi & Waibel, 2018). This paper mainly focuses on the organization *Fairtrade* ('FT'). However, when referring to the general concept behind this organization ('Fair Trade'), it is made clear by writing it out completely.

1.3. Structure and content

This thesis, firstly, reviews the existing body of literature on FT-theories by contextualizing the topic into the main research fields, and subsequently, continues with its economics as a supply chain. Building on this theoretical basis, the paper continues with a methodological approach which comprises of a case study in order to answer the research question. This case study incorporates the views of two actors in a FT-supply chain and contextualizes the setting into a geographical context. After having explained the data collection and -analysis process for this case, thirdly, the findings are described. Ultimately, based on the results of the qualitative research and the theoretical background, in the discussion section the paper highlights its main theoretical and practical contributions, identifies its limitations and allows room for future research.

2. Theoretical Background

2.1. The supply chain structure of Fairtrade

2.1.1. Fair Trade – an overlap of social- and business activities

When talking about Fair Trade, the official definition refers to:

> *"a trading partnership, based on dialogue, transparency and respect, that seeks greater equity in international trade (...) and contributes to sustainable development by offering better trading conditions to, and securing the rights of, marginalized producers and workers – especially in the South"* (FINE, 2001, p. 1).

By being at the intersection of the overlapping research fields of International Management, Social Entrepreneurship and CSR, Fair Trade has a justified significance in the academic community (Grant & Palakshappa, 2018). Firstly, since it refers to a global fair-trading partnership, its commodities are shipped all over the globe. Hence, it operates between multiple countries and is applied in a multinational environment (Luthans & Doh, 2021). Secondly, Fair Trade can be contextualized into Social Entrepreneurship because it seeks to find ways to generate social impact and implement long-term, economic and sustainable mechanisms (Cater et al., 2017; Hockerts, 2010). Thirdly, it portrays a strategic option for CSR-sensitive companies which can use the mechanisms of Fair Trade to show that their company "meets or exceeds the ethical, legal, commercial, and public expectations of stakeholders" (Cavusgil, Knight, & Riesenberger, 2012, p. 156; Low & Davenport, 2005).

Delivering on society's expectations is key for organizations that want to act in a socially responsible way (Luthans & Doh, 2021). Nowadays, companies that pro-actively implement CSR have a long-term competitive advantage as they can use their social responsibility as a form of differentiation (Giovannucci, von Hagen, & Wozniak, 2014; Mohan, 2009). One way to tackle this responsibility is by making trade fair

and by joining the Fair Trade-system which for a long time many companies around the globe have already opted into doing (Becchetti & Huybrechts, 2008).

When briefly looking at the historical cross-section, the sensibilization for the concept of Fair Trade originally emerged out of an economic, political and social movement in the 1950s and 1960s with the aim of helping producers finance a fair way of doing business (Low & Davenport, 2005; Mohan, 2009; Tiffen, 2019). The movement's objective was to address the economic injustice and imbalance between the Global North and the Global South[2] (Suzianti et al., 2018). Therefore, it paid attention that Adam Smith's metaphor of the *invisible hand* and the corresponding self-regulatory mechanism of the free-trade theory, does not work for countries of the Global South (Nicholls & Opal, 2005; von Hauff, 2017). What was needed was not the *invisible hand*, but the concept of cooperating hand in hand (Raynolds, 2002).

As a result, out of this movement a third-party certification emerged, the FT-certification in which certain production standards were set and communicated to the consumer through the FT-label (Castaldo, Perrini, Misani, & Tencati, 2009). It started in the Netherlands in 1988 with the first FT-labelling organization, called *Max Havelaar* (Lukas, 2015; Parvathi & Waibel, 2018). The certification incorporates voluntary sustainability standards, i.e., "independent and publicly determined standards that have, as primary criteria of compliance, multiple aspects of sustainability defined as specific social, environmental and economic guidelines" (Giovannucci et al., 2014, p. 359f.; Dragusanu, Giovannucci, & Nunn, 2014; Loske, 2017). From a scientific perspective, more than two decades ago, John Elkington (1999) already stressed the importance of the *triple bottom line*, a concept which requires a company to not only incorporate "the traditional measures of financial performance, but also social and environmental outcomes" (Nicholls & Opal, 2005, p. 217). Therefore, not surprisingly the FT-standards were based on those three pillars that ensure sustainable and fair development of small-scale producers in the Global South (Fairtrade Deutschland e.V., 2021; von Hauff, 2017). To be more precise, when buying a FT-product the consumer can be sure that the producer was paid a minimum price and a price premium on the product. Further, it complies with the standard of producers organized according to democratic principles, that labor conditions are fair and that the underlying supply chain is as short as possible by guaranteeing transparency at the same time (Darko, Lynch, & Smith, 2017; Luthans & Doh, 2021; Fairtrade International, 2021).

The lack of this last-named transparency in conventional supply chains brought European policy makers to act and to institutionalize due diligence obligations and CSR across supply chains (Emons et al., 2021). Due diligence, in this context, means that European companies must ascertain the impact on human rights and environmental standards in their supply chains, identify measures for improvement and account for their businesses abroad (Bueno, 2020). In June 2021, for example, the so-called *Act on Corporate Due Diligence in Supply Chains* was passed in Germany which obligates German companies with more than 3000 employees to carefully monitor and guarantee transparency and working conditions that comply with human rights in their whole supply chain (Emons et al., 2021). Besides, also in Switzerland in 2020 the so-called *Swiss Responsible Business Initiative* postulated due diligence for Swiss companies (Bueno, 2020). Although it was narrowly rejected by the Swiss cantons, there is still an open debate on elevating standards in international supply chains (Bueno, 2020). Summing up, for companies in consuming countries, standards will rise and companies will be made liable for their supply chains beyond their boarders (Emons et al., 2021; Lukas, 2015).

The implementation of higher economic, social and ecological standards as called for in these laws has always been in the nature of FT (von Hauff, 2017). However, during the last decades it has achieved more than just being a third-party certification which implements standards: By now, the FT-certification has become a tool that established its own supply-chain economics by setting a good example of what a transparent, sustainable, and socially responsible supply chain can look like (Lukas, 2015).

2.1.2. An exemplary Fairtrade-supply chain

There are several forms of a FT-supply chain (Loske, 2017). This paper, however, specifies on a simplified version which builds the basis for the underlying methodology in the course of this paper.

Commonly, within the FT-market a typical supply chain is of direct trade and without cost-intensive intermediaries (Loske, 2017). This compressed supply chain-length can also be considered as the main difference to conventional supply chains (Loske, 2017). All participants in a FT-supply chain need to be FT-certified so that the finished product is provided with the corresponding label (Dragusanu et al., 2014). Following the remarks of Moore (2004), the FT-supply chain can mainly be divided into producers and consumers. Nevertheless, there are more noteworthy actors cooperating within this trading partnership, as Figure 1 indicates.

On the organizational level there is the umbrella organization *Fairtrade Labelling Organizations International*, short: *Fairtrade International*, which has an advisory function and allocates the label to the respective products (Nicholls & Opal, 2005; Parvathi & Waibel, 2018). On the supply chain level, one has to divide between the producing country with its FT-cooperatives and the consuming country of those FT-products (Loske, 2017). The producers, therefore, are mostly grouped in small producer organizations, also referred to as cooperatives, i.e., organizations with democratic orientation, benefitting from an allied market presence (CEval,

[2] As the official definition of Fair Trade published by the FINE-network states, one of the main FT-actors are marginalized people, "especially *in the South*" (FINE, 2001, p. 1, underlined by author). As this phrase might be misleading when solely focusing on its geographical connotation, this paper uses the terms "Global North" and "Global South" as a classification for the countries involved in a FT-system. However, this does not refer to geographical occurrences, but classifies countries with respect to GDP, HDI, life expectancy etc. (Kowalski, 2020).

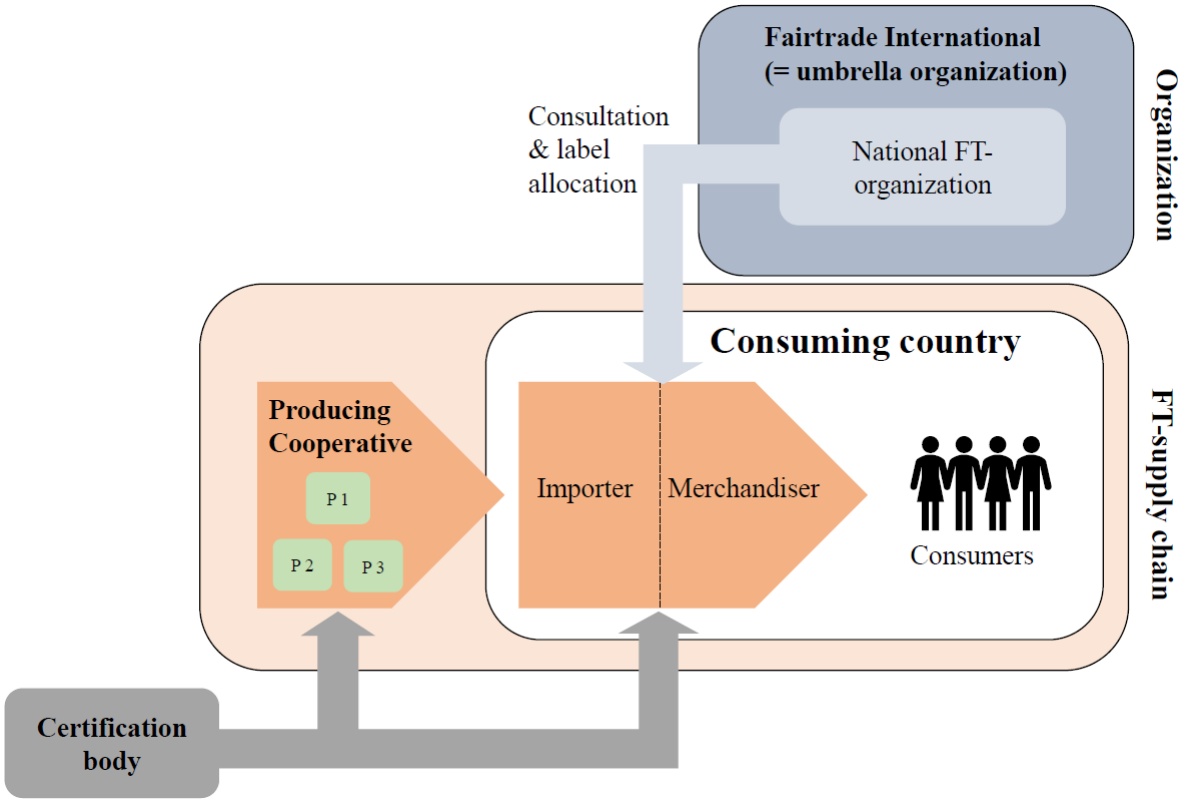

Figure 1: Exemplary FT-supply chain (own illustration following Fairtrade Max Havelaar Switzerland)

2012; Darko et al., 2017; Dragusanu, Montero, & Nunn, 2021). In order to obtain the certificate, an independent, ISO-accredited certification company is responsible for overseeing the processes and certifying the companies' products (Dragusanu et al., 2021; Parvathi & Waibel, 2018). After the FT-products are produced according to the standards set by *Fairtrade International*, subsequently, they are sold to importers or directly to merchandisers from wholesale or retail trade in the consuming country. Thereafter, the products are offered to the consumers in the retail (Loske, 2017).

2.2. The emergence of chances and challenges in a Fairtrade-supply chain

2.2.1. Different motivations for supply chain-actors

As already stated, a FT-supply chain consists of a heterogeneous network of different stakeholders from various parts of the world competing within the market (Doherty & Davies, 2012; Ruggeri et al., 2018). Therefore, the FT-market has to unify different needs and interests (Leiderman, 2018; Ruggeri et al., 2018). Thus, the implementation of the FT-certification is a political, cultural and logistical challenge, making the managerial practices and the implementation of such a certification very complex (Audebrand & Pauchant, Juli 2009; Bezençon & Blili, 2009; Leiderman, 2018). When and why do members of a FT-supply chain engage in this system and what do they hope and fear from it? In which aspects do stakeholders in a FT-supply chain also have converging or conflicting opportunities and challenges? In summary, these questions contribute to the main underlying research question of this paper. There are several social as well as economic chances and challenges within the FT-supply chain for producers as well as for merchandisers (Leiderman, 2018; Lukas, 2015).

2.2.2. The impact of social and economic aspects on merchandisers and producers

FT refers to a durable and trustful trading partnership with at least two sides involved in its supply chain (Rotondaro, 2012). In this mutual relationship based on "dialogue, transparency and respect" (FINE, 2001, p. 1) all stakeholders should have the rights to decision-making and an equal say (Lukas, 2015; Fairtrade Max Havelaar Switzerland). Small-scale producers, though, often lack knowledge on how to conduct the certification process and how to implement the necessary requirements (Kohts, 2016). Hence, producers need merchandisers' help in establishing such a supply chain. Lukas (2015) and Leiderman (2018) go so far as to reinforce that there is still dispute of power and governance between FT-members, even though the certificate was implemented to eradicate this power imbalance (Suzianti et al., 2018).

FT is also influenced by cultural factors (Nicholls & Opal, 2005). As this partnership works transnationally, it is perceived distinctively from various perspectives because both producers and merchandisers have different cultural backgrounds (Rotondaro, 2012). Culture, hereby, means the

"learned, shared, and enduring orientation patterns in a society (which people express) through values, ideas, attitudes, behaviors, and symbols" (Cavusgil et al., 2012, p. 124). There is one FT-system, however, which is implemented in several systems of values all around the globe. Following the remarks of Rotondaro (2012) about cultural relativism in FT, participating in such a supply chain requires internalizing its rules. Though, the question arises of what these rules are. Firstly, the FT-certification is known to be a long-term strategic partnership which requires a lead time until it pays off in a social, environmental and economic manner (Moore, 2004; Raynolds, 2002; von Hauff, 2017). It needs an upfront liability and, for the producing side, normally takes several years of implementation leading to a time-lag between certification and the first sales (Kleemann, 2018). However, time management styles vary from country to country and impact the way of doing business (Ashkanasy, Gupta, Mayfield, & Trevor-Roberts, 2004; Rotondaro, 2012). Hence, this poses a challenge in the FT-supply chain (Rotondaro, 2012). Secondly, the communication style, in this sense especially language barriers, can be difficult (Rotondaro, 2012).

When thinking in economic terms, a company's certification and its reliability are two interdependent factors (Meier, 2016). This means that by being FT-certified, a company provides evidence for its compliance with determined economic, social and ecological standards. Through labels like FT, both merchandisers and producers can make their engagement visible to their business environment and attract a certain consumer segment (Bezençon & Blili, 2009). This can bring competitive advantages to members of FT (Mohan, 2009).

Additionally, a certification always entails high costs in its annual fees and in the implementation (Meier, 2016). This can be a challenging financial aspect for the ones to be certified, which is even sharpened when consumers are not willing to bear these costs (Meier, 2016). Participants in the FT-system, therefore, hope for higher sales in order to pay off the costs.

However, the aspect of sale opportunities is considered to be a double-sided sword: On the one hand, the FT-certification offers producers of the Global South the chance for higher sale opportunities because it provides them with better access to new markets of the Global North (Giovannucci et al., 2014; Kohts, 2016). On the other hand, producers' hopes for sale opportunities can easily turn into disappointment when they are confronted with the challenging task of finding a buyer for their products (Herman, 2018).

One European market with a strong focus on FT is the Swiss market, which is worth having a look at.

2.3. Comparison of the Fairtrade market structures in Switzerland and Chile

Between 2004 and 2018 the worldwide sales of FT-products increased by twelve times from 832 million EUR to 9,8 billion EUR within 15 years (Fairtrade International 2019 quoted from de.statista.com (Statista)).

Switzerland, thereby, represents the country with the worldwide highest FT-consumption, namely with 99 CHF of FT-products per capita in 2020 and with total sales of 860 million CHF in the same year (Max Havelaar-Stiftung and Swiss Fair Trade (2021) quoted from de.statista.com; Lernoud & Willer, 2018). Given that the main distributors of FT-products in Switzerland are the two biggest supermarket chains, the country is entitled to claim to be one of the best performing FT-markets in the world (Low & Davenport, 2005; Bezençon & Blili, 2009; Fairtrade International 2018 quoted from de.statista.com; Rotondaro, 2012). With the supermarkets' long-time experience in this market they gained a lot of expertise in deciding which products are most in demand among Swiss consumers (Bezençon & Blili, 2009; Low & Davenport, 2005). The most traded FT-products on the Swiss market in 2020 were cane sugar, bananas, and, at the sixth and seventh place, also coffee beans and cacao (Nielsen 2020 quoted from de.statista.com (Statista)). However, since 2020 there is also a sharp increase in the sales of FT-nuts and dried fruits, with 25,5% more recorded sales than in the previous year (Max Havelaar Stiftung 2021 quoted from de.statista.de).

Turning to the other part of the world, to Latin America and the Caribbean, where FT-products have their origin, the region showed the most remarkable rise in FT-certified cooperatives (Dammert & Mohan, 2015). With 950 organizations certified in 2020, it represents more than half of the 1880 organizations existing in the world (Fairtrade International).

When thinking of FT-products in Latin America, it is mainly referred to banana- or coffee plantations. Consequently, there is only little association with Chile because climate conditions there are not adequate for such products. Nevertheless, there is a FT-market in Chile: The first contact with Fair Trade in Chile was initiated by three producer organizations of agricultural products (Proqualitas Sostenibilidad). Given that the small domestic Chilean market did not offer possibilities for their products, these producers searched for market options abroad where they encountered the existence of Fair Trade structures (Proqualitas Sostenibilidad). The first FT-producer became certified in 2005, leading to 18 certified Chilean cooperatives by 2022 (FLO-Cert., 2022; Herman, 2018). Nowadays, the main FT-certified product in Chile is wine grapes (Herman, 2018). In addition, honey, fresh- and dried fruits as well as nuts gained market growth in Chile (FLO-Cert., 2022; Herman, 2018).

3. Methodology: case study of Chile & Switzerland

3.1. Case Selection and Description

In order to get a deeper insight into the two previously portrayed FT-markets and to answer the underlying research question, this paper comprises of a single case study following the methodology of Yin (2018).

In terms of the technical approach, this research method was chosen because of several reasons. On the one hand,

according to Yin (2018) a case study favors research questions of 'how' and 'why', which are asked about contemporary events beyond the researcher's sphere of influence. Both apply in the present case. On the other hand, the strength of a case study is its incorporation of evidence, therefore, enabling data triangulation (Yin, 2018). By explaining the chances and challenges the members in a FT-supply chain face, several economic and social aspects intercorrelate with each other that cannot be seen separately. Thus, in addition to interviews, a wider and more objective relation to the research topic is guaranteed by including documentary information (Yin, 2018). In Yin (2018), this is referred to as "Documentation" (p. 113f.) and adds annual reports, website performances and a cultural analysis.

In terms of content, as indicated in the introduction, this paper contributes to the literature by providing a country-specific focus on the FT-supply chain (Cater et al., 2017). Therefore, the case-study integrates the views of two essential actors in this market and contextualizes this relationship against the background of a geographical setting: Hence, the main actors are FT-producers in Chile and merchandisers of FT-products operating in Switzerland. In order to guarantee an authentic view on FT, the main selection criteria for the case study were companies focusing on agricultural commodities and a supply chain which excludes cost-intensive intermediaries.

In order to explain rationales behind selecting the two countries, the following chapters will first present each country on the macro-level and then give a company-specific description on the micro-level[3].

3.1.1. Selection of Chile

Choosing Chile, at first glance, might be considered counterintuitive as the country is stable regarding its economy and currency and, additionally, performs as one of the top exporting countries in South America (Herman, 2018). In 2019 the country reached an export volume of goods of 69,89 billion USD (WTO 2021 quoted from de.statista.com). However, looking behind the scenes what has caused more than half of Chile's extraordinary export performance was the fuel- and mining industry with 36,93 billion USD in the same year (WTO 2021 quoted from de.statista.com). Thus, the primary sector is underrepresented and dominated by "precarious employment and agrochemical abuse, with small producers increasingly excluded" (Herman, 2018, p. 54). Consequently, the Chilean agricultural sector is underdeveloped and highly unequal, which both creates barriers to the country's sustainable national development. Fairtrade can help producers to overcome the social injustice, the discriminatory working conditions and the economic vulnerability which structures their everyday life (Herman, 2018; Proqualitas Sostenibilidad).

[3]The companies' descriptions on the micro-level refers to information retrieved from the documentary information (webpage, annual report) which will be explained in chapter 3.2.

When looking at the two Chilean producers selected for the case study, they are both dedicated to the production of agricultural products and target a high level of CSR. The first producer (P1), located near Santiago de Chile, has focused on the export of organic fruits for more than 30 years. At the moment, this producer has the *Fair for Life*-certification for organic apples and is in the FT-certification process. However, given its focus on efficiency and export, the company faces some challenging considerations in doing so. The second producer (P2) is a typical FT-cooperative which consists of 20 small-scale winegrowers. It was the first cooperative in their region of Colchagua to be FT-certified in 2009 and it remains the sole certification holder in 2022. The farmers have paid the certification costs on their own and have a direct trading partnership with a company in Belgium, as well as an indirect partnership with a client in England.

3.1.2. Selection of Switzerland

On macro-level, Switzerland at the other side of the supply chain was chosen because of its already-mentioned prominent position in one of the best-performing FT-markets in the world (Bezençon & Blili, 2009). The main idea behind this selection was that the Swiss experience can be of particular benefit for countries like Chile that still lack of extensive know-how in FT. Additionally, excluding any historically conditioned relationships between the countries was an important criterion to avoid distorting results, since many existing FT-partnerships are tied to prior colonial relationships (Rotondaro, 2012). Hence, Switzerland was selected because of its non-imperialistic background and because there was no such relationship with Chile (Rotondaro, 2012).

On micro-level, the main retail- and wholesale companies are decisive for the Swiss success on the FT-market (Bezençon & Blili, 2009; Rotondaro, 2012). This case study takes a closer look at one of them (M1). As it is the largest distributor of FT-products worldwide, it consists of several retail units, but also has its own food-production facility (M2). Herein, the view of the parent company and its chocolate production company is included. Both the parent company and the division have followed a label-oriented approach in order to make their engagement in CSR visible to their customers (Bezençon & Blili, 2009). One of those labels is FT. Additionally, on the organizational level, the national FT-organization also plays an important role in Switzerland. Founded in 1992 its main tasks are to promote FT in Switzerland, to support its B2B-clients when they want to establish a new supply chain and to allocate the label. Due to its work, FT has a brand awareness of over 90% in Switzerland.

3.2. Data Collection

By conducting a single case study of Switzerland and Chile, two different methods for collecting data are included in order to enable data triangulation for this case (Yin, 2018). This was done to ensure a robust description of the FT-market and to minimize distorted results in the study. The two methods are interviews and documentation. In conjunction with

Table 1: Methods of data collection applied in case study.

Ref.[b]	Type of organization	Interviews[a]			Documentation	
		Interviewee position	Length	Date	Company -level	Country -level
C	Swiss national certification organization	Commercial Director and Member of the Board	47'	Jan 2022	Press release annual report 2021, Webpage	
M1	Swiss merchandiser 1	Head of Projects & Overseas Buying Frozen Products	1h 03'	Jan 2022	Annual report 2020 Sustainability Blog	Cultural analysis of countries' 'future orientation' based on Globe Study
M2	Swiss merchandiser 2	Project Manager Sustainability	38'	Jan 2022	Webpage	
P1	Chilean producing & exporting company	Export Manager	26'	Jan 2022	Webpage	
P2	Chilean producer cooperative	General Manager	56'	Feb 2022	Webpage	

[a]Interviews were conducted in Spanish and German. For the sake of further analysis in the findings- and the discussion section, interview quotations in this paper were translated into English by the author.
[b]This reference is used in the text when referring to the respective companies and organization.

each other, they shed empirical light on the topic and incorporate different actors' perceptions in order to attain a many-faceted perspective (CEval, 2012; Yin, 2018). Table 1 will give an overview of the data collection tools applied.

As a first source of evidence, semi-structured expert interviews were conducted on the company-level with two experts, one representative for the Chilean producer side, the other one for the Swiss merchandiser side (Yin, 2018). In order to provide an overview of the topic, the perception of the Swiss national Fairtrade organization was also incorporated. The interviews were held in Spanish or German and conducted via video call and followed the characteristics of guided interviews (Flick, 2014). Hence, two subcategories of guided interviews were mixed: the semi-structured- and the expert interview (Flick, 2014). The semi-structured form was chosen as the outcome in terms of content can be valuable because of its open structure (Flick, 2014). However, by specifically focusing on the chances and challenges of the FT-supply chain, the focus on the relevant theoretical background was guaranteed. In addition, expert interviews were conducted with persons responsible for the business operating area of the FT-supply chain (Flick, 2014). The motivation was to ensure that the interviewees' answers are representative for a whole group and not just for a single person (Flick, 2014). It was possible to do so because all the interviewees hold leading position within their companies (cf. Table 1). The interviews followed a questionnaire which covers a set of up to five open questions with two to four sub-questions, distinguishing between the persons interviewed (cf. Appendix). The interview guidelines were designed individually according to the field of interest for the certification organization, merchandisers and the producer and were sent, at the request of the interview partners, in advance. In general, they started with an open question where the interviewee was able to answer according to his immediately available knowledge. Then the interviews were led into the areas of interest in order to answer the research question (Flick, 2014).

Furthermore, as a second source of evidence, documentation is included (Yin, 2018). In addition to the interviews, for each company and organization supplementary data was collected by looking at the annual report of 2020, sustainability blogs and website performances. This was done to derive the companies' and the organization's position towards the area of sustainability, CSR and their engagement in FT. Finally, in order to contribute to the already portrayed cultural aspects in a FT-supply chain, a cultural analysis was undertaken which was based on the "Global Leadership and Organisational Behavior Effectiveness Research Program", in short: GLOBE Study (House, Hanges, Javidan, Dorfman, & Gupta, 2004). It represents the largest and latest international research project which analyses 62 nations on their cultural practices and values and consolidates the results into cultural dimensions (House et al., 2004; Rotondaro, 2012). In accordance with existing literature and the interviews, relevant for

the research question was the dimension of 'future orientation'.

3.3. Data Analysis

The data was analyzed following the methodological approach elaborated by Gioia (2013) which guarantees qualitative rigor by transferring raw data into meaningful concepts. Therefore, all the five voice records of the interviews with a duration of 26 to 63 minutes were transcribed manually into exact transcripts of the spoken words. They built, subsequently, the basis for the open coding procedure according to Gioia (2013).

In a first step, initial codes were identified which ranged between 106 to 239 codes, depending on the length of the interviews. Further, these codes were grouped in categories, i.e., first-order concepts, where the initial focus is on the informant-centric point of view and the original meaning of the interviewees' responses (Gioia, 2013). In a second step, by the means of axial coding, second-order themes were developed which include the researcher-centric point of view as well. These second-order themes combine both the first-order concepts and the researcher's knowledge on the theoretical background of the topic (Gioia, 2013). For example, the interviewees talked about not having *sale options without the certification, neither in the Chilean market nor abroad*. Additionally, they mentioned the *high demand for FT-products in markets of the Global North*. These two categories were then aggregated into a more general concept, namely into the second-order theme *sale opportunities.*

The same was done for the data analysis of the documentation part which the case study comprises of. Thereby, companies' websites, annual reports and the results of the GLOBE Study on the dimension 'future orientation' took the same process of open coding as described above. Afterwards, the data from the documentation part was aggregated into first- and second-order concepts and themes respectively, together with the concepts already derived from the interviews.

Keeping the underlying research question in mind, the second-order themes were then distilled into aggregate dimensions (Gioia, 2013). Coming back to the above-mentioned example, besides the second-order theme *sale opportunities, internal company processes, transparency* and *certification as awareness- and educational process* were grouped together into the overarching dimension of *chances*. This last step represents the basis for the following data structure in Figure 2 and generates a meaningful and well-founded response to the research question.

4. Findings

This research aims to answer the questions of the chances and challenges for members in a FT-supply chain. The insights into this topic were retrieved from a single case study including five semi-structured expert interviews and documentation leading to the following three aggregate dimensions: entrepreneurial motivations, chances, and challenges. In the following, these aspects are exemplified in more detail.

4.1. Entrepreneurial motivations

As shown in Figure 2, the entrepreneurial motivations for companies to participate in a FT supply chain are categorized into companies' *characteristics, internal implementation, objectives* and *reliability*.

Firstly, the data structure refers to the *characteristics* the examined merchandiser in Switzerland and the producers in Chile had. Following the remarks of M1 not every company can represent a commitment in FT. Considering the internal corporate policies, Swiss merchandisers and Chilean producers stressed that CSR and sustainable, long-term business relationships based upon mutual respect built the pillars of their corporate philosophy (Webpages_P1+M1; I_M2). In the interviews, all of the companies confirmed their nature of being socially responsible companies. Hypothetically spoken, in a world without certificates and labels, according to them they claim they would still engage in the principles of Fair Trade (I_P1; I_M2). With regards to their external corporate policy, M1 as a Swiss cooperative society followed a social mission and although it had an intention to make profit, it did not have the pressure to maximize it (I_M1+M2). By leaving profit orientation out of focus, M1 and M2 were able to reinvest their profits "in the form of [...] what you can give back to [...] the consumer: Prices at the end, services in the form of nice and reasonable product portfolios and reasonable outlets, service and that kind of thing" (I_M1, p.1).

Referring to the *internal implementation* of the certificate, M1 had a whole brand-management department which is dedicated to sustainability and its labels (I_M1). P1 and P2, in contrast, had their internal teams which addressed FT (I_P1+P2). All along the FT-supply chain it was necessary to work together with the FT-certification organization C in order to obtain the certificate. Due to its long-time experience and the gained knowledge, M1 used already existing structures in countries of the Global South when looking for a new cooperative and establishing the supply chain on site (Webpage_M1; I_M1+M2). The implementation on the producer side, in contrast, depended on the size and organization form and on the cooperative's product (I_C). For example, a very small cooperative without democratic organization and which produces palm-tree oil cannot be FT-certified. Since FT requires a minimum size of plantation and palm-tree oil is considered to be a critical raw material, such a cooperative would be out of certification- and product scope.

What motivated both producers and merchandisers to participate in a FT-model was that it helped them reach their *objectives*. On the one hand, all of the interviewees' companies had the willingness to change the conventional supply chain, which nowadays exists in international trade, and to compensate producers fairly for their work and creation of value. On the other hand, an important aspect, especially for producers, was opening up new options for commercialization which incentivized them to unite together as a cooperative (I_P2). Given that FT in Chile is still a niche market, P2 stressed its intention of wanting to tap into this market niche back in 2009. P1, in contrast, had a more economic point of

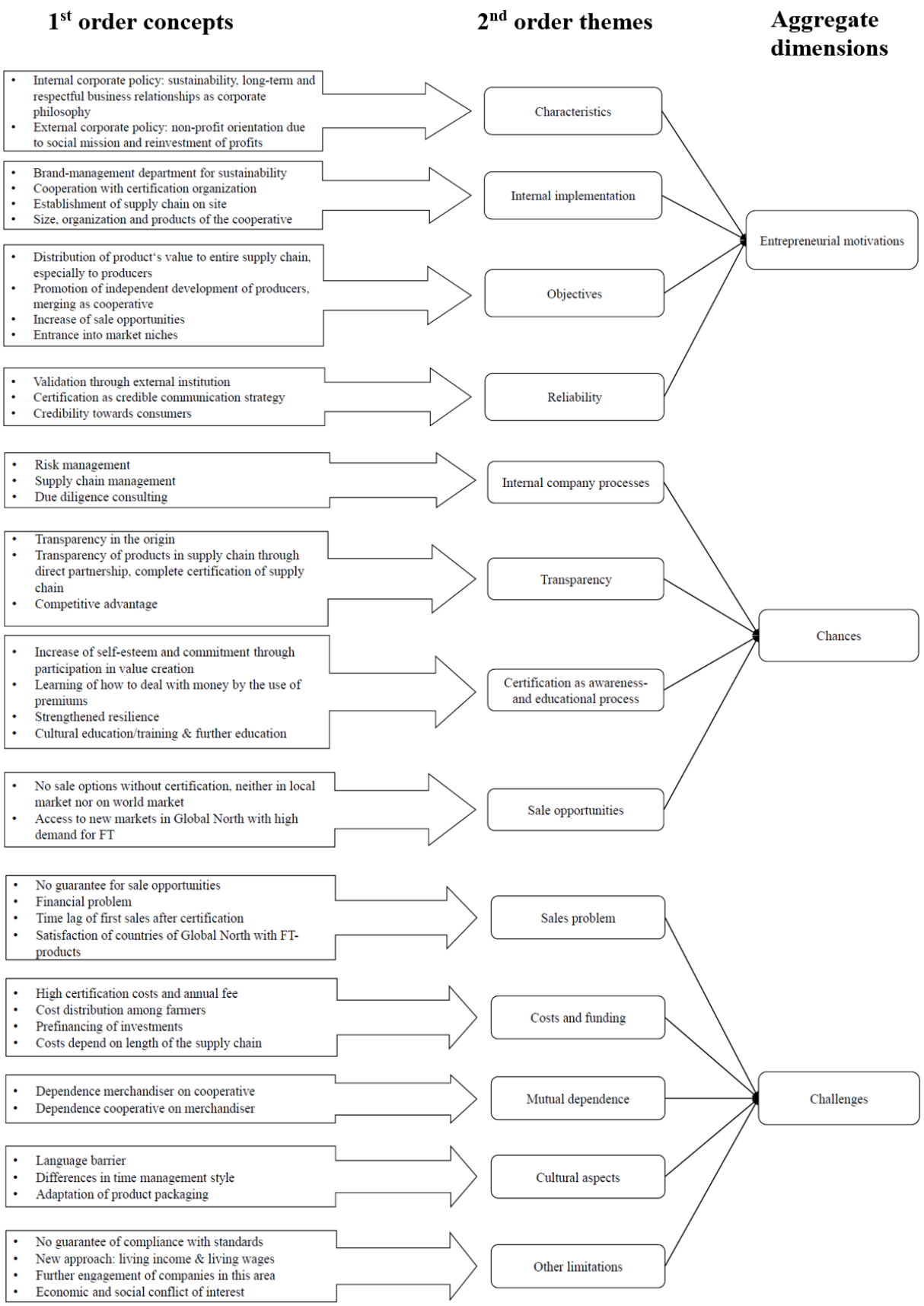

Figure 2: Data structure.

view by stating that it first wants to have demand and then, commissioning the certification.

By having a closer look into why the examined companies established or want to establish the certification, the reason was not just the label on the product. Rather, it was the *reliability* the certification offered them. As all the examined companies had a strong focus on social mission, they confirmed that they could only comply with their social mission when being proved officially by an external validation institution (I_P1; I_M1+M2). Thus, credibility in front of the consumer was of great relevance as without significant evidence consumers do not know if a company really does what it claims to do (I_P1). Even if a company engages in Fair Trade, without evidence, the consumer just has to believe in the correctness of the statements (I_C). However, with FT as a credible and proven system the consumers' "belief suddenly turned into knowledge" (I_M1, p.13). As Swiss consumers are very well informed about product sustainability and also demand this type of product, companies like M1 and M2 can credibly communicate their commitment towards customers.

4.2. Chances

Many chances that can be realized with a FT-certification are a result of the economic, social and ecological standards established by the certificate itself. According to the underlying data structure, the chances can be divided into *internal company processes, transparency, certification as awareness- and educational process* and *sale opportunities.*

One of the biggest chances of FT is that *internal company processes* could be improved. FT was named to be a tool for a company's risk management (I_M2). Given that M2 acts in the area of sustainability, it is exposed to a high reputation risk in case that it were to fail to meet its social and societal responsibilities as a cooperative society. Obtaining the FT-certification worked as a way to reduce this risk because M2 collaborates with the Swiss national certification organization as a reliable partner and has, therefore, a proven system on its side (I_M2).

Furthermore, FT supported M2 in terms of its supply chain management as it ensured the compliance with standards, i.e., with social conditions, human rights and due diligence in international supply chains (I_M2). Keeping in mind the German *Act on Corporate Due Diligence* or the *Swiss Responsible Business Initiative*, companies like M1 and M2 knew that regulatory requirements regarding standards in international supply chains were likely to rise. FT already has the standards and the expertise in establishing a transparent supply chain (I_C, Webpage_C). In this regard, organization C considered FT to be a future partner for companies that need to implement these new requirements in their supply chains.

Moreover, the certificate also serves for producers' internal processes: Although P1 is not yet completely FT-certified, the *Fair-for-life* certification already changed their internal processes in a way that guaranteed internal processes to be done well. For example, information about contracts or courses of business became pellucid and farmers could be better educated for conversations with clients (I_P1).

Focusing on the big picture, i.e., on the whole supply chain, another big chance that the certification brings is that it adds *transparency* to the whole supply chain.

> *"But that only works if you and I buy directly from the source, or at least close enough to the source that I know exactly what's in between. The moment I have shadowy intermediary trade (.) you have a problem"* (I_M1, p. 11).

Although FT's effort is to make the supply chain as short as possible, this does not mean that intermediaries are generally excluded. However, as the quotation shows, M1, and M2 respectively, were representative for their strategy of always trying to avoid intermediaries. The rationale behind their strategy was that they realized the fundamental problem of conventional supply chains: "The first stage is the one that suffers. (...) The second stage already has a good life" (I_M1, p. 4). Summing it up, the more members are participating in such a supply chain the more cost are aggregated to intermediaries that are not part of adding any value to the supply chain. Consequently, the money needs to be split among all members. Hence, according to M1, with as few intermediaries as possible the money could be directly transferred to the producing unit of the supply chain. In a broader sense, the national certification organization named several ways through which transparency in a FT-supply chain is guaranteed: All the members of the supply chain need to be FT-certified for the respective product, the external certification organization creates transparency, the source and potential intermediaries are clearly declared on the final product and, finally, the consumer can track the supply chain of the product via a digital code (I_C). For P1, for example, this transparency has led to a competitive advantage because its reliability rose compared to its competitors (I_P1).

Apart from the legal- and competitive advantages, all the interview' partners considered the *awareness- and educational process* arising through FT to be an important chance to overcome producers' strained situation. Due to their limited opportunity to act freely and self-determined, they faced severe economic consequences which often brought them into debt-bondage (I_M1). Additionally, with lack of education, it was difficult for them to be active in an entrepreneurial and sustainable way (I_M1+C). However, by means of the FT certification the producers became aware of the fact that they have options to improve their lives (I_M1+C). The general manager of P2 illustrated that, by getting certified, its farmers underwent a development "from being people who were not visualized to being part of what the territory offers today" (I_P2, p. 2). What benefited this development positively is the premium payment for those farmers which is set through the standards of the certification (Webpage_C). It accounted for 12,2 million USD of extra money generated through FT-sales in Switzerland in 2020 (Press release of annual report 2021_C). This caused producers to have 10% to

15% more income available on household level than without the certification (Sustainability blog_M1). If invested wisely, the premium contributes positively to producers' life. The example of P2 showed, how beneficial an investment of such a premium can be because it enabled them to be part of the value creation: By buying machines to make wine, those farmers developed from being mere producers of raw materials, in this case grapes, to producers of their own processed commodity (I_P2). Thus, they specialized on wine production and started to coin their own brands (I_P2). Hence, the farmers realized that they were valuable members of society:

> *"And that's where you suddenly have a situation where you are lifting people up to a level or helping to lift them up to a higher level, in terms of their self- esteem. Suddenly (...) they see possibilities that they never considered before, like, 'Gee, my kids could get an education'"* (I_M1, p. 7).

Further, when referring to *awareness- and educational process*, an increasing social activity was stressed by both merchandisers and producers. As stated in the standards, producers need to be organized as a cooperative with democratic order (Webpage_C). This caused the necessity to establish internal structures for the cooperative to function: "By suddenly being together, they are a completely different interlocutor for a factory or a processor" (I_M1, p. 7). Together with the premium pay, this sense of community also strengthened their resilience and empowered them (I_C). Furthermore, what P2 described impressively was the establishment of a local culture which was mainly advanced through FT.

> *"We [the cooperative] give that value to the farmers and we began to generate a whole movement and development based on local culture that did not exist here in Colchagua in the past"* (I_P2, p. 2).

What they finally achieved was the composition of books about the history of their farmers, the flora and fauna in the region and the regional recipes (Webpage_P2, I_P2).

As it is already made clear from the description of the mission which FT has, it shall create *sale opportunities* to producers who would otherwise not have had a chance to sell their products neither on the world market nor on the Chilean market. Both P1 and P2 stressed the necessity for them to export products because in Chile they do not have the chance to commercialize their products due to a smaller population size and different consumers' behavior. "If we were to leave Chile's production in Chile, the truth is that there would be some fruit left over and it would have to be thrown away" (I_P1, p. 3). In this sense, the FT-certification assured producers the export of products to countries of the Global North (I_M1). However, P2 already admitted that this promised guarantee on sales was not as easy in real life as it seems and can easily turn into a challenging task to accomplish.

4.3. Challenges

Besides the *sales problem*, other challenges which emanated out of the case study were *costs and funding, mutual dependences, cultural aspects* and *other limitations.*

Apart from the chance for high sales, finally having FT-*sales* was considered as one of the main challenges for members in a FT-supply chain: "I also hear this again and again when I am in the origin, that is sales, sales, sales, so the possibility to be able to sell as much as possible at FT-conditions" (I_C, p. 6). However, these sales numbers vary depending on country and product (I_C). As organization C affirmed it is a misbelief that a FT- certified cooperative sells all of its products under FT-conditions (I_C). Just to name the most common example, only one-third of the whole worldwide FT-coffee production was sold at FT-conditions, the rest needed to be sold otherwise (I_C). Whereas none of the merchandisers named sales as a challenge, both P1 and P2 focused strongly on this aspect. Both claimed that the lack of sale opportunities for their products made it difficult for them to justify the costs involved (I_P1+P2). The above-mentioned guarantee for sale opportunities stated by merchandisers did, therefore, not always apply to producers. Given the example of P2, its initial thought of quickly finding clients after being FT-certified in 2009 turned into disappointment when in the following year the company had not a single sale of its newly certified products (I_P2). This also turned into a problem when thinking in business terms: "We had to pay for the certification in 2009, and 2010 had no Fairtrade sales, and then it became a financial problem. To what extent do you manage to keep the costs of getting certified if you don't have sales?" (I_P2, p. 4).

Closely related to having sales is the challenge of bearing the *costs and the funding*. The case study revealed that the costs involved in FT emerged at two points: Firstly, within the implementation- and certification process and secondly, along the supply chain itself. Regarding the implementation- and certification costs for producers, they depend on the size of the cooperative to be certified (I_C). It consists of both the certification- and the annual fee (approximately 600 EUR and 2000 EUR, state 2022) (I_C). M1 and M2 did not mention certification costs to be challenging for them, probably because of their company size and revenue.

The evolving costs in the supply chain, however, were not as easy to quantify as the fees. There, the results of the case study showed a trade-off. On the one hand, due to a short and transparent supply chain like the one FT represents, costs could be reduced because cost-intensive intermediaries were taken out and the additional money was transferred to producers (I_M1). On the other hand, however, "[i]f you have transparency in your supply chain, then you are aware that products cost something. This, of course, prevents you from simply ignoring that reality exists" (I_M1, p. 10). Further, the question of the funding arose: For M1 and M2 costs represented something that is given and needed to be paid (I_M1+M2). For them, the certification proved its worth and helped to reach their goals in the area of sustainability

(I_M2). Therefore, they usually prefinanced any costs arising out of the producers' certification and implementation by the means of a sustainability fund with financial resources of 16,5 million CHF per year for such projects (Annual report 2020_M1; Sustainability blog_M1). Furthermore, costs emerged at the point when the company conducts projects to establish supply chains on site (I_M2). M1 and M2 were regularly abroad in these projects which also needed to be paid. Although merchandisers face a high-cost burden with FT as well, their big advantage is that they can charge these costs to their consumers (I_M2). This is possible because of the Swiss consumers' demand for having purchasing security in sustainable products (I_M1+M2). Though, it is not the rule that the merchandiser bears the overall costs: Whereas P2 financed the certification all by itself, P1 was still in the process, but will also bear the costs on itself.

Resulting from a two-sided involvement within a FT-supply chain is the emergence of mutual *dependencies*. Both for merchandisers and for producers this can result into a challenging task. As Chilean cooperatives often only had one purchaser for their products, they were dependent in terms of sales and dismissals on the part of the merchandiser (I_P2+M2). Additionally, finding a buyer who paid fair prices and who supported the cooperative in a social manner was difficult (I_M2). Merchandisers also faced dependency on the commodity in itself. Finding new producers went along with having additional effort and expenses (I_M2). However, M2 admitted that the dependency exists, though, it is "greater on the Global South than on the Global North, but that's always the problem, (...) that whoever buys is also in the driver's seat, unfortunately" (I_M2, p. 7).

Cultural aspects also portrayed an underestimated challenge in a FT-partnership. P2 stressed that the second biggest challenge, after finding a client, was the language barrier. Speaking Spanish and not English restrained the farmers not only in building up personal customer contact, but also the way they performed online on their webpage (I_P2; Webpage_P2). This led into a vicious cycle, as without being able to present themselves due to a lack of language knowledge, it was also difficult to find new clients (I_P2). Step by step they addressed this problem by, for example, translating their webpage into English (I_P2, Webpage_P2).

Additionally, as stressed by all the interview partners alike, a FT-partnership is designed for the long-run and highly future-oriented as the certification and the first sales are often facing a time lag. According to organization C, it could take about one to two years' time to comply with the requirements necessary for certification. P1, for example, was still biased regarding the FT-certification because the company focused on maximizing current profits without regard to future profits (I_P1). In contrast, the Swiss merchandisers and P2 developed a strategy with FT that combined both profits on long and short terms (I_M1+M2+P2). In a cultural context, the GLOBE Study explains this behavior with one of its dimensions which is defined as follows: Future orientation is "[t]he extent to which individuals engage in future-oriented behaviors such as delaying gratification, planning, and investing in the future" (Webpage_GLOBE Study; Ashkanasy et al., 2004). Retrieving relevant data from the GLOBE Study, Switzerland, with a practice score of 4,73, is highly future oriented whereas Latin America scores lower with 3,54 which is even beneath the average of 3,85 (Ashkanasy et al., 2004).

One last cultural aspect was the cultural adaption of products. Both M1 and M2 stressed their position within the supply chain in between the producers and consumers. This implied the necessity to adjust the product and the package to the taste of consumers in the Swiss market. "I [Head of Project Overseas] have to make the product so that it does not appear like from third world store, right? But I have to make it the way you want to have it" (I_M1, p. 7).

Finally, there are *other limitations* of the FT-certification left which caused additional challenges for members in a FT-supply chain. Firstly, partnering with a FT-certified cooperative did not guarantee a full coverage that, e.g., there is no child labor happening or that farmers are paid living wages and income (I_M2). Although in this area, FT is already about to improve its approach, there is no complete assurance that it complies with all standards (I_C). Especially for a market like Switzerland, whose consumers highly demand fair and sustainable products, FT was already a prerequisite and, thus, did not provide M1 or M2 with a big competitive advantage anymore (I_M2). Consequently, both of them needed to go even beyond FT and establish other approaches to address their social responsibility (Webpage_M2; I_C). Secondly, the FT-certification organization is not an independent institution but stands in a conflict of interest between delivering to its clients and fulfilling its social mission (I_M2). Therefore, one should not forget that Fairtrade is also a business and needs to discharge its economic interest as well (I_M1).

5. Discussion

5.1. Theoretical and practical implications

In order to answer the research question, a case study was conducted with two different sources of evidence which highlighted the principal opportunities and challenges from a supply chain-perspective (Yin, 2018). Based on the findings of this study, the discussion will reflect the study's contributions and implications both for existing literature and practical application.

Firstly, with regards to theoretical implications, this paper widely explores a variety of beneficial and challenging aspects in a FT-supply chain. As seen in the data structure (cf. Figure 2), it goes beyond the scope of mere chances and challenges and also includes the entrepreneurial motivations of companies for FT. This may be especially informative, because the way a company is motivated to become FT-certified can have consequences on the chances and challenges it faces. In relevant literature, authors have already been focusing on actors' managerial motivations to engage in a FT-business model (Bezençon & Blili, 2009; Cater et al., 2017; Low & Davenport, 2005). Following the findings of

Cater et al. (2017) the main incentives for a merchandiser to operate in FT are ethical beliefs, religious faith, shared- and business values and altruism. Thereby, Cater et al.'s study (2017) focused on small US-businesses with less than 500 employees led by social entrepreneurs. Although this paper at hand focuses on a large-scale enterprise in Switzerland, it comes to similar conclusions. Even though M1 and M2 is one of the biggest supermarket chains in Switzerland, it is led by the ethical conviction of assuming responsibility beyond their boarders and would do FT even if there was no certification. This allows the potential conclusion that if a company is already about to engage in FT, then the motivations are similar across all sizes of companies.

However, the question posed by Bezençon and Blili (2009) is well-founded. They ask if a firm, which uses FT as a strategy for CSR, is "designing and implementing its CSR policy in order to appear good or is it doing it because it is good?" (p. 111, underlined by author). The difference here consists in the kind of entrepreneurial motivation. As Cater et al. (2017) described, social entrepreneurs are intrinsically motivated. However, FT is not just a social mission, but also an economic one (Mookerjee, 2019). Although M1 and M2 are considered to be proactive CSR-companies, they expect certain economic opportunities deriving from the certification (Bezençon & Blili, 2009). It then becomes clear that for producers, merchandisers and the certification organization economic considerations, like commercialization, sales and competitive advantages, are at least as important as ethical values. Thus, the first contribution this paper makes is that motivations cannot be seen separately from the chances and challenges those agents are confronted with.

Secondly, already existing research on the FT-supply chain focused mainly on consumers, producers or merchandisers, i.e., just on one side of the supply chain (Bezençon & Blili, 2009; Cater et al., 2017; CEval, 2012; Dragusanu et al., 2021). Based on their approach, valuable insights about, e.g., the right to have a say, power and governance within the FT-supply chain were derived (Leiderman, 2018; Lukas, 2015). Following Lukas (2015), the imbalance of power between the stakeholders is a barrier to transparency and trust in such a supply chain. Furthermore, producers are at merchandisers' mercy when it comes to adapting to their interests (Lukas, 2015). However, by talking about 'power imbalance' in Fair Trade, the very same dichotomy of Southern producers and Northern buyers is preserved and emphasized which Fair Trade actually wants to equalize (Ruggeri et al., 2018).

The findings of this paper, therefore, challenge this assumption of power imbalance in a FT-supply chain, leaning on the underlying approach which empirically analyses the whole supply chain, and not just one side of it. All of the five interview partners were asked on their experience on decision-making and interdependency within the supply chain. None of them argued that FT is dominated by Northern interest and that producer need to bow to those interest (Lukas, 2015). Rather, both merchandisers and producers stressed that especially the FT-premium gives producers the means to decide independently and autonomously about their future (I_C). Of course, dependencies exist in the way how this extra money is invested, which is influenced by Swiss merchandisers (I_M1). In general, though, producers are involved in a participatory manner (I_C). Furthermore, the FT-standards are developed in accordance with the cooperatives. The overall aim, hereby, is to integrate the producer more into the supply chain (von Hauff, 2017). Therefore, the second contribution of this paper is to provide a better phrase for talking about this relationship: Instead of 'power' between producers and merchandisers the phrase 'cooperation on eye level' would be more adequate.

Thirdly, the question arises in which areas merchandisers and producers have converging and conflicting interests. One converging chance both sides see is that they realize self-serving benefits out of the participation in FT. For producers, FT represents a meaningful opportunity to overcome their strained financial situation. For M1 and M2, by being member of FT, they can foster a coherent communication strategy towards their consumers of being a socially responsible company (Bezençon & Blili, 2009). Additionally, FT can help merchandisers in their marketing strategy because they can use such certifications as a unique selling proposition (Kohts, 2016; Parvathi & Waibel, 2018). Since in Switzerland FT is already considered to be a prerequisite, the examined merchandisers tend to have a variety of labels and certifications in order for their products to stand out against competitors (Kohts, 2016).

With regard to sales, stakeholders' interest might differ: Chilean producers mainly hope for better access to markets of the Global North and promising sale opportunities because, e.g., Swiss consumers are willing to pay a remarkable amount of money for FT-products (Giovannucci et al., 2014; Max Havelaar-Stiftung and Swiss Fair Trade (2021) quoted from de.statista.com). Though, merchandisers rather focus on providing reasonable product portfolios to their consumers. Thereby, they need to consider the Swiss consumers' preference. For example, P2 tried to enter the Swiss market with its FT-wines but was not successful. Firstly, because the Swiss market is already saturated with its own wines, and secondly, Swiss consumers prefer regional products if they can be produced in Switzerland as well (I_P2; Hochschule Luzern 2020 as quoted from de.statista.com).

Fourthly, this paper's findings shows that cultural factors are a previously neglected factor in the literature on FT. The original focus of the analysis was on the chances and challenges of FT-members and was directed towards cultural aspects in the course of the case study. Hence, what cultural chances and challenges impact a participation in a FT-supply chain? P2 stated that the lack of foreign language represents the second biggest challenge for them, right after having sales (I_P2). Without adequate language skills factors like the response time, the quality of information or the interpersonal element suffer in a trading relation (Rotondaro, 2012). Furthermore, time management, and especially future orientation, represent one of culture's most significant values (Ashkanasy et al., 2004). In a FT-partnership, this orientation

becomes especially relevant. Countries like Switzerland that score high in this dimension are more likely to have economic success than lower-scoring countries like Chile (Ashkanasy et al., 2004). This is due to the different strategic future-orientation of the organizations in the country (Ashkanasy et al., 2004). As the results of the case study imply, M1 and M2 use FT as a long-term strategy to accomplish their sustainability objectives (I_M1). Sustainability is deep-seated in their genetics. Since their stakeholders do not require them to maximize profits, they have the time for establishing long-lasting sustainability programs (I_M1+M2). Further, M1 and M2 have the Swiss national FT-organization and the consumers on their side which all support this long-time orientation because it is in the nature of the country's culture. In Latin America, in contrast, companies are little future oriented as the GLOBE Study shows (Ashkanasy et al., 2004). They tend to have a shorter strategic orientation which also causes certifications to not have such a significance as they have in Switzerland (Ashkanasy et al., 2004). For P1 and P2 it is, therefore, remarkable having applied for a future-oriented certification like FT although their domestic market does not appreciate or support it. Finally, this country-specific time orientation leads to an additional challenge on the part of the producers. In summary, the paper's findings complement existing literature on FT by putting this partnership in relation to the cultural level.

Lastly, the discussion focuses on practical implications. For political discussions in the Global North on due diligence in international supply chains, the compliance with social, labor and environmental standards is highly relevant (Emons et al., 2021). Companies' self-commitments in the form of "codes of conducts" (p. 5) are a first step to guarantee minimum standards along the supply chain (Emons et al., 2021). However, with their noncommittal character these codes are not legally binding (Emons et al., 2021). Therefore, policymakers in various countries of the world have institutionalized those standards into national state law as portrayed in the theoretical background (Bueno, 2020; Emons et al., 2021). This causes many companies to rethink their current supply chain management and question how to adapt.

Following Emons et al. (2021) transparency regulations and CSR help to implement those legal requirements in companies' corporate policy. FT, therefore, can be an option in increasing transparency in supply chains and implementing CSR. When Switzerland discussed the due diligence obligation for companies, the national FT organization for the first time actively positioned itself with a clear statement: "With the *Business Responsibility Initiative*, we have made a bit of a fundamental decision and said that when it comes to issues, political ones that directly affect us, we want to make a statement" (I_C, p. 10). In a practical sense, with its experience FT can be a partner for companies that need to adapt to the new legal requirements. Thus, the paper at hand is addressed to actors of the private sector as well, i.e., merchandisers with little experience in due diligence might consider implementing FT as a way to keep pace with increasing standards in supply chains.

5.2. Limitations

Even though the theoretical and practical implications detailed here forward the existing literature and practices on the FT-supply chain, like every empirical research it is limited in several aspects. Firstly, despite having an exploratory approach the study focuses solely on social and economic chances and challenges, leaving ecological aspects excluded. However, they also belong to Elkington's *triple bottom line* (1999) and recently experience relevance in new FT-strategies.

Secondly, since an empirical case study was conducted the findings are highly specific for the case at hand. By focusing on the geographical scope of Chile and Switzerland, results cannot be easily transferred to other geographical settings. Especially in the case of Switzerland this is particularly evident because their "opportunities and chances are really very Swiss" (I_M1, p. 9). What Audebrand and Pauchant (Juli 2009) meant when stating that "social and ecological costs are not 'externalities' [...], but instead are *integral* costs that must be included in the sale price" (p. 348), is something that lies in the nature of Switzerland's economy. Against the background of Switzerland, there are not many countries that perform such an engagement in the FT-market. Due to this very special position Switzerland has regarding its FT-market, its companies also have special strategies. Therefore, M's strategy of direct trade and the prefinancing of all the necessary investment in the origin is not the standard procedure in FT.

Lastly, the methodological approach of a case study leaves the results limited in several ways: On the one hand, the interview transcripts were freely translated from German and Spanish into English. Consequently, the original meaning of the interviewees' responses might be lost in translation. On the other hand, the sample size of five interview partners and the respective documentation leaves the generalizability of this study limited.

5.3. Recommendations for future research

The relevance of the topic becomes particularly clear when looking at the sizable future research directions remaining. Due to its political relevance, conducting further research, specifically on FT's contribution to due diligence laws, is necessary. In this sense, it would be necessary to conduct interviews with actors outside the private sector. In particular, such an approach requires research on the organizational level, e.g., with members of the umbrella organization *Fairtrade International* or law makers responsible for the due diligence laws. Furthermore, future papers could integrate more agents and operators of the whole FT-supply chain than just producers and merchandisers. Specifically, exporters and importers of FT-products could give valuable insight to the question if challenges and chances in the supply chain change when more actors are involved. Finally, this study analyzed social and economic factors. However, the FT's standards also include environmental considerations. Hence, resulting out of the paper's limitations, conducting

research on the ecological impact FT has could expand the approaches of this study (von Hauff, 2017).

6. Conclusion

The aim of the paper at hand is to examine the chances and challenges of members in a FT-supply chain. Therefore, by means of a case study various social and economic aspects were identified. This study offers several insights into the FT-supply chain. Thereby, it sheds light on the fact that merchandisers' and producers' chances and challenges intercorrelate with the motivations they have to engage in FT. Further, the paper highlights FT as being a cooperation on eye-level that developed a feasible approach in breaking with the power imbalance of conventional international trade. Moreover, it also shows that different cultural backgrounds regarding language and time orientation of the actors in the FT-system impact those chances and challenges. Finally, the future will show if FT is able to permanently partner companies in their way of establishing higher standards and what is more to come with regards to due diligence laws in supply chains. It is obvious that FT is not an 'allrounder' that can solve all the challenges of conventional international trade. However, Keynes' 100-years prophecy has already been broken which should now be seen as an incentive to continue to spread even more fairness across all producers in this world.

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Career entry in times of mobile work: An empirical study on the influence of mobile working on the psychological well-being of commercial apprentices in Hamburg

Berufseinstieg in Zeiten mobiler Arbeit: Eine empirische Studie über den Einfluss mobilen Arbeitens auf das psychische Wohlbefinden kaufmännischer Auszubildender in Hamburg

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Abstract

The COVID 19 pandemic has led to an increase in the number of employees in Germany who work from home. The cohort of apprentices is also particularly affected by this development. Since the beginning of the pandemic, some of them have started their working lives, partly completely, in a virtual manner. In the study conducted, the JDR model was used to investigate the influences of remote working on the psychological well-being of apprentices. One assumed that the intensity of remote working has a negative impact on job resources on the one hand and a positive impact on job demands on the other. A structural equation model was specified to analyze the theoretically derived relations between the constructs. The underlying data resulted from a conducted online survey (n= 110). Contrary to expectations, the results of the survey did not provide evidence that the intensity of remote working negatively affects apprentices' psychological well-being through the path of job demands or job resources. Based on the results, it became apparent that a special focus in apprenticeship design should be on the topics of boundary management, technostress and learning opportunities.

Zusammenfassung

Durch die aufgetretene COVID-19-Pandemie stieg die Anzahl der Homeoffice nutzenden Erwerbstätigen in Deutschland. Von dieser Entwicklung ist in besonderer Weise auch die Kohorte der Auszubildenden betroffen. Diese ist seit Beginn der Pandemie teilweise vollständig virtuell ins Berufsleben gestartet. In der durchgeführten Studie wurde das JDR-Modell verwendet, um die Einflüsse mobilen Arbeitens auf das psychische Wohlbefinden Auszubildender zu untersuchen. Dabei wurde davon ausgegangen, dass die Intensität mobilen Arbeitens einerseits die Arbeitsressourcen negativ und andererseits die Arbeitsanforderungen positiv beeinflusst. Um die theoretisch abgeleiteten Beziehungen zwischen den Konstrukten zu analysieren, wurde ein Strukturgleichungsmodell spezifiziert. Die zugrunde gelegten Daten ergaben sich aus einer durchgeführten Onlinebefragung (n= 110). Entgegen den Erwartungen liefern die Ergebnisse der Befragung keine Hinweise dafür, dass die Intensität mobilen Arbeitens das psychische Wohlbefinden der Auszubildenden über die Pfade der Arbeitsanforderungen oder der Arbeitsressourcen negativ beeinflusst. Anhand der Studienergebnisse zeigte sich, dass ein besonderer Fokus in der Ausbildungsgestaltung auf den Themen Entgrenzung, Technostress und Lernmöglichkeiten liegen sollte.

Keywords: JD-R model; Well-being; Onboarding; Mobiles Arbeiten; Ausbildung.

1. Einleitung

Unter Arbeiten vom eigenen Zuhause aus – auch als Telearbeit, mobiles Arbeiten, Homeoffice oder Remote Work bezeichnet – wird ein Konzept verstanden, bei dem Angestellte für das Leisten ihrer Arbeit nicht mehr einen Arbeitsplatz im Unternehmen aufsuchen (Bellmann & Hübler, 2020, S. 424).

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Durch die im Jahr 2020 aufgetretene COVID-19-Pandemie (World Health Organization, 2020b) und die daraus resultierenden politischen und gesellschaftlichen Einschränkungen zur Eindämmung der Verbreitung der Pandemie sowie die unternehmerischen Maßnahmen zur Aufrechterhaltung der betrieblichen Abläufe stieg die Anzahl der Homeoffice nutzenden Erwerbstätigen in der Bundesrepublik Deutschland bis Ende 2020 im Vergleich zu 2019 von 12.9 % auf circa 35 % (Wirtschafts- und Sozialwissenschaftliches Institut, 2021). In besonderer Weise ist von dieser Entwicklung die Kohorte der Auszubildenden in Deutschland betroffen. Diese hat seit Beginn der Pandemie teilweise einen signifikanten Abschnitt der betrieblichen Ausbildung von ihrem Zuhause aus absolviert und ist zum Teil vollständig virtuell ins Berufsleben gestartet (Biebeler & Schreiber, 2020, S. 16), obwohl § 14 Absatz 1 Nummer 2 des Berufsbildungsgesetzes (BBiG) diese Möglichkeit bisher nicht vorsieht. Die Tendenz, dass Unternehmen planen, das Konzept der mobilen Arbeit nach der Pandemie beizubehalten (Bartik, Cullen, Glaeser, M. & C.T., 2020, S. 4; Deloitte, 2020, S. 5), und die bereits vor Ausbruch der COVID-19-Pandemie bestehenden wissenschaftlichen (Gajendran & Harrison, 2007; Hill, Ferris & Märtinson, 2003) und unternehmerischen (Simons, 2017) Diskussionen zu diesem Thema führen zu der Fragestellung, inwiefern sich bei kaufmännischen Auszubildenden das mobile Arbeiten auf ihr psychisches Wohlbefinden auswirkt.

Durch die Digitalisierung und Flexibilisierung von Arbeitsplätzen stehen Unternehmen vor der Herausforderung, die potenzielle Zunahme bestehender und neuer mentaler Arbeitsbelastung für Mitarbeitende zu analysieren, zu bewerten und zu reduzieren (Hagemann et al., 2021, S. 2; Kniffin et al., 2021, S. 72). Auf der einen Seite können digitale Technologien, die beispielsweise mobiles Arbeiten ermöglichen, als Ressource dienen, um die eigene Arbeit selbstbestimmter und flexibler zu gestalten (Schwarzmüller, Brosi, Duman & Welpe, 2018, S. 131). Auf der anderen Seite können sie allerdings auch zu höheren Anforderungen führen, die möglicherweise Belastungen verursachen (Hartwig, Wirth & Bonin, 2020, S. 1; Ragu-Nathan, Tarafdar, Ragu-Nathan & Tu, 2008, S.430). Das Verhältnis zwischen Anforderungen und Ressourcen ist nicht nur im klassischen, sondern auch im digitalen Arbeitsumfeld entscheidend für die Gesundheit der Beschäftigten (Härtwig & Sapronova, 2021, S. 70). Ressourcen und ausgewogene Arbeitsanforderungen unterstützen in der Regel die Entwicklung der Beschäftigten. Eine übermäßige Arbeitsbelastung kann hingegen zu negativen Auswirkungen bei Leistung und Gesundheit führen (Hartwig et al., 2020, S. 5).

In der Bundesrepublik Deutschland gab es im Jahr 2020 insgesamt 700.6 Millionen Arbeitsunfähigkeitstage, die wirtschaftliche Verluste in Höhe von 87 Milliarden Euro durch Produktionsausfälle verursacht haben (Brenscheidt, Siefer, Hünefeld, Backhaus & Halke, 2022, S. 49). Psychische und Verhaltensstörungen machten dabei einen Anteil von 14 % an den gesamten Arbeitsunfähigkeitstagen aus (Brenscheidt et al., 2022, S. 47). Seit 2010 haben Krankheitstage aufgrund psychischer Erkrankungen um 56 % zugenommen, wobei die durchschnittliche Falldauer im Jahr 2020 mit 30.3 Tagen je Fall mehr als doppelt so lang ausfiel wie der Durchschnitt aller Erkrankungen am Arbeitsplatz mit 13.8 Tagen je Fall (M. Meyer, Wing, Schenkel & Meschede, 2021, S. 443). Die Erfassung von psychischen Belastungen am Arbeitsplatz wird daher immer wichtiger, um die Arbeitsfähigkeit zu beurteilen und zu fördern. Sie ist für deutsche Unternehmen mittlerweile verpflichtend im Arbeitsschutzgesetz geregelt (§§ 5, 6 ArbSchG).

Das Bundesinstitut für Berufsbildung (BIBB) hat seit dem Beginn der Corona-Pandemie zahlreiche Forschungsarbeiten zu den mit dieser verbundenen Auswirkungen auf die Berufsbildung in Deutschland veröffentlicht (Biebeler & Schreiber, 2020; Kohl, Diettrich & Faßhauer, 2021). So befragten Biebeler und Schreiber (2020) für eine Studie 1,343 Ausbildungsbetriebe. In ihrem Diskussionspapier fassen sie einige zentrale Aspekte dieser Studie zusammen, die die Relevanz der vorliegenden Arbeit verdeutlicht. So gaben 20 % der Betriebe zum Zeitpunkt der Befragung an, dass Teile der Ausbildung im Homeoffice stattfinden konnten. Darüber hinaus ergab die Studie, dass die Potenziale der digitalen Ausbildung bisher kaum ausgeschöpft werden. Die befragten Ausbildungsleiter ($n = 343$) gaben an, dass diverse Ausbildungsinhalte (siehe Abbildung 1) im Homeoffice absolviert werden könnten. Hierzu ist aktuell allerdings nur ein Drittel der Ausbildungsbetriebe in der Lage. Es mangelt insbesondere an mobilen Endgeräten, um den Auszubildenden das Lernen und Arbeiten auf Distanz zu ermöglichen (Biebeler & Schreiber, 2020, S. 6). Ähnliche Bedarfe zeigten sich bereits 2019, also vor Ausbruch der COVID-19-Pandemie, in einer qualitativen Interviewstudie des Bundesinstituts für Berufsbildung (BIBB) mit Ausbildungsverantwortlichen. Eines der Ankerzitate lautete: „eine Flexibilität, dass der Azubi auch mal außerhalb was machen kann, dass er nicht immer an das Büro gebunden ist“ (Kohl et al., 2021, S. 229).

Demnach zeichnet sich der Bedarf einer intensiveren Auseinandersetzung mit dieser Ausbildungsform ab, um auf zukünftige Anforderungen des Arbeitsmarktes (Bartik et al., 2020, S. 4; Deloitte, 2020, S. 5) reagieren zu können. So ist es erforderlich, vor allem für die Berufsausbildung neue didaktische Homeoffice-Konzepte und Guidelines zu entwickeln, ohne dabei die potenziellen Gefahren zusätzlicher psychischer Belastungen zu vernachlässigen (Marsh, Vallejos & Spence, 2022, S. 1).

Diese Studie trägt zur Forschung über die Auswirkungen der Corona-Pandemie auf die Arbeitsbedingungen bei, indem sie die Wahrnehmung Auszubildender während der Pandemie in Deutschland untersucht. Darüber hinaus leistet die Studie einen Beitrag zur allgemeinen Forschung über die Auswirkungen mobilen Arbeitens auf Arbeitsanforderungen und -ressourcen. Damit kommt sie dem Aufruf von Biebeler und Schreiber (2020, S. 36) nach, die in ihrem Diskussionspapier des Bundesinstituts für Berufsbildung (BIBB) weitere Forschung zu den Möglichkeiten und Grenzen digitaler Ausbildung fordern. Außerdem folgt diese Studie der Forschungsperspektive von Marsh et al. (2022) und Jooss, McDonnell und Conroy (2021), indem ein besonderes Augen-

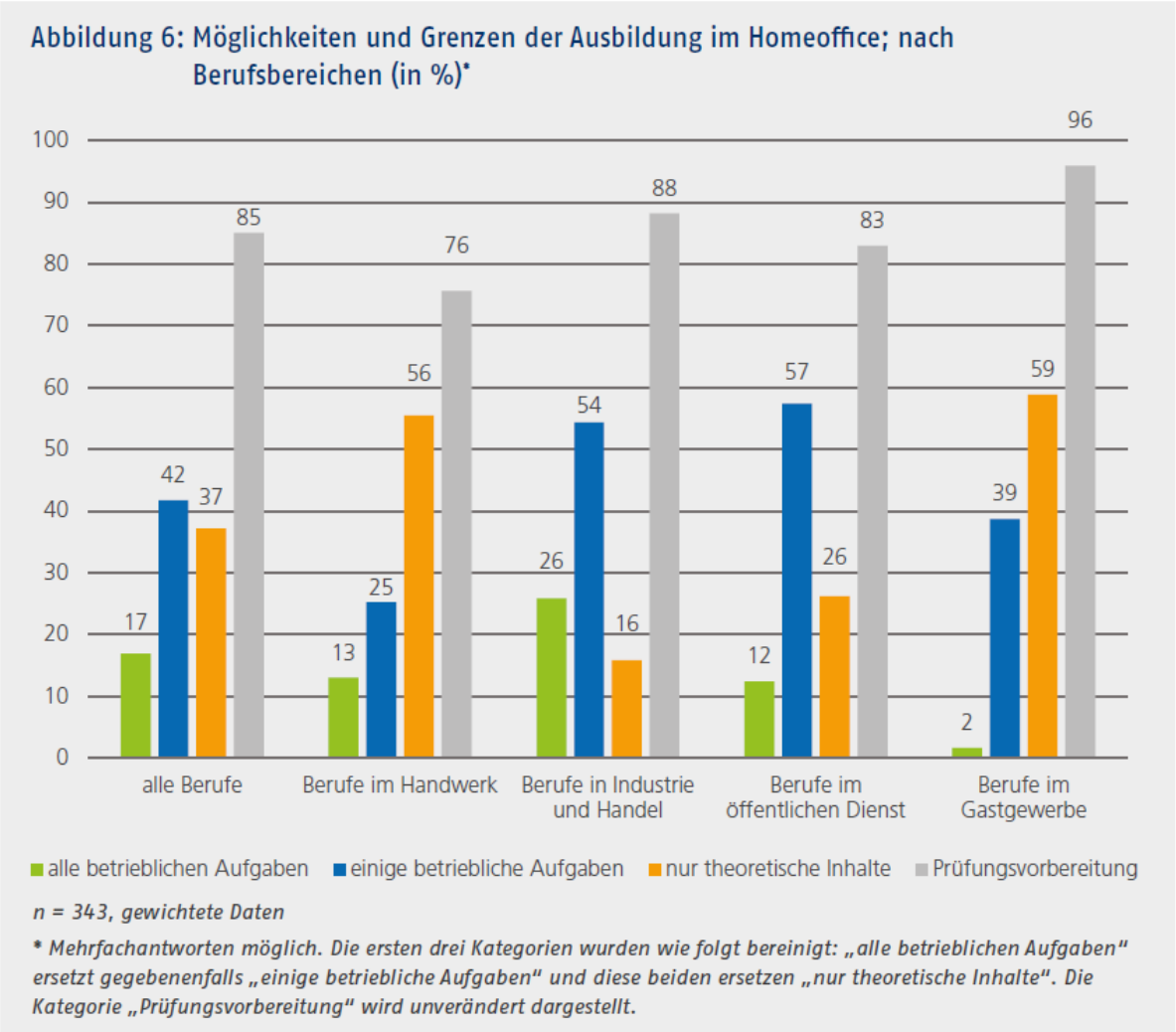

Abbildung 1: Möglichkeiten und Grenzen der Ausbildung im Homeoffice nach Berufsbereichen (in %)*

Quelle: Biebeler & Schreiber, 2020, S. 18
Anmerkung:
$n = 343$ gewichtete Daten
* Mehrfachantworten möglich. Die ersten drei Kategorien wurden wie folgt bereinigt: „alle betrieblichen Aufgaben" ersetzt gegebenenfalls „einige Aufgaben" und diese beiden ersetzten „nur theoretische Inhalte". Die Kategorie „Prüfungsvorbereitung" wird unverändert dargestellt.

merk auf die potenziellen Schattenseiten des digitalen beziehungsweise mobilen Arbeitens gerichtet wird.

Auf Basis einer Onlinebefragung kaufmännischer Auszubildender in Hamburg werden mittels Strukturgleichungsmodellierung die Zusammenhänge zwischen mobiler Arbeit, Arbeitsanforderungen und -ressourcen sowie dem psychischen Wohlbefinden untersucht. Als theoretisches Fundament dient dabei das Job-Demands-Resources-Modell (JDR) von Evangelina Demerouti, Arnold Bakker, Friedhelm Nachreiner und Wilmar Schaufeli, dem für diesen Themenkomplex ein höherer Nutzen im Vergleich zu anderen Modellen zugeschreiben wird. Aufgrund des zugrundeliegenden Beeinträchtigungs- und Motivierungsprozesses des JDR-Modells können die Auswirkungen mobilen Arbeitens auf beide Prozesse berücksichtigt werden (Marsh et al., 2022, S. 6).

Nachfolgend werden der konzeptionelle Hintergrund der Arbeit sowie die daraus abgeleiteten Forschungshypothesen dargestellt. Anschließend erfolgt eine genauere Beschreibung der Datenerhebung und der methodischen Vorgehensweise. Die Darstellung und Diskussion der Ergebnisse schließen diese Arbeit ab. Das Ziel der vorliegenden Studie ist eine Analyse der durch mobiles Arbeiten beeinflussten arbeitsbezogenen Ressourcen und Anforderungen kaufmännischer Auszubildender in Hamburg. Der Fokus liegt dabei auf den Effekten der Homeoffice-Nutzung während der betrieblichen Phasen der Berufsausbildung.

2. Konzeptioneller Hintergrund und Hypothesen

In diesem Abschnitt erfolgt zunächst eine Darstellung des Konzeptes der mobilen Arbeit. Anschließend werden der Begriff des psychischen Wohlbefindens sowie das Job-Demands-Resources-Modell vorgestellt. Eine Übersicht der wissenschaftlich diskutierten Faktoren des Job-Demands-Resources-Modells im Zusammenhang mit mobiler Arbeit schließt gemeinsam mit den daraus abgeleiteten Forschungshypothesen dieses Kapitel ab.

2.1. Mobiles Arbeiten

Die erste Beschreibung des mit der mobilen Arbeit verwandten Konzeptes der Telearbeit lässt sich auf den Physiker und ehemaligen Ingenieur der National Aeronautics and Space Administration (NASA) Jack Nilles zurückführen. Er befasste sich, motiviert durch die chaotische Verkehrssituation in Los Angeles, erstmals in den 1970er Jahren mit dem Thema und veröffentlichte 1976 eine Arbeit mit dem Titel „Telecommunications-Transportation Tradeoff: Options for Tomorrow" (Nilles, 1976). Dank dieses Werks gilt er als Urvater des Konzepts der mobilen Arbeit (Berthiaume, 2020). In der 2007 publizierten Metaanalyse von Gajendran und Harrison zum Einfluss der Telearbeit wird dieses Konzept erneut aufgegriffen und beschrieben als „... arrangements that allow employees and their tasks to be shared across settings away from a central place of business or physical organizational location" (Gajendran & Harrison, 2007, S. 1524). Seitdem wird in den USA häufig der Begriff Telework verwendet (Madsen, 2003, S. 36). Damit werden alle Arten von Arbeit bezeichnet, die außerhalb des Hauptsitzes eines Unternehmens stattfinden, aber dennoch mit diesem verbunden sind (Bailey & Kurland, 2002, S. 384; Golden & Veiga, 2005, S. 301). In Europa wurde hingegen der Begriff E-Work verwendet, um virtuell ausgeführte Arbeit zu beschreiben. Kirk und Belovics (2006, S. 39) definieren E-Worker als Vollzeit-Telearbeiter, die von ihrem Zuhause aus arbeiten und hauptsächlich über elektronische Medien (z. B. Firmen-Intranets und E-Mails) kommunizieren. Dadurch haben sie nur sehr wenig persönlichen Kontakt mit ihrem Hauptsitz oder ihren Kollegen und Vorgesetzten. Obwohl die Telearbeit vom eigenen Zuhause aus traditionell die häufigste Form der Fernarbeit war (Halford, 2005, S. 19), hat in den letzten Jahren die Zahl der Arbeitnehmenden zugenommen, die an mehr als einem Ort arbeiten (Eurofound and the International Labour Office, 2017, S. 13). Mit dem Begriff des Remote E-Working wurde ein umfassenderes Konzept eingeführt, das verwendet wird, um diejenige Art von Arbeit zu beschreiben, die überall und zu jeder Zeit unabhängig vom jeweiligen Standort erledigt werden kann und durch den Einsatz von Technologien unterstützt wird (Grant, Wallace & Spurgeon, 2013, S. 529). Nach dieser Definition kann die Arbeit vom eigenen Zuhause aus, aber auch an anderen Firmenstandorten, in Hotels, an Flughäfen und anderen Orten erledigt werden. In der vorliegenden Studie wird diese Konzeptualisierung verwendet, da mit ihr alle Arbeitnehmenden erfasst werden, die Zeit außerhalb des Büros verbringen und Informations- und Kommunikationstechnologien für den Zugang zur Arbeit nutzen (Charalampous, Grant, Tramontano & Michailidis, 2018, S. 2).

Neben den verschiedenen Definitionen in internationalen wissenschaftlichen Fachartikeln werden in Deutschland vor allem drei Begriffe aufgrund ihrer unterschiedlichen rechtlichen Rahmenbedingungen differenziert. Dabei handelt es sich um Telearbeit, Homeoffice und mobiles Arbeiten (Industrie- und Handelskammer (IHK) Kassel-Marburg, 2022).

Das Konzept der Telearbeit findet sich in der Arbeitsstättenverordnung (ArbStättV) in § 2 Absatz 7 wieder. Hier ist hervorzuheben, dass der entsprechende Telearbeitsplatz durch den Arbeitgebenden im Privatbereich des Arbeitnehmenden fest ausgestattet wird. Als Grundlage hierfür dient eine arbeitsvertragliche Regelung zwischen den beiden Parteien, die darüber hinaus die wöchentliche Arbeitszeit und Dauer am heimischen Arbeitsplatz regelt. Da für den Begriff des Homeoffice noch keine rechtliche Definition existiert, wird dieser entsprechend dem allgemeinen Sprachgebrauch synonym zur Telearbeit verwendet. Somit wird darunter im Kern eine teilweise oder vollständige Arbeit in den privaten Räumen des Arbeitnehmenden verstanden. Zur mobilen Arbeit findet sich wie beim Homeoffice noch keine gesetzliche Regelung. Aufgrund des weit gefassten Begriffes besteht keine Assoziation mit der Arbeitsstättenverordnung, sodass lediglich die Arbeitsleistung außerhalb der Betriebsstätte mittels Verbindung zum Betrieb darunter verstanden wird. Dabei muss diese Arbeit nicht notwendigerweise von der eigenen Wohnung aus erbracht werden, sondern kann auch an anderen Orten, etwa in einem Zug oder einem Café erfolgen. Trotz der rechtlichen Unterschiede ist sowohl bei der mobilen Arbeit als auch bei der Telearbeit das Arbeitsschutzgesetz (ArbSchG) uneingeschränkt anzuwenden, sodass die Verantwortung der Arbeitgeber hinsichtlich der Fürsorgepflicht und Verantwortung für die Sicherheit und die Gesundheit der Arbeitnehmenden uneingeschränkt besteht (Industrie- und Handelskammer (IHK) Kassel-Marburg, 2022).

Für den Bereich der Berufsausbildung findet sich darüber hinaus über das Bundesamt für Soziale Sicherung ein entsprechender rechtlicher Hinweis zum mobilen Arbeiten. So lässt sich aus § 14 Abs. 1 Nr. 2 i. V. m. § 28 Abs. 2 des Berufsbildungsgesetzes (BBiG) ableiten, dass aufgrund der Unmittelbarkeit die Ausbildung grundsätzlich in der Ausbildungsstätte unter Anwesenheit von Auszubildenden und Ausbildenden zu erfolgen hat (Bundesamt für Soziale Sicherung, o. D.). Unabhängig vom Ende der pandemiebedingten Homeoffice-Pflicht am 19. März 2022 liegt weiterhin ein Gesetzesentwurf zur Schaffung rechtlicher Rahmenbedingungen mobilen Arbeitens des Bundesministeriums für Arbeit und Soziales der deutschen Bundesregierung zur Verabschiedung vor (Bundesministerium für Arbeit und Soziales, 2021). Diese Initiative zeigt die anhaltende Relevanz, auch über die Corona-Pandemie hinaus, klare Rahmenbedingungen zwischen Arbeitnehmenden und Arbeitgebenden zu schaffen. Dieser Ansatz wird durch das Impulspapier des Deutschen Industrie- und Handelskammertags e. V. (DIHK) bezüglich der berufli-

chen Ausbildung unterstützt (Deutscher Industrie- und Handelskammertag e. V. (DIHK), 2022). Eine intensivere Auseinandersetzung fordern darüber hinaus auch die modernisierten Standardberufsbildpositionen des Bundesinstituts für Berufsbildung. Hierbei liegt ein besonderer Fokus auf der digitalisierten Arbeitswelt und den damit einhergehenden betrieblichen Routinen zum sicheren Umgang mit digitalen Medien und IT-Systemen (Bundesinstitut für Berufsbildung, 2021).

Da die rechtlichen Aspekte nicht im Fokus der vorliegenden Studie stehen, wird an dieser Stelle ausdrücklich darauf hingewiesen, dass die Begriffe mobiles Arbeiten, Telearbeit und Homeoffice im Folgenden synonym verwendet werden und als Grundlage für ein einheitliches Begriffsverständnis die Definition von Charalampous et al. (2018, S. 2) zugrunde gelegt wird. Nach dieser Konzeptualisierung werden alle Arbeitnehmenden erfasst, die Zeit außerhalb des Büros verbringen und Informations- und Kommunikationstechnologien für den Zugang zur Arbeit nutzen.

2.2. Psychisches Wohlbefinden

Für den Begriff des psychischen Wohlbefindens findet sich in der wissenschaftlichen Literatur keine einheitliche Definition, weshalb an dieser Stelle auf die etablierte synonyme Verwendung von psychischer Gesundheit und psychischem Wohlbefinden hingewiesen wird (Zeike, 2020, S. 19). Die World Health Organization (WHO) definiert psychische Gesundheit als "... a state of well-being in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community" (World Health Organization, 2021, S. 1). Die World Health Organization weist darüber hinaus darauf hin, dass das psychische Wohlbefinden neben dem physischen Wohlbefinden eine essenzielle Rolle für die Gesundheit spielt, wobei darunter nicht nur das Freisein von Erkrankungen zu verstehen ist. Psychische und physische Gesundheit können nicht eigenständig existieren, da geistige, körperliche und soziale Faktoren voneinander abhängig sind (World Health Organization, 2020a, S. 1). Hinsichtlich der Einflussfaktoren auf das psychische Wohlbefinden grenzt die World Health Organization drei zentrale Bereiche ab. Dies sind zum einen individuelle Attribute wie genetische und biologische Faktoren; daneben Umweltfaktoren, beispielsweise der kulturelle Einfluss oder der Zugang zur Grundversorgung und drittens soziale und wirtschaftliche Bedingungen, etwa die Wohnsituation oder Arbeitsbedingungen und -möglichkeiten (World Health Organization, 2019, S. 1). Aufgrund der oben formulierten Forschungsfrage wird im weiteren Verlauf dieser Arbeit die Facette der sozialen und wirtschaftlichen Bedingungen näher beleuchtet. Die anderen Einflussfaktoren werden demgegenüber zurückgestellt.

Bevor im nachfolgenden Abschnitt 2.3 das verwendete JDR-Modell näher beschrieben wird, ist an dieser Stelle darauf hinzuweisen, dass bereits vor der Veröffentlichung des JDR-Modells zahlreiche wissenschaftliche Artikel über die Auswirkungen hoher Arbeitsanforderungen auf das psychische Wohlbefinden berichteten. So stellten Danna und Griffin (1999) in ihrer Review zentrale Einflussfaktoren für das Wohlbefinden am Arbeitsplatz dar, etwa Arbeitsbedingungen oder Persönlichkeit und zeigten darüber hinaus mögliche Konsequenzen auf individueller und organisationaler Ebene auf (Danna & Griffin, 1999, S. 360).

2.3. Das Job-Demands-Resources-Modell (JDR)

Das im Jahr 2001 publizierte Job-Demands-Resources-Modell (JDR) (Demerouti, Bakker, Nachreiner & Schaufeli, 2001) wurde bis Ende 2017 in über 2.650 Veröffentlichungen zitiert und in diversen Studien sowohl genutzt als auch weiterentwickelt (Demerouti & Nachreiner, 2019, S. 121). Im JDR-Modell wird der bereits umfassend erforschte Zusammenhang zwischen Arbeitsressourcen und -anforderungen auf Grundlage von Belastungs-Beanspruchungsmodellen aufgegriffen. Dieser Ansatz wird genutzt, um zu erklären, welchen Effekt gewisse Arbeitsressourcen und -anforderungen – sowohl isoliert als auch interferierend – auf arbeitsbedingte Erfahrungen wie Burnout und Arbeitsengagement haben. Dabei wird die Annahme vorausgesetzt, dass diese beiden Erfahrungen aus einem Beeinträchtigungs- und einem Motivierungsprozess resultieren. Die beiden Prozesse sind dabei voneinander zu unterscheiden. Sie werden allerdings jeweils durch die Arbeitsaufgaben und die Bedingungen zu deren Bewältigung initiiert (Demerouti & Nachreiner, 2019, S. 121).

Für die Begriffserklärung des Resultats des oben genannten Beeinträchtigungsprozesses – Burnout – wird die Definition von Maslach und Jackson (1984, S. 145) herangezogen. In ihrer Definition wird Burnout als das Empfinden emotionaler Erschöpfung, Depersonalisierung und reduzierter Leistungsfähigkeit von Mitarbeitenden beschrieben, die im arbeitsbedingten Austausch mit anderen Mitarbeitenden stehen. Dabei werden auch die einzelnen Aspekte des Konstrukts Burnout erklärt. Unter emotionaler Erschöpfung wird hier das Gefühl einer emotionalen Überanstrengung durch zwischenmenschlichen arbeitsbezogenen Kontakt verstanden. Depersonalisierung wird beschrieben als ein Gefühl, das in Zynismus und wenig emotional involvierte Reaktionen von Mitarbeitenden hinsichtlich der Übermittlung ihrer Arbeitsresultate mündet. Bei reduzierter Leistungsfähigkeit handelt es sich um ein Empfinden von Abnahme der eigenen Kompetenz sowie fehlendem Erfolg in der Kooperation mit anderen Menschen (Demerouti & Nachreiner, 2019, S. 120).

Arbeitsengagement – als Resultat des zuvor genannten Motivationsprozesses – wird als positiver Gegenpol von Burnout aufgefasst. Es wurde von Schaufeli und Bakker (2004, S. 294) als positiver Zustand charakterisiert, der sich durch Lebendigkeit, Hingabe und direkte Aufnahme von Informationen im Arbeitskontext auszeichnet. Laut Definition wird dieser Zustand als länger andauernd und als nicht personen-, objekt- oder ereignisspezifisch erachtet.

Dem JDR-Modell liegen zwei Hauptannahmen zu Grunde. Die erste beinhaltet, dass sich die Risikofaktoren für das Entstehen eines Burnouts in zwei Kategorien unterteilen lassen, wobei die erste Kategorie die Arbeitsanforderungen und

die zweite die Arbeitsressourcen umfasst. Die Arbeitsanforderungen werden dabei als „physische, psychische, soziale und organisatorische Aspekte“ (Demerouti & Nachreiner, 2019, S. 120) betrachtet, die sowohl psychologische als auch psychische Kosten verursachen, ausgelöst durch längerfristige Anspannung. Die Arbeitsressourcen hingegen umfassen die „physischen, psychischen, sozialen und organisatorischen Arbeitsbedingungen, die (1) funktional für das Erreichen der arbeitsbezogenen Ziele sind, (2) Arbeitsanforderungen und damit zusammenhängende physische und psychische Kosten reduzieren und (3) persönliches Wachstum und persönliche Entwicklung stimulieren“ (Demerouti & Nachreiner, 2019, S. 120). Die Arbeitsressourcen können dabei in Bezug zur Organisation, den Arbeitsaufträgen, Bedingungen, Auftragsausführungen bzw. den zwischenmenschlichen Beziehungen im Arbeitsalltag stehen (Demerouti & Nachreiner, 2019, S. 121).

Die zweite Hauptannahme des JDR-Modells umfasst die prozessuale Entwicklung von Burnout bzw. Arbeitsengagement. Dabei werden zwei unterschiedliche Prozesse betrachtet: zum einen das Entstehen des Gefühls von Erschöpfung als Resultat eines anhaltenden Gefühls von hohen oder ungenügend verteilten Arbeitsanforderungen, zum anderen der Prozess des Entstehens der Gefühle von Frustration und Scheitern, der auf das Fehlen entsprechender Arbeitsressourcen und das damit einhergehende erschwerte Erreichen von Arbeitsergebnissen erzeugt wird. Durch diese negativen Gefühle wird die Motivation für das erfolgreiche Erreichen weiterer Arbeitsziele verringert und es entsteht eine emotional negativ belastete Distanz zur eigenen Arbeit. Im gegensätzlichen positiven Fall, wenn die benötigten Arbeitsressourcen vorhanden sind und Arbeitsaufträge daher erfolgreich bewältigt werden können, entsteht in diesem Prozess Arbeitsengagement (Demerouti & Nachreiner, 2019, S. 122).

Zudem wird im JDR-Modell darauf hingewiesen, dass auch der Einfluss der Wechselwirkungen zwischen Arbeitsressourcen und -anforderungen auf das resultierende Entstehen von Burnout und Arbeitsengagement einbezogen werden kann. Die Arbeitsressourcen können konkret so konzipiert werden, dass sie das Entstehen von Burnout mindern können. Hierbei handelt es sich um die sogenannte Puffer-Hypothese (Bakker, Demerouti & Euwema, 2005, S. 179).

2.4. Mobiles Arbeiten & Psychisches Wohlbefinden

In diesem Abschnitt erfolgt eine erste Übersicht über einige Studien, in denen die Auswirkungen mobilen Arbeitens auf das psychische Wohlbefinden untersucht wurden. Berücksichtigt werden dabei vor allem solche Studien, die aufgrund vergangener und aktueller Meta-Studien regelmäßig im Zentrum fachlicher Diskussionen standen (Charalampous et al., 2018; Gajendran & Harrison, 2007; Jooss et al., 2021; Marsh et al., 2022; Park, Jeong & Chai, 2021). Im anschließenden Abschnitt 2.5 werden die Auswirkungen in strukturierter Weise aus der Perspektive des JDR-Modells betrachtet, um ein theoretisches Pfadmodell abzuleiten, das danach im Rahmen dieser Arbeit empirisch geprüft wird.

Die Popularität des mobilen Arbeitens basierte weitgehend auf der Annahme, dass dadurch die Vereinbarkeit von Beruf und Familie erleichtert und sich die Überschneidung der Anforderungen von Arbeits- und Familienrolle verringern würde (Gajendran & Harrison, 2007, S. 1529; Tavares, 2017, S. 34).

Sewell und Taskin (2015, S. 1518) wiesen diesbezüglich darauf hin, dass Privatleben und Work-Life-Balance der Beschäftigten besonders davon profitieren, dass die Beschäftigten in Pausen und Notfällen zu Hause sind und während der Arbeitszeit am Familienleben teilhaben können. Darüber hinaus sind weitere positive Effekte mobilen Arbeitens der verringerte Zeit- und Kostenaufwand für das Pendeln von der eigenen Wohnung aus zum Arbeitsplatz (Hill et al., 2003, S. 234), ein verringertes Potenzial an Arbeitsunterbrechungen durch Kolleginnen und Kollegen im Büro (Gray, Markus & PonTell, 1996, S. 139) sowie ein gesteigertes Autonomie-Empfinden (Suh & Lee, 2017, S. 153).

Neben diesen beobachteten Vorteilen kann mobiles Arbeiten auch Risiken mit sich bringen. Durch das Wegfallen des Pendelns zur Arbeit entfällt die damit einhergehende Möglichkeit der persönlichen Grenzziehung. Dies erhöht das Potenzial für eine Verwischung der Grenzen zwischen Arbeits- und Privatleben und damit die Gefahr für Konflikte zwischen diesen Bereichen (Jachimowicz, Cunningham, Staats, Gino & Menges, 2020, S. 79). Darüber hinaus besteht bei mobil Arbeitenden eine höhere Wahrscheinlichkeit, dass sie Überstunden leisten (Derks, van Duin, Tims & Bakker, 2015, S. 172; Song & Gao, 2019, S. 5). Beschäftigte, die von ihrem Zuhause aus arbeiten, befürchten möglicherweise, dass ihre Kollegen im Büro den Eindruck haben, sie würden sich nicht vollständig ihrer Arbeit widmen. Daher fühlen sie sich beispielsweise gezwungen, sofort auf E-Mails zu antworten, um ihre virtuelle Präsenz und Verfügbarkeit zu signalisieren (Sewell & Taskin, 2015, S. 1518). Zwei weitere Aspekte der möglichen Schattenseiten mobilen Arbeitens sind ein stärker wahrgenommenes Isolationsgefühl, das durch die reduzierte persönliche Interaktion mit Kollegen entstehen kann. Außerdem besteht die Gefahr, durch die reduzierte Interaktion im Hinblick auf soziale Unterstützung durch Kolleginnen und Kollegen sowie Vorgesetzte benachteiligt zu werden. Dies kann sich in einer reduzierten persönlichen Förderung und Integration widerspiegeln (Grant et al., 2013, S. 543), was wiederum zu einer Stagnation der individuellen Karriere (Cooper & Kurland, 2002, S. 520) sowie einer Benachteiligung bei der Karriereentwicklung führen kann (Tavares, 2017, S. 33). Golden und Eddleston (2020, S. 1) zufolge führt mobiles Arbeiten nicht per se zu weniger Beförderungen. Allerdings zeigte sich mit zunehmender Intensität ein geringerer Gehaltszuwachs.

Aufgrund dieser unterschiedlichen Forschungsergebnisse zu einzelnen Bereichen des Arbeitslebens ergibt sich für übergreifende abhängige Konstrukte wie die Arbeitszufriedenheit ebenfalls ein widersprüchliches Bild (Bailey & Kurland, 2002, S. 389). Die Auswirkungen mobilen Arbeitens auf die allgemeine und psychische Gesundheit und das Wohlbefinden sind ambivalent (Charalampous et al., 2018, S. 16; Mann & Holdsworth, 2003, S. 208). So wies Tavares (2017, S. 32) darauf hin, dass diese Arbeitsform einerseits Stress aufgrund größerer Flexibilität, weniger Konflikten zwischen Arbeits-

und Privatleben und besserer Work-Life-Balance reduzieren kann, andererseits aber auch Stress aufgrund unklarer Grenzen zwischen Arbeit und Privatleben und Konflikten innerhalb der Familie erhöhen kann.

2.5. Mobiles Arbeiten & Arbeitsanforderungen

Im Nachfolgenden werden die Arbeitsanforderungen näher beschrieben, die als potenzieller Mediator zwischen der Intensität mobilen Arbeitens und der wahrgenommenen emotionalen Erschöpfung wirken. Hierbei werden die Anforderungen berücksichtigt, die sowohl vor als auch seit der COVID-19-Pandemie Gegenstand wissenschaftlicher Untersuchungen waren. Zu diesen gehören Leistungsdruck, Arbeitsunterbrechungen, ständige Verfügbarkeit, Rollenambiguität, Technostress und Entgrenzung. Der Kürze halber wird in der theoretischen Darstellung intensiver auf den möglichen Zusammenhang zwischen der Intensität mobilen Arbeitens und den Anforderungen eingegangen, da diese kaum empirisch untersucht wurden, hingegen die Wirkungszusammenhänge des JDR-Modells bereits stärker erforscht sind (Demerouti et al., 2001; Schaufeli & Bakker, 2004). In Anbetracht der in Abschnitt 2.4 dargestellten Studien und der avisierten Forschungsperspektive dieser Arbeit ist davon auszugehen, dass mit zunehmender Intensivierung mobilen Arbeitens die emotionale Erschöpfung bei Auszubildenen zunimmt.

> Hypothese 1: Die Intensität mobilen Arbeitens wirkt sich positiv auf die emotionale Erschöpfung aus.

2.5.1. Leistungsdruck

Den Begriff des Leistungsdrucks definiert Baumeister (1984) als „... any factor or combination of factors that increases the importance of performing well on a particular occasion" (Baumeister, 1984, S. 610). Diese Konzeptualisierung erweiterte unter anderem Gardner (2012) um die Facette des Leistungsdrucks innerhalb von Teams und die damit einhergehenden sozialpsychologischen Einflussfaktoren. In einer qualitativen Längsschnittstudie untersuchte sie dabei die Auswirkungen des Leistungsdrucks innerhalb von unterschiedlichen Teams im Arbeitskontext. Ihre Analyse zeigte, dass Mitarbeitende, die unter Druck stehen, eher zu leistungsmindernden Verhaltensweisen neigen. Dies führte sie anhand der analysierten Interviews auf das Streben nach Konsens, die Konzentration auf gemeinsames Wissen, die Verlagerung des Lernens auf den Projektabschluss und die verstärkte Anpassung an die Statushierarchie zurück (Gardner, 2012, S. 33). Neben diesen negativen Auswirkungen der Arbeitsanforderung auf die Arbeitsleistung, die sich auch in vorherigen Studien beobachten ließen (Baumeister & Showers, 1986; Beilock & Gray, 2007; DeCaro, Thomas, Albert & Beilock, 2011), berichteten Leinhos, Rigotti und Baethge (2017, S. 7) über eine verstärkende Wirkung auf die emotionale Erschöpfung.

Im Jahr 2014 publizierten Richardson & McKenna eine Arbeit, in der sie den Zusammenhang zwischen mobiler Arbeit und Leistungsdruck näher erforschten. Als Analysegegenstand diente ein kanadisches Unternehmen der Tech-Industrie. Anhand der qualitativen Analyse der 80 durchgeführten teilstrukturierten Tiefeninterviews mit leitenden Angestellten und Mitarbeiterinnen und Mitarbeitern des Unternehmens, die alle in einem gewissen Ausmaß mobil arbeiteten, stellte sich heraus, dass der Aufbau und die Erhaltung einer vertrauensvollen Beziehung zwischen Vorgesetzten und Kollegen als besonders problematisch beschrieben wurden. Mobil Arbeitende bemühten sich im Homeoffice stärker darum, ihre Vertrauenswürdigkeit unter Beweis zu stellen. Auf der anderen Seite fiel es den Führungskräften schwerer, den mobil Arbeitenden zu vertrauen. Infolge dieses Vertrauensdefizits berichteten die mobil Arbeitenden von einem höheren Leistungsdruck, dem sie durch eine Fokussierung des individuellen Zeitmanagements, die Pflege der Verbindungen zu ihren Kollegen und die Öffentlichmachung ihrer Leistungen entgegenzutreten versuchten (Richardson & McKenna, 2014).

Continuing with the theme of establishing and/or maintaining trust, both managerial and non-managerial *flexworkers reported feeling under more pressure to meet performance objectives* [Hervorhebung hinzugefügt]. In addition, many spoke of a felt need to make their achievements more public compared with when they were office-based. The need to maintain their trustworthiness, in particular, was understood as an ongoing accomplishment where trust had to be continuously performed and produced. (Richardson & McKenna, 2014, S. 730)

Diese qualitativen Eindrücke konnten anschließend von quantitativen Studien wie von Groen, van Triest, Coers und Wtenweerde (2018, S. 733) sowie Ajzen und Taskin (2021, S. 9) bestätigt werden.

Dementsprechend ist davon auszugehen, dass sich ein hohes Ausmaß mobilen Arbeitens bei Auszubildenden positiv auf den wahrgenommenen Leistungsdruck auswirkt, im Vergleich zu einem geringen Ausmaß. Der gesteigerte Leistungsdruck wirkt sich wiederum positiv auf die emotionale Erschöpfung aus. Mit steigendem Leistungsdruck ist daher eine Verringerung des Arbeitsengagements zu erwarten (Demerouti & Nachreiner, 2019, S. 124).

> Hypothese 2a: Die Intensität mobilen Arbeitens wirkt sich positiv auf den wahrgenommenen Leistungsdruck aus.
>
> Hypothese 2b: Ein hohes Ausmaß an wahrgenommenem Leistungsdruck erhöht die emotionale Erschöpfung.
>
> Hypothese 2c: Ein hohes Ausmaß an wahrgenommenem Leistungsdruck wirkt sich negativ auf das Arbeitsengagement aus.

2.5.2. Arbeitsunterbrechungen

„Eine Unterbrechung ist die kurzzeitige Aussetzung einer menschlichen Handlung, welche durch eine externe Quelle verursacht ist. ... Sie führt zu einem Aufschub der eigentlichen Handlung, da eine ungeplante Aufgabe angefangen

wird. Dies geschieht mit der Absicht, die eigentliche Handlung später fortzusetzen“ (Baethge & Rigotti, 2010, S. 9). Diese Definition ergänzten Jett und George (2003) um psychologische Reaktionen, die durch die Unterbrechungen ausgelöst werden (Jett & George, 2003, S. 500). Die beiden Autoren wiesen darauf hin, dass gemäß der Selbstregulationstheorie von Kanfer und Ackerman (1989) bei gleichzeitiger Erlernung komplexer Aufgaben die Aufmerksamkeit geteilt und unterbrochen werden kann, sobald parallel herausfordernde Ziele bestehen (Jett & George, 2003, S. 501). Aufgrund der Situation der Auszubildenden, die Neues erlernen und gleichzeitig mit herausfordernden Zielen konfrontiert sind, könnten sie besonders von Arbeitsunterbrechungen betroffen sein.

Hinsichtlich der Auswirkungen mobilen Arbeitens auf das Konstrukt Arbeitsunterbrechung und emotionale Erschöpfung wiesen E. Meyer, Schöllbauer und Korunka (2021, S. 10) darauf hin, dass mobil Arbeitende aufgrund der gesteigerten Anforderungen an Flexibilität und Anpassungsfähigkeit unter hohem Druck hinsichtlich ihrer Selbstkontrolle stehen, um den Erwartungshaltungen ihres beruflichen Umfelds zu entsprechen. In diesem Zusammenhang zeigte die Studie von C. Ter Hoeven und van Zoonen (2015, S. 250), dass aus Perspektive des JDR-Modells das psychologische Wohlbefinden mobil arbeitender Personen über den Pfad der gesteigerten Informations- und Kommunikationstechnologien bedingten Arbeitsunterbrechungen negativ beeinflusst wird. Konträr zu diesen negativen Auswirkungen berichteten Autoren früherer Studien allerdings auch über positive Auswirkungen mobilen Arbeitens. So kommt es beispielweise zu einer natürlichen Reduktion der Arbeitsunterbrechungen, die ansonsten durch das Kollegium im Büro verursacht werden (Koroma, Hyrkkänen & Vartiainen, 2014, S. 147). Auf der anderen Seite stehen allerdings Unterbrechungen, die zuhause bspw. durch Familienangehörige entstehen (Vartiainen, 2021, S. 131). Während Koroma et al. (2014, S. 147) beobachteten, dass durch das Arbeiten vom eigenen Zuhause aus Ablenkungen während der Arbeitszeit reduziert werden, kamen Bergefurt, Weijs-Perrée, Maris und Appel-Meulenbroek (2021, S. 9) zuletzt zu gegenteiligen Ergebnissen. In ihrer Studie beobachteten sie, dass vor allem jüngere Arbeitnehmende im Homeoffice durch Ablenkungen bei der Arbeit negativ beeinflusst werden. Dabei führen die Autoren diese Beobachtung beispielsweise auf familiäre Konflikte zurück. Bei Personen, die über eher große Homeoffice-Arbeitsplätze verfügen, die sauber, aufgeräumt und ruhig sind, konnte wiederum in Übereinstimmung mit früheren Studien (Koroma et al., 2014) eine Senkung der wahrgenommenen Arbeitsunterbrechungen und der daraus folgenden Stress-Beschwerden beobachtet werden. Charalampous et al. (2018, S. 17) sowie Leroy, Schmidt und Madjar (2021, S. 1455) wiesen ebenfalls auf ein höheres Unterbrechungspotenzial bei mobil arbeitenden Personen hin. Sie führten dies auch auf die hohe Abhängigkeit von Informations- und Kommunikationstechnologien zurück, die bei mobil Arbeitenden naturgemäß stärker ausfällt. Dabei entstehen die Unterbrechungen vor allem durch die Vielfalt parallel zu nutzender Technologien, etwa E-Mails und Instant Messages. Durch die Abhängigkeit sind Mitarbeitende im Homeoffice gezwungen, verschiedene Kanäle gleichzeitig im Blick zu behalten. Sie werden hierdurch tendenziell häufiger in ihren Arbeitsprozessen unterbrochen als Personen im Büro, die zumeist auf weniger Informations- und Kommunikationstechnologien angewiesen sind. Auf die negativen Effekte der durch Informations- und Kommunikationstechnologien bedingten Unterbrechungen auf das psychologische Wohlbefinden wiesen bereits C. L. Ter Hoeven, van Zoonen und Fonner (2016, S. 252) und andere Autoren hin (Chesley, 2014, S. 604; Fonner & Roloff, 2012, S. 224).

Angesichts dieser Beobachtungen ist davon auszugehen, dass sich ein hohes Ausmaß mobilen Arbeitens bei Auszubildenden positiv auf die wahrgenommenen Arbeitsunterbrechungen auswirkt, im Vergleich zu einem geringen Ausmaß. Die erhöhte Anzahl und Intensität von Arbeitsunterbrechungen wirken sich wiederum positiv auf die emotionale Erschöpfung aus. Mit steigenden Arbeitsunterbrechungen ist eine Verringerung des Arbeitsengagements zu erwarten (Demerouti & Nachreiner, 2019, S. 124).

> Hypothese 3a: Die Intensität mobilen Arbeitens wirkt sich positiv auf die wahrgenommenen Arbeitsunterbrechungen aus.
>
> Hypothese 3b: Ein hohes Ausmaß an wahrgenommenen Arbeitsunterbrechungen erhöht die emotionale Erschöpfung.
>
> Hypothese 3c: Ein hohes Ausmaß an wahrgenommenen Arbeitsunterbrechungen wirkt sich negativ auf das Arbeitsengagement aus.

2.5.3. Ständige Verfügbarkeit

Eine weitere Arbeitsanforderung, die regelmäßig im Zentrum wissenschaftlicher Publikationen steht, ist die ständige Verfügbarkeit. Dettmers, Vahle-Hinz, Bamberg, Friedrich und Keller (2016) definieren dieses Konstrukt als „a condition in which employees formally have of-job time but are flexibly accessible to supervisors, coworkers, or customers and are explicitly or implicitly required to respond to work requests” (Dettmers et al., 2016, S. 106). Auf die negativen Auswirkungen dieser Anforderung auf das psychologische Wohlbefinden weisen zahlreiche Studien hin (Bakker, Demerouti, Oerlemans & Sonnentag, 2013, S. 104; Boswell & Olson-Buchanan, 2007, S. 608; Dijkhuizen, Gorgievski, van Veldhoven & Schalk, 2016, S. 565). Ein wichtiges Konzept in diesem Zusammenhang ist das Abschalten von der Arbeit (psychological detachment). Unter dem Abschalten von der Arbeit im organisationalen Kontext wird das Gefühl eines Mitarbeitenden verstanden, sich nicht in einer Arbeitssituation zu befinden (Etzion, Eden & Lapidot, 1998, S. 579). Dies schließt sowohl eine physische als auch eine emotionale Distanzierung von der Arbeit ein (Sonnentag & Fritz, 2007, S. 205). Die negativen Auswirkungen des Nichtabschaltens auf die emotionale Erschöpfung beziehungsweise das psychische Wohlbefinden beobachteten Hetland, Bakker, Demerouti, Espevik und Olsen (2021, S. 253). Ihrer Ansicht nach ist es zentral,

den Mitarbeitenden genügend Freiraum zu geben, um sich ausreichend von der Arbeit erholen zu können und daher vor allem ihre privaten Freiräume zu respektieren, um etwaige Burnouts zu vermeiden.

Im Kontext mobiler Arbeit wiesen Grant et al. (2013, S. 538) auf länger empfundene Arbeitszeiten bei betroffenen Mitarbeitenden hin, die sie auf die durch Informations- und Kommunikationstechnologien bedingte ständige Verfügbarkeit zurückführten. Die daraus folgende Schwierigkeit, von der Arbeit abzuschalten, beobachteten zuvor bereits Lautsch, Kossek und Eaton (2009, S. 816). In ihrer Meta-Analyse von 2018 erwähnten Charalampous et al. (2018, S. 3) darüber hinaus das Konzept der Always on-Culture und wiesen damit auf die wahrgenommene mentale Umstellung hin, die durch mobiles Arbeiten entstehen kann. Dabei versuchen Mitarbeitende häufiger, durch ständige Erreichbarkeit den unklaren Erwartungen der Kollegen und Führungskräfte (Derks et al., 2015, S. 170) entgegenzuwirken. Ähnliches beobachteten auch van Van Zoonen, Sivunen und Treem (2021, S. 877), die sich tiefergehend mit dem Faktor der Technologien beschäftigten und den Begriff des technology-assisted supplemental work (TASW) prägten. TASW definierten sie als Arbeit mittels mobiler Endgeräte, die über die vertragliche geregelte Arbeitszeit hinaus stattfindet und nicht vergütet wird (Van Zoonen et al., 2021, S. 868). Aus ihren Studienergebnissen schließen sie, dass die ständige Verfügbarkeit neben einer individuellen auch eine Ursache auf Teamebene haben kann. Insbesondere zeigten sie, dass die Arbeit zwischen Teams, die durch den Einsatz von Kollaborationstechnologie unterstützt wird, die TASW erhöht. Dieser Einsatz ist bei Personen, die mehr mobil arbeiten, tendenziell höher. Falls innerhalb eines Teams darüber hinaus hohe Reaktionserwartungen herrschen, können die Mitarbeitenden diesem Anspruch mit zusätzlicher Arbeit begegnen. Dieser Prozess ist dabei unabhängig von der individuellen Nutzung der Kollaborationstechnologie und zeigt den zusätzlichen sozialpsychologischen Einfluss auf die ständige Verfügbarkeit und zusätzliche Belastung auf (Van Zoonen et al., 2021, S. 878).

Ausgehend von diesen Beobachtungen lässt sich annehmen, dass sich ein hohes Ausmaß mobilen Arbeitens bei Auszubildenden positiv auf die wahrgenommene ständige Verfügbarkeit auswirkt, im Vergleich zu einem geringen Ausmaß. Dieses wiederum wirkt sich positiv auf die emotionale Erschöpfung aus. Mit steigender ständiger Verfügbarkeit ist eine Verringerung des Arbeitsengagements zu erwarten (Demerouti & Nachreiner, 2019, S. 124).

> Hypothese 4a: Die Intensität mobilen Arbeitens wirkt sich positiv auf die wahrgenommene ständige Verfügbarkeit aus.
>
> Hypothese 4b: Ein hohes Ausmaß an wahrgenommener ständiger Verfügbarkeit erhöht die emotionale Erschöpfung.
>
> Hypothese 4c: Ein hohes Ausmaß an wahrgenommener ständiger Verfügbarkeit wirkt sich negativ auf das Arbeitsengagement aus.

2.5.4. Rollenambiguität

Die Rollenambiguität gehört zu den am häufigsten untersuchten Stressoren im Kontext der Arbeits- und Organisationspsychologie (Bowling & Beehr, 2006, S. 998; Jackson & Schuler, 1985, S. 16) und entsteht laut Urien, Osca und García-Salmones (2017, S. 139), wenn die Position inklusive der damit einhergehenden Ziele und Aufgabenbestandteile eines oder einer Mitarbeitenden nicht oder unzureichend kommuniziert wird. Dieses Phänomen lässt sich vor allem bei Wissensarbeitern beobachten, die aufgrund ihrer Arbeitsinhalte und der vermehrten Nutzung von Informations- und Kommunikationstechnologien häufig mit unklaren Aufgaben, sich überschneidenden Prioritäten sowie verschiedenen Auftraggebern konfrontiert sind.

Sardeshmukh, Sharma und Golden (2012) untersuchten in diesem Zusammenhang 417 mobil arbeitende Personen eines Logistikunternehmen in den USA hinsichtlich der Auswirkungen der Intensität mobilen Arbeitens auf die Rollenambiguität. Im Einklang mit früheren Studien zu Arbeitsanforderung (Cooper & Kurland, 2002, S.528; Golden, Veiga & Dino, 2008, S.1414) führten die Autoren den positiven Zusammenhang zwischen den Variablen auf eine erhöhte Nutzung der Informations- und Kommunikationstechnik zurück und auf die dadurch gesteigerte potenzielle Schwierigkeit, Informationen während der Abwesenheit vom Büro richtig zu deuten. Dies erklärten sie mit der Medienreichhaltigkeitstheorie (Daft & Lengel, 1986) und wiesen auf die begrenzte Interpretations- und Interaktionsmöglichkeit neuer Medien im Vergleich zum persönlichen Kontakt hin. Dieser ist essenziell für die Reduktion von Mehrdeutigkeiten im Arbeitskontext (Sardeshmukh et al., 2012, S. 196).

Angesichts dieser Beobachtungen ist davon auszugehen, dass sich ein hohes Ausmaß mobilen Arbeitens bei Auszubildenden positiv auf die wahrgenommene Rollenambiguität auswirkt, im Vergleich zu einem geringen Ausmaß. Dieses wiederum wirkt sich positiv auf die emotionale Erschöpfung aus. Eine Verringerung des Arbeitsengagements ist mit steigender Rollenambiguität zu erwarten (Demerouti & Nachreiner, 2019, S. 124).

> Hypothese 5a: Die Intensität mobilen Arbeitens wirkt sich positiv auf die Rollenambiguität aus.
>
> Hypothese 5b: Ein hohes Ausmaß an wahrgenommener Rollenambiguität erhöht die emotionale Erschöpfung.
>
> Hypothese 5c: Ein hohes Ausmaß an wahrgenommener Rollenambiguität wirkt sich negativ auf das Arbeitsengagement aus.

2.5.5. Technostress

Im Kontext des JDR-Modells führten Bakker, Demerouti und Schaufeli (2003) eine Studie mit 477 Mitarbeitenden eines niederländischen Telekommunikationsunternehmens zu den Einflüssen technologiebezogener Arbeitsanforderungen und -ressourcen durch. Dabei analysierten sie erstmals die Auswirkungen technischer Herausforderungen und wiesen auf mögliche Gefahren für die psychische Gesundheit

hin (Bakker et al., 2003, S. 400). Das Forschungsinteresse an diesem Themenbereich entwickelte sich vor allem in den letzten Jahren durch die starke Verbreitung von Informations- und Kommunikationstechnologien in der Arbeitswelt sowie die Entwicklungen hinsichtlich flexibler Arbeitsumgebungen und Gestaltungen weiter (Taser, Aydin, Torgaloz & Rofcanin, 2022, S. 1). Diesbezüglich ist besonders die Technostress-Creator-Scale von Ragu-Nathan et al. (2008) hervorzuheben, die das Konzept des Technostress einführte und ein Messinstrument dazu etablierte. Die Forschenden definierten Technostress als „... stress experienced by end users in organizations as a result of their use of ICTs" (Ragu-Nathan et al., 2008, S. 417) und identifizierten insgesamt fünf Subskalen des Konstruktes. Die erste dieser Subskalen bezeichnen sie als Techno-Overload, was sich auf das Potenzial bezieht, dass Informations- und Kommunikationstechnologien möglicherweise zu schnellerem und längerem Arbeiten führen. Techno-Invasion beinhaltet das potenzielle Eindringen von Informations- und Kommunikationstechnologien ins Privatleben. Techno-Complexity meint das Potenzial, dass sich Anwender durch die Komplexität von Informations- und Kommunikationstechnologien mit ihren bisherigen Fähigkeiten überfordert fühlen. Techno-Insecurity bezieht sich auf das Potenzial, dass sich Mitarbeitende durch mögliche Automatisierungsprozesse im Zusammenhang mit Informations- und Kommunikationstechnologien bedroht fühlen. Techno-Uncertainty schließlich meint die Angst vor dem Ungewissen, die Anwendende durch kontinuierliche Veränderungsprozesse und Erweiterungen wahrnehmen. Die durch Technostress entstehenden Risiken für ein erhöhtes Erschöpfungspotential wurden anschließend in diversen Studien nachgewiesen (Hang, Hussain, Amin & Abdullah, 2022, S. 6; Oksa, Saari, Kaakinen & Oksanen, 2021, S. 16; Tarafdar, Tu & Ragu-Nathan, 2011, S. 326).

Die Ergebnisse von Studien, die zusätzlich die Variable mobilen Arbeitens berücksichtigten, zeigten, dass die Intensität mobilen Arbeitens über den Pfad des Technostress das Wohlbefinden Mitarbeitender signifikant beeinflussen kann (Camacho & Barrios, 2022, S. 450; Suh & Lee, 2017, S. 152). Camacho und Barrios (2022) untersuchten im ersten Lockdown während der COVID-19-Pandemie in Kolumbien Ende März 2020 und ca. 2 Monate später diese Auswirkungen längsschnittlich. Die Ergebnisse zeigten, dass vor allem die Überforderung mit dem mobilen Arbeiten als neue Arbeitsform die Erschöpfung im Homeoffice signifikant beeinflusste (Camacho & Barrios, 2022, S. 451). In einer weiteren Studie untersuchten Taser et al. (2022, S. 6) mobiles Arbeiten als persönliche Arbeitsanforderung im Zusammenhang mit Technostress auf die abhängige Variable Flow, die eine starke Nähe zum Konstrukt des Arbeitsengagements hat, wobei sie die Perspektive des JDR-Frameworks verwendeten. Dabei zeigten die Autoren erneut die negativen Auswirkungen von Technostress auf das Wohlbefinden bei der Arbeit und stellten zudem fest, dass bei hoher Zufriedenheit mit der mobilen Arbeit der wahrgenommene Technostress signifikant reduziert werden kann.

Entsprechend diesen Beobachtungen ist davon auszugehen, dass sich ein hohes Ausmaß mobilen Arbeitens bei Auszubildenden positiv auf den wahrgenommenen Technostress auswirkt, im Vergleich zu einem geringen Ausmaß. Dieses wiederum wirkt sich positiv auf die emotionale Erschöpfung aus. Mit steigendem Technostress ist eine Verringerung des Arbeitsengagements zu erwarten (Demerouti & Nachreiner, 2019, S. 124).

> Hypothese 6a: Die Intensität mobilen Arbeitens wirkt sich positiv auf wahrgenommene technische Probleme und Technostress aus.
>
> Hypothese 6b: Ein hohes Ausmaß an wahrgenommenen technischen Problemen und Technostress erhöht die emotionale Erschöpfung.
>
> Hypothese 6c: Ein hohes Ausmaß an wahrgenommenen technischen Problemen wirkt sich negativ auf das Arbeitsengagement aus.

2.5.6. Entgrenzung

Aus den anhaltenden Diskussionen zum Thema Entgrenzung (Hofmann, Piele & Piele, 2021) resultierten in den vergangenen Jahrzehnten (Kossek & Ozeki, 1998; Schein, 1971; Van Maanen, 1982) verschiedene Konzeptualisierungen, die die zugrunde liegenden Wirkungsmechanismen zu beschreiben versuchten. Ashforth, Kreiner und Fugate (2000) entwickelten in diesem Kontext aufbauend auf der Rollentheorie von Katz und Kahn (1978) mit der Boundary Theory ein wegweisendes Konzept für den Themenkomplex der Grenzen zwischen Lebensbereichen. Das Konzept umfasst Ansätze, wie Menschen Grenzen schaffen, bewahren oder verändern, um die Umwelt um sie herum zu simplifizieren und zu ordnen (Ashforth et al., 2000, S. 474). Die sogenannten Transitions, ein zentrales Element der Theorie, sind grenzüberschreitende Aktivitäten, bei denen eine Rolle verlassen und betreten wird, indem Rollengrenzen überwunden werden. Rollen können auf einem Kontinuum angeordnet werden, das von starker Segmentierung bis zu starker Integration reicht. Dabei postuliert das Modell, dass die Segmentierung zwar die Rollenunschärfe reduziert, aber gleichzeitig auch das Ausmaß der Anstrengung erhöht, das für die Durchführung einer Transition benötigt wird. Als Resultat werden Grenzüberschreitungen zwischen Rollen verschiedener Anforderungsbereiche erschwert. Die Integration von Rollen verringert zwar die notwendige Mühe, um diese zu verändern, erhöht aber die Unschärfe, wodurch die Schaffung und Aufrechterhaltung von Grenzen schwieriger wird (Ashforth et al., 2000, S. 472). In Bezug auf die Integration dieser Konzeptualisierung in das JDR-Framework untersuchten Bakker et al. (Bakker et al., 2005, S. 174) die Auswirkungen der Interferenz zwischen Arbeits- und Privatleben als Folge einer unzureichenden Grenzziehung auf die wahrgenommene Arbeitsbelastung und Burnout. Hierbei beobachteten sie verstärkende Effekte der Interferenz zwischen Arbeits- und Privatleben auf die wahrgenommene emotionale Erschöpfung (Bakker et al., 2005, S. 174), die auch in nachfolgenden Studien repliziert wurden (Mostert, Peeters & Rost, 2011, S. 246).

Basierend auf weiterführenden Studien hinsichtlich der Interferenz zwischen Arbeits- und Privatleben bei mobil arbeitenden Personen (Kossek, Lautsch & Eaton, 2006, S. 347; Mariappanadar & Kramar, 2014, S. 214) führten Kossek und Lautsch (2012, S. 114) den Begriff der Boundary Management Styles ein. Mit ihm werden verschiedene Ansätze zusammengefasst, wie Grenzen zwischen Arbeits- und Privatleben vollzogen werden können. Im Rahmen der vorliegenden Studie sind besonders die cross-role interruption behaviors relevant, da sie in diversen Studien (Jostell & Hemlin, 2018, S. 478; Kinnunen et al., 2016, S. 108) als Operationalisierungsgrundlage verwendet wurden, um Entgrenzung zu erfassen. Durch die Zunahme an mobil arbeitenden Personen während der Corona-Pandemie verstärkte sich das Interesse am Themenbereich der Entgrenzung, weshalb zahlreiche neue Studien entstanden (Allen, Merlo, Lawrence, Slutsky & Gray, 2021, S. 60; Rigotti et al., 2021, S. 7; Wang, Liu, Qian & Parker, 2020, S. 21). Beispielsweise untersuchten Allen et al. (2021) 155 Personen mit einem längsschnittlichen Panel-Design, wobei die Auswirkungen des Arbeitsmodellwechsels hin zur mobilen Arbeit auf das Boundary-Management der Betroffenen im Fokus standen. Dabei konnten sie aufzeigen, dass sowohl eine Segmentierungspräferenz als auch die im Haushalt lebenden Personen sowie die Nutzung eines separaten Arbeitszimmers die wahrgenommene Balance zwischen Arbeits- und Privatleben maßgeblich beeinflussen können (Allen et al., 2021, S. 74). Darüber hinaus beobachteten Kerman et al., dass es durch die Arbeit im Homeoffice häufiger zu einer sogenannten Boundary Violation kommt. Durch die Bemühung, diese Unterbrechungen gering zu halten und Grenzen während der Arbeit zuhause aufrechtzuerhalten, können sowohl private als auch berufliche Aufgaben tendenziell ineffizienter oder gar nicht beendet werden, was wiederum das Wohlbefinden in der jeweiligen Domäne negativ beeinflussen kann (Kerman, Korunka & Tement, 2022, S. 800). Diese Erkenntnisse stehen im Einklang mit den Beobachtungen von Piszczek (2017, S. 605). Er untersuchte vor dem Hintergrund der Boundary Theory und des JDR-Modells 163 Absolventen eines HR-Management-Masterstudiengangs in den USA bezüglich der Auswirkungen der Entgrenzung, die durch Informations- und Kommunikationstechnologien bedingte grenzüberschreitende Kommunikation entstehen. Dabei stellte er fest, dass sich diese signifikant negativ auf das Wohlbefinden auswirkt, abhängig davon, ob eher Segmentierung oder Integration angestrebt wird und inwiefern dabei die Kontrolle über die Grenzen aufrechterhalten werden kann. Die Analyse der Daten zeigte, dass sich bei Personen, die eher eine Trennung von Arbeits- und Berufsleben bevorzugen, viel grenzüberschreitende Kommunikation negativ auf die wahrgenommene Grenzkontrolle und damit auch auf das Wohlbefinden wirkt. Diese grenzüberschreitende Kommunikation ist bei mobil Arbeitenden aufgrund der Abhängigkeit von Informations- und Kommunikationstechnologien tendenziell höher als bei Personen, die ausschließlich im Büro arbeiten. Diese Beobachtungen lassen darauf schließen, dass die Kombination aus viel grenzüberschreitender Kommunikation mittels Informations- und Kommunikationstechnologien sowie der Situation eines gemeinsamen Zusammenlebens mit mehreren Personen in einem Haushalt ohne gesondertes Arbeitszimmer dazu führen kann, dass die wahrgenommene Kontrolle zur Aufrechterhaltung der Grenzen zwischen Beruf und Privat durch mobiles Arbeiten eher erschwert wird. Diese zunehmende Entgrenzung kann zu einer erhöhten emotionalen Erschöpfung führen. Darüber hinaus weisen aktuelle Studien zusätzlich auf die Bedeutung des Arbeitsweges hin. Durch das Wegfallen des Arbeitsweges bei mobil arbeitenden Personen können neben dem positiven Effekt der Zeitersparnis auch negative Effekte auftreten. So entfällt die Option, den Arbeitsweg als Möglichkeit der Grenzziehung zu nutzen. Dies lässt sich als weiterer Aspekt einstufen, der bei mobil Arbeitenden über die erhöhte Entgrenzung zu mehr psychischen Belastungen führen kann (Jachimowicz et al., 2020, S. 64). In Deutschland untersuchte eine Forschungsgruppe des Fraunhofer-Instituts für Arbeitswirtschaft und Organisation (IAO) mögliche Gefahren für das psychische Wohlbefinden, die durch das mobile Arbeiten im Hinblick auf Entgrenzung entstehen. Insgesamt ergab die Befragung von 179 HR- bzw. Unternehmensverantwortlichen, dass über 70 % der Befragten zwar negative Auswirkungen bei Mitarbeitenden wahrnehmen, allerdings nur in weniger als der Hälfte der Betriebe Maßnahmen diesbezüglich ergriffen werden, etwa gemeinsame Regelungen zu Erreichbarkeit und Reaktionszeiten (Hofmann et al., 2021).

Entsprechend dieser Beobachtungen ist davon auszugehen, dass ein hohes Ausmaß mobilen Arbeitens bei Auszubildenden positiv auf die wahrgenommene Entgrenzung auswirkt, im Vergleich zu einem geringen Ausmaß. Dieses wiederum wirkt sich positiv auf die emotionale Erschöpfung aus. Mit steigender Entgrenzung ist eine Verringerung des Arbeitsengagements zu erwarten (Demerouti & Nachreiner, 2019, S. 124).

> Hypothese 7a: Die Intensität mobilen Arbeitens wirkt sich positiv auf die wahrgenommene Entgrenzung aus.
>
> Hypothese 7b: Ein hohes Ausmaß an wahrgenommener Entgrenzung wirkt sich positiv auf die emotionale Erschöpfung aus.
>
> Hypothese 7c: Ein hohes Ausmaß an wahrgenommener Entgrenzung wirkt sich negativ auf das Arbeitsengagement aus.

2.6. Mobiles Arbeiten & Arbeitsressourcen

Im Folgenden werden die Arbeitsressourcen näher beschrieben, die als potenzielle Mediatoren zwischen der Intensität mobilen Arbeitens und dem wahrgenommenen Arbeitsengagement wirken. Hierbei werden die Ressourcen berücksichtigt, die sowohl vor als auch seit der COVID-19-Pandemie Gegenstand wissenschaftlicher Untersuchungen waren. Zu diesen gehören Partizipation, Autonomie, Lernmöglichkeit, interne Karriereentwicklung, soziale Unterstützung und Feedback. Der Kürze halber wird in der theoretischen Darstellung intensiver auf den möglichen Zusammenhang zwischen der Intensität mobilen Arbeitens und den

Ressourcen eingegangen, da diese weniger umfassend empirisch untersucht wurden und die Wirkungszusammenhänge des JDR-Modells bereits stärker erforscht sind (Demerouti et al., 2001; Schaufeli & Bakker, 2004). In Anbetracht der in Abschnitt 2.4 dargestellten Studien und der avisierten Forschungsperspektive dieser Arbeit ist davon auszugehen, dass mit zunehmender Intensivierung mobilen Arbeitens das Arbeitsengagement bei Auszubildenen abnimmt.

> Hypothese 8: Die Intensität mobilen Arbeitens wirkt sich negativ auf das Arbeitsengagement aus.

Darüber hinaus wird der postulierte Zusammenhang zwischen Arbeitsanforderungen und -ressourcen über den Pfad der emotionalen Erschöpfung auf das Arbeitsengagement geprüft (Bakker & Demerouti, 2007, S. 317; Demerouti und Nachreiner (2019), S. 124).

> Hypothese 15: Die wahrgenommene emotionale Erschöpfung wirkt sich negativ auf das Arbeitsengagement aus.

2.6.1. Partizipation

Die Beteiligung an Entscheidungsfindungen definiert Probst (2005) auf Grundlage des mit dem JDR-Modell verwandten Demand-Control-Modells von R. A. Karasek (1979) und der systematischen Übersichtsarbeit von Miller und Monge (1986) als „... the extent to which an organization and its managers encourage employee input into organizational decisions“ (Probst, 2005, S. 321). Studien, die diese Arbeitsressource untersucht haben (Sagie, Elizur & Koslowsky, 1995; Spector, 1986, S. 1012; Xia, Zhang & Zhao, 2016, S. 7), zeigten, dass mit einer stark wahrgenommenen Partizipation an Entscheidungsprozessen positive Effekte hinsichtlich des Arbeitsengagements einhergehen. Zudem traten verstärkende Effekte auf die emotionale Erschöpfung bei entsprechend fehlender Wahrnehmung auf (Probst, 2005, S. 327; Todolí-Signes, 2021, S. 271). Demerouti et al. (2001) nahmen dieses die Arbeitsorganisation betreffende Konstrukt bereits in ihre ursprüngliche Publikation des JDR-Modells auf und wiesen in ihren Studien signifikante Effekte auf das Arbeitsengagement und die emotionale Erschöpfung nach (Demerouti et al., 2001, S. 508). Diesen direkten Effekt und den abmildernden Effekt auf die emotionale Erschöpfung konnten Bakker, ten Brummelhuis, Prins und van der Heijden (2011, S. 172) mit ihrer Studie bestätigen.

Zu den Auswirkungen mobilen Arbeitens untersuchten Vander Elst et al. (2017) die Arbeitsressource Partizipation. Sie befragten hierzu 878 mobil arbeitende Personen aus dem Telekommunikationsbereich. Dabei konnten die Wissenschaftler die negativen Effekte der Intensität mobilen Arbeitens auf die Partizipation nachweisen (Vander Elst et al., 2017, S. 182). Dies deckt sich mit früheren Beobachtungen von Golden et al. (2008, S. 1418), die bereits auf die eingeschränkte Partizipation aufgrund der erschwerten Interaktion zwischen Führungskräften und Mitarbeitenden im Homeoffice und das erhöhte Risiko einer beruflichen Isolation hinwiesen.

Gemäß diesen Beobachtungen ist davon auszugehen, dass sich ein hohes Ausmaß mobilen Arbeitens bei Auszubildenden negativ auf die wahrgenommene Partizipation auswirkt, im Vergleich zu einem geringen Ausmaß. Dieses wiederum wirkt sich positiv auf das Arbeitsengagement aus. Mit steigender Partizipation ist somit eine Verringerung der emotionalen Erschöpfung zu erwarten (Demerouti & Nachreiner, 2019, S. 124).

> Hypothese 9a: Die Intensität mobilen Arbeitens wirkt sich negativ auf die wahrgenommene Partizipation aus.
>
> Hypothese 9b: Ein hohes Ausmaß an wahrgenommener Partizipation wirkt sich positiv auf das Arbeitsengagement aus.
>
> Hypothese 9c: Ein hohes Ausmaß an wahrgenommener Partizipation wirkt sich negativ auf die emotionale Erschöpfung aus.

2.6.2. Autonomie

Aufgrund der besonderen Relevanz der Autonomie im organisationalen Kontext haben sich über die letzten Jahrzehnte in der Forschung zahlreiche Konzeptualisierungen dazu entwickelt (J. R. Hackman & Oldham, 1975, S. 160; Morgeson & Humphrey, 2006, S. 1330; Ryan & Deci, 2000, S. 68). Eine häufig zitierte Definition bieten Hackman & Oldham, die Jobautonomie definieren als „the degree to which the job provides substantial freedom, independence, and discretion to the individual in scheduling the work and in determining the procedures to be used in carrying it out” (J. Hackman & Oldham, 1976, S. 258). Diese Auffassung ähnelt der Interpretation der JDR-Modell-Autoren Bakker et al. (2005), die Jobautonomie verstehen als “... on the one hand, independence from other workers while carrying out tasks, and on the other, decision latitude concerning one’s work pace and phases” (Bakker et al., 2005, S. 172). Die essenzielle Bedeutung der Jobautonomie in Stress- und Motivationstheorien (R. A. Karasek, 1979, S. 287; Ryan & Deci, 2000, S. 68) sowie der Nachweis der positiven Effekte auf das psychologische Wohlbefinden (Karatepe, 2011, S. 55) unterstreichen die fundamentale Bedeutung dieser Arbeitsressource für das JDR-Modell.

Bei mobil arbeitenden Personen erhöht sich durch die räumliche und zeitliche Trennung von anderen Kollegen und den Bürogegebenheiten die Möglichkeit, Bearbeitungszeiträume flexibler zu gestalten und den eigenen Präferenzen anzupassen (Golden, Veiga & Simsek, 2006, S. 1342). Darüber hinaus lässt sich neben der zeitlichen auch die inhaltliche Komponente hervorheben. Hier besteht aufgrund der tendenziell geringeren Übersicht der Vorgesetzten die Möglichkeit einer freieren Aufgabenbearbeitung (Dubrin, 1991, S. 1224). Mit zunehmender Jobautonomie besteht somit für Mitarbeitende die Möglichkeit, die Arbeit stärker den

eigenen Bedürfnissen anzupassen. Dies führt zu einer Verringerung der Erschöpfungssymptome, indem die wahrgenommene Belastung gemildert wird. Darüber hinaus neigen Arbeitnehmende mit größerer Autonomie auch dazu, sich mehr für ihre Arbeit zu engagieren, da die mit der Autonomie verbundenen positiven Gefühle des Engagements oft zu einem größeren Arbeitseinsatz führen (Bakker & Demerouti, 2007, S. 316). Im Gegensatz zu diesen positiven Effekten des mobilen Arbeitens auf die wahrgenommene Autonomie und das psychische Wohlbefinden weisen einige Wissenschaftler auf das Phänomen des Autonomie-Paradoxons hin (Eurofound, 2020, S. 25; Mazmanian, Orlikowski & Yates, 2013, S. 1337). Damit ist gemeint, dass durch die Nutzung von mobilen Endgeräten auf der einen Seite zwar mehr Flexibilität und Autonomie entstehen, auf der anderen Seite allerdings in der Folge Arbeitnehmende länger arbeiten, sich kontrollierter fühlen und Grenzen verschwimmen (Molino et al., 2020, S. 13). Bei einer Befragung von 624 mobil arbeitenden Personen in Italien während der Corona-Pandemie konnten Santarpia, Borgogni, Consiglio und Menatta (2021, S. 15) dieses Paradoxon beobachten. Ihren Hypothesen zufolge führte die vermehrte Nutzung mobilen Arbeitens im Vergleich zur klassischen Arbeit im Büro dazu, dass durch die erschwerte Grenzziehung zwischen Arbeit und Privatleben die ansonsten positiven Effekte der Jobautonomie auf das Wohlbefinden nahezu aufgehoben wurden.

In Anbetracht dieser Beobachtungen ist davon auszugehen, dass sich ein Ausmaß mobilen Arbeitens bei Auszubildenden negativ auf die wahrgenommene Autonomie auswirkt, im Vergleich zu einem geringen Ausmaß. Dieses wiederum wirkt sich positiv auf das Arbeitsengagement aus. Mit steigender Autonomie ist daher eine Verringerung der emotionalen Erschöpfung zu erwarten (Demerouti & Nachreiner, 2019, S. 124).

> Hypothese 10a: Die Intensität mobilen Arbeitens wirkt sich negativ auf die wahrgenommene Autonomie aus.
>
> Hypothese 10b: Ein hohes Ausmaß an wahrgenommener Autonomie wirkt sich positiv auf das Arbeitsengagement aus.
>
> Hypothese 10c: Ein hohes Ausmaß an wahrgenommener Autonomie wirkt sich negativ auf die emotionale Erschöpfung aus.

2.6.3. Lernmöglichkeit

Die wahrgenommenen Lernmöglichkeiten sind für Auszubildende elementarer Bestandteil ihrer Ausbildung. Ein Hinweis auf deren entsprechende Wichtigkeit findet sich auch im Berufsbildungsgesetz (BBiG) § 14 Berufsausbildung (1), in dem es heißt, dass Ausbildende dafür zu sorgen haben, dass „…den Auszubildenden die berufliche Handlungsfähigkeit vermittelt wird…“ und (5) „[Auszubildende] charakterlich…gefördert werden“. Darüber hinaus sind Lernmöglichkeiten auch bei Stress-Modellen wie dem JDR-Modell (Schaufeli, Bakker & Rhenen, 2009, S. 905) oder Motivationstheorien wie der Self-Determination-Theory von Ryan und Deci (2000, S. 68) essenzieller Bestandteil. Das Konstrukt der Lernmöglichkeiten definieren Proost und Kollegen als “…the extent to which employees perceive their workplace as …offering them opportunities to develop new skills and practices” (Proost, van Ruysseveldt & van Dijke, 2012, S. 10).

Im Kontext der COVID-19-Pandemie untersuchten Pretti, Etmanski und Durston (2020) die Auswirkungen mobilen Arbeitens auf Lernmöglichkeiten bei Werkstudenten in Kanada. Hierzu führten sie insgesamt 50 teilstrukturierte Interviews durch. Hinsichtlich der Lernmöglichkeiten wurden vor allem zwei Herausforderungen hervorgehoben: Auf der einen Seite berichteten Probanden über den Wegfall von Möglichkeiten zur Zusammenarbeit (bspw. eine Tafel im Büro), die sich beim mobilen Arbeiten nicht ergaben, sodass es weniger Austausch zum Lernen und zur Motivation gab. Auf der anderen Seite konnten Führungskräfte schlechter neue Themen vermitteln oder neue Aufgaben zur persönlichen Entwicklung der Werkstudenten übertragen.

> Motivation probably decreased just because our design team functions very collaboratively. So, whenever we want to take a look at something we would post on a bulletin board and everyone gathers around it to discuss out in the open… When other people in the company walk by, they’d be like “well, that’s cool. I wanna join in. I want to take a peek,” which is really motivating as a designer, because we want the discipline of designing to be more influential…When working remotely… it almost felt like we weren’t being seen as much. (Pretti et al., 2020, S. 406)

Die befragten Studierenden wiesen darauf hin, wie wichtig es für sie sei, in einer Homeoffice-Situation sinnvolle Aufgaben zugewiesen zu bekommen. Einige Studierende berichteten, dass ihre Arbeitgeber anfänglich Schwierigkeiten damit hatten, ihnen solche Aufgaben zuzuweisen. Die Studierenden waren der Meinung, dass den Vorgesetzten ihre Fähigkeiten möglicherweise nicht in vollem Umfang bewusst waren, dass sie mit ihren eigenen Umstellungen beschäftigt waren oder dass sie keine Aufgaben für sie hatten. Infolgedessen wurden einigen Studierenden eher niedere Aufgaben zugewiesen (z. B. Dateneingabe). Dies trug dazu bei, dass sie eine weniger sinnvolle Beschäftigung erlebten, als sie erwartet hatten (Pretti et al., 2020, S. 407). Interviewübergreifend identifizierten die Autoren vor allem den Themenbereich der organisationalen Sozialisation als relevant für erfolgreiches mobiles Arbeiten bei neuen Mitarbeitenden. Durch das mobile Arbeiten war der Sozialisationsprozess für die Studierenden insofern schwierig, als eine kontinuierliche Aufrechterhaltung der Informations- und Kommunikationstechnologien essenziell war, um sowohl informelle als auch formelle Informationen zu erhalten und somit ein Gefühl der Verbundenheit zu empfinden. Auch die Erlernung fachlicher Inhalte gestaltete sich im Homeoffice schwieriger, da keine natürliche Beobachtung und Interaktion mit Kollegen im direkten Arbeitsumfeld möglich waren (Pretti et al., 2020, S. 409).

Angesichts dieser Beobachtungen ist davon auszugehen, dass sich ein hohes Ausmaß mobilen Arbeitens bei Auszubil-

denden negativ auf die wahrgenommenen Lernmöglichkeiten auswirkt, im Vergleich zu einem geringen Ausmaß. Dieses wiederum wirken sich positiv auf das Arbeitsengagement aus. Mit steigenden Lernmöglichkeiten ist folglich eine Verringerung der emotionalen Erschöpfung zu erwarten (Demerouti & Nachreiner, 2019, S. 124).

> Hypothese 11a: Die Intensität mobilen Arbeitens wirkt sich negativ auf die wahrgenommenen Lernmöglichkeiten aus.
>
> Hypothese 11b: Ein hohes Ausmaß an wahrgenommenen Lernmöglichkeiten wirkt sich positiv auf das Arbeitsengagement aus.
>
> Hypothese 11c: Ein hohes Ausmaß an wahrgenommenen Lernmöglichkeiten wirkt sich negativ auf die emotionale Erschöpfung aus.

2.6.4. Interne Karriereentwicklung

Die interne Karriereentwicklung als Arbeitsressource ist vor allem mit Blick auf jüngere Arbeitnehmende Bestandteil wissenschaftlicher Untersuchungen hinsichtlich des psychologischen Wohlbefindens gewesen (Akkermans, Brenninkmeijer, Schaufeli & Blonk, 2015; Akkermans, Schaufeli, Brenninkmeijer & Blonk, 2013). So befragten etwa Akkermans et al. (2013) insgesamt 305 junge Arbeitnehmende zwischen 16 und 30 Jahren auf Grundlage des Job Content Questionnaire (JCQ) von R. Karasek et al. (1998) zur Bedeutung der Karriereentwicklungsmöglichkeiten im beruflichen Kontext (Akkermans et al., 2013, S. 359). Dabei ergab die Auswertung, dass berufliche Kompetenzen einen Zusammenhang zwischen Arbeitsressource und Engagement vermitteln. Dieser Zusammenhang wurde auch in nachfolgenden Studien beobachtet (Akkermans et al., 2015, S. 547; Akkermans, Paradniké, der Heijden & Vos, 2018, S. 8).

Im Zusammenhang mit mobilem Arbeiten zeigte die Studie von Mann und Holdsworth (2003, S. 198), dass insbesondere die Angst von Mitarbeitenden, bei Vorgesetzten und Kollegen wenig sichtbar zu sein, im Homeoffice erhöht ist. Hinzu kommt die Angst, sich dadurch weniger im Büro vernetzen zu können und bei der internen Karriereentwicklung benachteiligt zu werden. In Studien konnten diese wahrgenommenen Gefahren längsschnittlich bestätigt werden (Golden & Eddleston, 2020, S. 1). In einer Studie mit 405 Befragten stellten die Autoren fest, dass die Intensität mobilen Arbeitens in einem negativen Zusammenhang mit den Beförderungen und der Gehaltsentwicklung stand, was sie primär auf die reduzierten Face-to-Face-Kontakte zurückführten (Golden & Eddleston, 2020, S. 1). Raišienė, Rapuano, Varkulevičiūtė und Stachová (2020) befragten ihrerseits während der Corona-Pandemie 436 Probanden zu den Auswirkungen mobilen Arbeitens. Auch in ihrer Studie zeigten sich signifikante Effekte auf die Reduktion der Karrierechancen aufgrund von eingeschränkten Möglichkeiten, die eigenen Fähigkeiten und Kenntnisse sowie die eigene Arbeit zu präsentieren (Raišienė et al., 2020, S. 20). Zur Erklärung und theoretischen Verbindung mobilen Arbeitens mit der reduzierten Karriereentwicklung und dem psychischen Wohlbefinden zogen Park et al. (2021, S. 228) die Social-Cognitive-Career-Theorie (SCCT) (Lent, Brown & Hackett, 1994) heran. Für diese sind die Selbstwirksamkeits- und Ergebniserwartung sowie die Interessen-Verbindung von zentraler Bedeutung. Dementsprechend schlossen Park et al. (2021, S. 228) darauf, dass mobiles Arbeiten vor allem dann Entwicklungsbestrebungen negativ beeinflusst, wenn durch geringere Selbstwirksamkeitserwartung und weniger soziales Feedback Ziele weniger stark wahrgenommen werden. Infolgedessen reduzieren sich dann auch Bestrebungen bezüglich der eigenen Karriereentwicklung (Park et al., 2021, S. 228).

Entsprechend diesen Beobachtungen ist davon auszugehen, dass sich ein hohes Ausmaß mobilen Arbeitens bei Auszubildenden negativ auf die wahrgenommene interne Karriereentwicklung auswirkt, im Vergleich zu einem geringen Ausmaß. Dieses wiederum wirkt sich positiv auf das Arbeitsengagement aus. Mit steigender interner Karriereentwicklung ist daher eine Verringerung der emotionalen Erschöpfung zu erwarten (Demerouti & Nachreiner, 2019, S. 124).

> Hypothese 12a: Die Intensität mobilen Arbeitens wirkt sich negativ auf die wahrgenommene interne Karriereentwicklung aus.
>
> Hypothese 12b: Ein hohes Ausmaß an wahrgenommener interner Karriereentwicklung wirkt sich positiv auf das Arbeitsengagement aus.
>
> Hypothese 12c: Ein hohes Ausmaß an wahrgenommener interner Karriereentwicklung wirkt sich negativ auf die emotionale Erschöpfung aus.

2.6.5. Soziale Unterstützung

Unterstützung durch Kollegen und Vorgesetzte definieren Morgeson und Humphrey (2006) als „the degree to which a job provides opportunities for advice and assistance from others“ (Morgeson & Humphrey, 2006, S. 1323). Diese Variable ist unter denjenigen Faktoren, die Arbeitserschöpfung reduzieren können, vergleichsweise gut erforscht (Haines, 1991). Im Kontext des JDR-Modells zeigten diverse Studien die positiven Effekte solcher Unterstützung auf das Arbeitsengagement (Akkermans et al., 2013 (social support); Demerouti et al., 2001 (supervisor support); Schaufeli, 2017 (co-worker support).

Im Zusammenhang mit mobiler Arbeit wiesen diverse Studien auf negative Effekte der Homeoffice-Intensität auf die wahrgenommene Unterstützung durch Kollegen (Gajendran & Harrison, 2007, S. 1535) und Führungskräfte hin (Golden, 2006, S. 333; Sardeshmukh et al., 2012, S. 200). So untersuchten beispielsweise Vander Elst et al. (2017) 878 Mitarbeitende eines belgischen Telekommunikationsunternehmens hinsichtlich der Auswirkungen der Intensität mobilen Arbeitens auf das psychologische Wohlbefinden. Im Einklang mit vorherigen Studien zeigte sich ein signifikant negativer Effekt auf die wahrgenommene Unterstützung durch Kollegen. Ebenfalls ließ sich mit Blick auf das JDR-Modell ein vermittelnder Effekt der sozialen Unterstützung auf das Arbeitsengagement der Mitarbeitenden feststellen (Vander Elst

et al., 2017, S. 183). Diese Beobachtung, die sich bereits in einer Studie Sardeshmukh et al. (2012, S. 202) findet, führten die Wissenschaftler auf die durch Informations- und Kommunikationstechnologien verursachte geringere persönliche Face-to-Face-Interaktion zurück, die ihrerseits ein stärkeres soziales Zugehörigkeitsgefühl mit sich bringen würde.

Angesichts dieser Beobachtungen ist davon auszugehen, dass sich ein hohes Ausmaß mobilen Arbeitens bei Auszubildenden negativ auf die wahrgenommene soziale Unterstützung auswirkt, im Vergleich zu einem geringen Ausmaß. Dieses wiederum wirkt sich positiv auf das Arbeitsengagement aus. Mit steigender sozialer Unterstützung ist folglich eine Verringerung der emotionalen Erschöpfung zu erwarten (Demerouti & Nachreiner, 2019, S. 124).

> Hypothese 13a: Die Intensität mobilen Arbeitens wirkt sich negativ auf die wahrgenommene Unterstützung durch Kollegen und Vorgesetzte aus.
>
> Hypothese 13b: Ein hohes Ausmaß an wahrgenommener Unterstützung durch Vorgesetzte und Kollegen wirkt sich positiv auf das Arbeitsengagement aus.
>
> Hypothese 13c: Ein hohes Ausmaß an wahrgenommener Unterstützung durch Vorgesetzte und Kollegen wirkt sich negativ auf die emotionale Erschöpfung aus.

2.6.6. Feedback

Bakker, van Veldhoven und Xanthopoulou (2010, S. 6) verwendeten für ihre Forschungen mit dem JDR-Modell eine Definition des Konzeptes Feedback, die auf dem Job-Characteristics-Survey (J. R. Hackman & Oldham, 1975) sowie dem Job-Content-Questionnaire (R. A. Karasek, 1985) basiert. Demgemäß definieren die Autoren Feedback als “the degree to which carrying out the work activities required by the job results in the employee obtaining direct and clear information about the effectiveness of his or her performance” (J. R. Hackman & Oldham, 1975, S. 162). Die besondere Bedeutung des Feedbacks zeigt sich darüber hinaus auch in anderen Motivationstheorien wie der Self-Determination-Theory (Deci & Ryan, 1985). Hierdurch wird wiederum die zentrale Bedeutung des Feedbacks als Arbeitsressource im JDR-Modell unterstrichen (Bakker et al., 2010, S. 4).

Einen theoretischen Ansatz zur Herstellung einer Verbindung zwischen dem Feedback als Form der Kommunikation und mobilen Arbeitens bietet die Media-Richness-Theory (Daft & Lengel, 1984). Basierend auf dieser Theorie lassen sich unterschiedliche Kommunikationsmedien entsprechend ihrer Passung für eine spezifische Kommunikationsaufgabe definieren. Dabei zeigte sich in den Untersuchungen zur Konzeption der Media-Richness-Theory, dass für besonders mehrdeutige und komplexe Themen wie ein Mitarbeiterfeedback ein reichhaltiges Medium besser geeignet ist. Als reichhaltiges Medium definieren die Autoren dabei beispielsweise das persönliche Face-to-Face-Gespräch (Daft & Lengel, 1986, S. 560), wobei hier besondere Vorteile in der Unmittelbarkeit liegen sowie in der Möglichkeit, Hinweise beispielsweise durch die Körpersprache oder den Tonfall wahrzunehmen (Daft & Lengel, 1984, S. 199). Bei Mitarbeitenden geht diese persönliche Interaktion mit zunehmender Nutzung des mobilen Arbeitens verloren (Sardeshmukh et al., 2012, S. 202), was zu persönlichen Herausforderungen führen und den ansonsten positiven Nutzen des Feedbacks (Schaufeli, 2017, S. 122) reduzieren kann. Aufgrund der hohen Abhängigkeit mobil Arbeitender von Informations- und Kommunikationstechnologien im Homeoffice, zeigten Studien wie die von Rice und Gattiker (2001), dass durch den veränderten Kommunikationskanal davon auszugehen ist, dass vermehrt mobil arbeitende Mitarbeitende weniger stark von der positiven Wirkung eines Feedbacks beeinflusst werden. Hinzu kommt ein verstärktes Gefühl der Abgeschnittenheit (Cooper & Kurland, 2002, S. 527; Golden et al., 2008, S. 1416). Entsprechend diesen Studien ist davon auszugehen, dass das Feedback mit einer höheren Intensität mobilen Arbeitens qualitativ und quantitativ abnimmt und sich somit negativ auf das Arbeitsengagement auswirkt.

Der Media-Richness-Theory zufolge ist bei weniger persönlichen Rückmeldungen davon auszugehen, dass Mitarbeitende sich im Homeoffice intensiver anstrengen müssen, um an relevante Informationen für ihre Arbeit zu gelangen. Dieser Anstrengungsprozess kann zum einen die wahrgenommene Erschöpfung erhöhen und zum anderen aufgrund des eingeschränkten oder nicht vorhandenen Informationsflusses zu einer Reduzierung des Arbeitsengagements führen (Sardeshmukh et al., 2012, S. 197).

> Hypothese 14a: Die Intensität mobilen Arbeitens wirkt sich negativ auf das wahrgenommene Feedback aus.
>
> Hypothese 14b: Ein hohes Ausmaß an wahrgenommenem Feedback wirkt sich positiv auf das Arbeitsengagement aus.
>
> Hypothese 14c: Ein hohes Ausmaß an wahrgenommener Autonomie wirkt sich negativ auf die emotionale Erschöpfung aus.

Darüber hinaus wird die postulierte Puffer-Hypothese des JDR-Modells über den Pfad des Arbeitsengagements auf die emotionale Erschöpfung geprüft (Bakker & Demerouti, 2007, S. 317).

3. Daten und Methoden

In diesem Kapitel erfolgt zunächst eine Beschreibung des Studiendesigns und eine Auflistung der verwendeten Skalen. Mit der Analyse der Messmodelle schließt dieses Kapitel, bevor im nachfolgenden eine Evaluation der Ergebnisse vorgenommen wird. Dabei wird sich an der vorgeschlagenen Vorgehensweise zur Strukturgleichungsanalyse orientiert. Diese besteht aus einer theoretischen Fundierung und Hypothesenbildung, einer geeigneten Methodenwahl, der Modellformulierung, der empirischen Erhebung sowie der Parame-

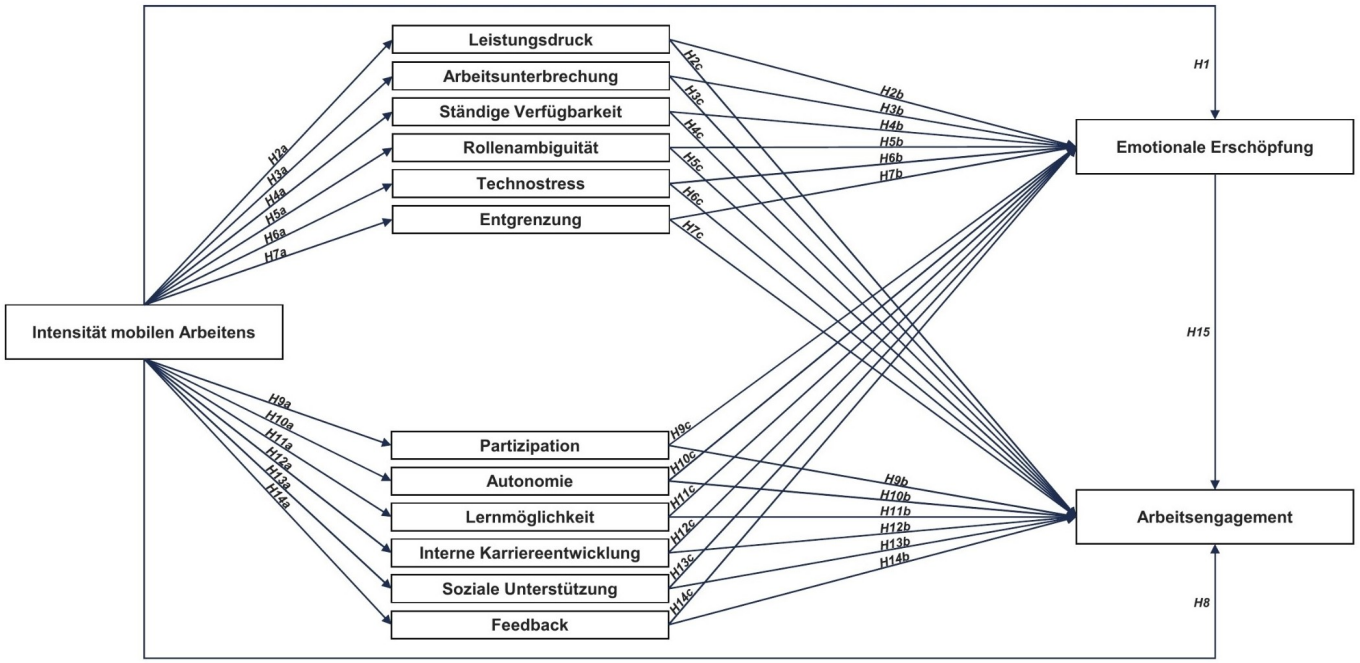

Abbildung 2: Theoretisches Pfadmodell

Quelle: Eigene Darstellung

terschätzung und Beurteilung der Schätzergebnisse (Fuchs, 2011, S. 10).

3.1. Studiendesign

Als Grundlage für die Analyse und Überprüfung der oben formulierten Forschungshypothesen wurden im Zeitraum vom 11.01.2022 bis 31.01.2022 Daten mittels Onlinefragebogen über die Web-Applikation „SoSci Survey“ erhoben (siehe Anhang E). Der Feldzugang fand nach schriftlicher Genehmigung des Forschungsvorhabens durch die Behörde für Schule und Berufsbildung Hamburg am 10.01.2022 (siehe Anhang C) über folgende beruflichen Schulen Hamburgs statt, die kaufmännische Ausbildungsberufe führen: Berufliche Schule Anckelmannstraße (BS 01), Berufliche Schule für Wirtschaft und Handel Hamburg-Mitte (BS 02) Berufliche Schule Hotellerie, Gastronomie und Lebensmittelhandwerk (BS 03), Berufliche Schule Wirtschaft, Verkehrstechnik und Berufsvorbereitung – Bergedorf (BS 07), Berufliche Schule für Logistik, Schifffahrt und Touristik (BS 09), Berufliche Schule für Banken, Versicherungen und Recht mit Beruflichem Gymnasium St. Pauli (BS 11), Berufliche Schule ITECH Elbinsel Wilhelmsburg (BS 14), Berufliche Schule für Medien und Kommunikation (BS 17), Berufliche Schule Hamburg-Harburg (BS 18), Berufliche Schule für Wirtschaft Hamburg-Eimsbüttel (BS 26), Berufliche Schule City Nord (BS 28), Berufliche Schule Am Lämmermarkt (BS 31), Berufliche Schule an der Landwehr (BS 32). Das Sample umfasste 110 Auszubildende.

Um die theoretisch abgeleiteten Beziehungen zwischen den Konstrukten zu analysieren, wurde ein Strukturgleichungsmodell spezifiziert. Zu dessen Entwicklung wurden 64 Items verwendet, mithilfe derer die Zusammenhänge zwischen exogenen und endogenen latenten Variablen entsprechend den formulierten Forschungshypothesen geprüft werden konnten.

Über die Analyse des in Abbildung 2 dargestellten theoretischen Pfadmodells besteht so die Möglichkeit, sowohl die direkten als auch die indirekten Einflüsse der Intensität mobilen Arbeitens auf die Konstrukte emotionale Erschöpfung und Arbeitsengagement zu messen. Anhand der Gesamtdarstellung des Strukturgleichungsmodells lässt sich evaluieren, inwiefern die Konstrukte Leistungsdruck, Arbeitsunterbrechung, ständige Verfügbarkeit, Rollenambiguität, Technostress, Entgrenzung, Partizipation, Rollenklarheit, interne Karriereentwicklung, Autonomie, Lernmöglichkeit, soziale Unterstützung und Feedback den Effekt der Intensität mobilen Arbeitens auf die beiden abhängigen Variablen beeinflussen. Für die statistischen Analysen und Spezifikationen des Strukturmodells wurde das Statistikprogramm RStudio (Version 1.3.1093) in Verbindung mit dem Partial least squares path modeling-Anwendungspaket (PLS-PM) plspm von Gaston Sanchez verwendet. Dieses steht über den netzbasierten Dienst zur Versionsverwaltung GitHub frei zur Verfügung (Sanchez, 2022). Diese Methode hat den Vorteil, dass keine Intervallskalierung der Items für die Berechnungen notwendig ist und im Gegensatz zu kovarianzbasierten Verfahren bereits mit kleinen Stichprobengrößen zwischen 30-100 gearbeitet werden kann (Chin, 1998, S. 307; Chin & Newsted, 1999, S. 314).

3.2. Untersuchungsvariablen

Für die Untersuchungsziele dieser Studie wurden Messungen zur Intensität mobilen Arbeitens, sechs Arbeitsanforderungen (siehe Anhang B), sechs Arbeitsressourcen (siehe Anhang B), emotionaler Erschöpfung und Arbeitsengagement durchgeführt, die das innere Modell darstellen. Diese latenten Konstrukte lassen sich jeweils reflektiv durch die vorhandenen Indikatoritems messen. Die Messungen der exogenen Variablen Intensität mobilen Arbeitens, Arbeitsanforderungen und Arbeitsressourcen sowie die der endogenen Variablen Emotionale Erschöpfung und Arbeitsengagement werden nachfolgend kurz dargestellt. Die Intensität mobilen Arbeitens wird auf einer sechsstufigen Likert-Skala abgefragt, die von 0 (an keinem Tag) bis 5 (jeden Tag) reicht.

Für die Erfassung der Arbeitsanforderungen wurde der „Ressourcen und Anforderungen (ReA) in der Arbeitswelt"-Fragebogen von Schulte, Wittner und Kauffeld (2021) verwendet. Für dessen Nutzung wurde im Vorhinein eine Kooperationsvereinbarung mit Psychologin und Co-Autorin, Eva-Maria Schulte, unterzeichnet (siehe Anhang F). Das Analysetool umfasst, basierend auf dem Job-Demand-Resources-Modell, insgesamt 17 verschiedene Anforderungen, die unter dem Aspekt der Arbeitsanforderungen zusammengefasst werden. Dadurch werden entsprechend der formulierten Forschungshypothesen vier Anforderungen erfasst, die in besonderem Zusammenhang mit mobiler Arbeit stehen. Hierbei handelt es sich um: Leistungsdruck, Arbeitsunterbrechungen, ständige Verfügbarkeit und Rollenambiguität. Diese vier Konstrukte werden mit jeweils drei Items operationalisiert. Die Antwortskala reicht dabei auf einer sechsstufigen Likert-Skala von 1 (trifft überhaupt nicht zu) bis 6 (trifft völlig zu). Ein Beispiel-Item zur Messung der ständigen Verfügbarkeit lautet „Ständige Erreichbarkeit ist bei uns selbstverständlich". Darüber hinaus werden zwei weitere Anforderungen erfasst, die von besonderer Relevanz für das mobile Arbeiten und die Beantwortung der Hypothesen sind und durch das Tool von Schulte et al. (2021, S.407) nicht explizit berücksichtigt werden. Dabei handelt es sich um Technostress und Entgrenzung. Technostress wird mithilfe der ins Deutsche übersetzten Technostress Creators Scale von Ragu-Nathan et al. (2008) erhoben. Mit insgesamt sechs Items werden dabei die drei Sub-Skalen Techno-Overload, Techno-Invasion und Techno-Complexity berücksichtigt. Die Antworten werden auf einer fünfstufigen Likert-Skala von 1 (trifft überhaupt nicht zu) bis 5 (trifft völlig zu) erfasst. Ein Beispiel-Item lautet: „Ich bin durch diese Technologie (bezogen auf mobiles Arbeiten) gezwungen, mehr zu arbeiten, als ich bewältigen kann." Für die Anforderung durch Entgrenzung werden fünf ins Deutsche übersetzte Items von Kossek, Ruderman, Braddy und Hannum (2012, S.126) verwendet. Ein Beispiel-Item lautet: „Wenn ich von zu Hause aus arbeite, kümmere ich mich während der Arbeit um persönliche oder familiäre Angelegenheiten".

Für die Erfassung der Arbeitsressourcen wird ebenfalls der „Ressourcen und Anforderungen (ReA) in der Arbeitswelt"-Fragebogen von Schulte et al. (2021) verwendet. Das Analysetool umfasst, basierend auf dem Job-Demand-Resources-Modell, insgesamt 20 verschiedene Ressourcen, die unter dem Aspekt der Arbeitsressourcen zusammengefasst werden. Dabei werden aufgrund der formulierten Forschungshypothesen sechs Konstrukte erfasst, die in besonderem Zusammenhang mit mobilem Arbeiten stehen. Hierzu zählen: Partizipation, interne Karriereentwicklung, Autonomie, Lernmöglichkeit, soziale Unterstützung und Feedback. Die sechs Konstrukte werden bis auf die soziale Unterstützung mit jeweils drei Items operationalisiert. Dieses wird hingegen mit sechs Items gemessen und setzt sich aus den zwei Subskalen Unterstützung durch Führungskraft und Unterstützung durch Kollegen zusammen. Die Antwortskala reicht dabei auf einer sechsstufigen Likert-Skala von 1 (trifft überhaupt nicht zu) bis 6 (trifft völlig zu). Ein Beispiel-Item zur Erfassung der Autonomie lautet: „Ich kann selbst entscheiden, wann ich Aufgaben erledige."

Die arbeitsbezogene emotionale Erschöpfung wurde mittels neun Items der leicht modifizierten deutschen Übersetzung des Maslach Burnout Inventory (Büssing & Perrar, 1992) mit einer siebenstufigen Likert-Skala von 0 (nie) bis 6 (täglich) erhoben. Ein Beispielitem lautet: „Mein Interesse an dem Ausbildungsberuf ließ nach dem ersten Ausbildungstag nach." Das Arbeitsengagement wurde durch die Neun-Item-Kurzskala der Utrecht Work Engagement Scale (Schaufeli, Bakker & Salanova, 2006, S. 714) auf einer siebenstufigen Likert-Skala von 0 (nie) bis 6 (täglich) erfasst. Ein Beispielitem lautet: „Ich bin stolz auf meine Arbeit.".

3.3. Analyse der Messmodelle

Nach der Darstellung des methodischen Vorgehens und des Studiendesigns sowie der Beschreibung der verwendeten Items schließt in diesem Abschnitt die Evaluation der Messmodelle an. Hierbei werden sowohl die Reliabilität als auch die Validität der Skalen geprüft, um die Voraussetzungen für eine differenzierte Modell- und Hypothesenevaluation in Kapitel 4 zu schaffen.

3.3.1. Arbeitsanforderungen

Für alle sechs untersuchten Konstrukte aus der Kategorie Arbeitsanforderungen ergab sich im Zuge der Überprüfung der Homogenität und Eindimensionalität der Indikatoren eine akzeptable (Hair, Hult, Ringle & Sarstedt, 2017, S. 122) interne Konsistenz von Cronbach's Alpha zwischen .725 und .864. Zusätzlich wurden die Ladungen und Kommunalitäten des Messmodells überprüft. Hier fordern Hair et al. (2017, S. 114), dass Indikatoren mit einer Ladung von $< .40$ aus dem Modell entfernt werden sollten. Dies war bei keinem der 22 Items der Fall (siehe Anhang B). Boßow-Thies und Panten (2009, S. 375) empfehlen darüber hinaus eine Kommunalität von $> .50$, was einer Faktorladung von etwa .70 entspricht. Die drei Items (siehe Anhang B), die diesen Wert nicht erreicht haben, bleiben aufgrund der internen Konsistenz im Messmodell erhalten. Zur Überprüfung der konvergenten Validität werden die Kreuzladungen analysiert, also die Ladungen auf das ihnen zugeordnete Konstrukt. Hier ergab sich kein Anpassungsbedarf bei der Indikatorauswahl,

da alle Items der jeweiligen Konstrukte am stärksten auf das eigene Konstrukt laden. Darüber hinaus sind alle Indikatoren des Konstruktes signifikant ($p \leq .05$). Mithilfe der durchschnittlich erfassten Varianz (AVE = average variance extracted) wird auf der Ebene des latenten Konstruktes überprüft, wie reliabel die erfassten Indikatoren das entsprechende Konstrukt wiedergeben. Die modellierten Konstrukte erklärten hierbei zwischen 50 % und 78.5 % (AVE = .500 - .785) der Varianz und erreichten damit den geforderten Schwellenwert von .50 (Fornell & Larcker, 1981, S. 46). Folglich bestand kein weiterer Anpassungsbedarf. Die konvergente Validität des Messmodells ist somit als bedingt gegeben anzusehen. Die vollständige Auswertung der Daten mit dem Statistikprogramm RStudio in Verbindung mit dem PLS-PM-Anwendungspaket plspm im Anhang G beinhaltet die Übersicht der Kreuzladungen sowie die der durchschnittlich erfassten Varianz (AVE) der Konstrukte.

3.3.2. Arbeitsressourcen

Für alle sechs untersuchten Konstrukte aus der Kategorie der Arbeitsressourcen ergab sich im Zuge der Überprüfung der Homogenität und Eindimensionalität der Indikatoren eine akzeptable (Hair et al., 2017, S. 122) interne Konsistenz von Cronbach's Alpha zwischen .858 und .918. Zusätzlich wurden die Ladungen und Kommunalitäten des Messmodells überprüft. Hier fordern Hair et al. (2017, S. 114), dass Indikatoren mit einer Ladung von $< .40$ aus dem Modell entfernt werden sollten. Dies war bei keinem der 21 Items der Fall (siehe Anhang B). Boßow-Thies und Panten (2009, S. 375) empfehlen darüber hinaus eine Kommunalität von $> .50$, was einer Faktorladung von etwa .70 entspricht und von allen Items erfüllt wird. Zur Überprüfung der konvergenten Validität werden die Kreuzladungen analysiert, also die Ladungen auf das ihnen zugeordnete Konstrukt. Hier ergab sich kein Anpassungsbedarf bei der Indikatorauswahl, da alle Items der jeweiligen Konstrukte am stärksten auf das eigene Konstrukt laden. Darüber hinaus sind alle Indikatoren des Konstruktes signifikant ($p \leq .05$). Mithilfe der durchschnittlich erfassten Varianz (AVE) wird auf der Ebene des latenten Konstruktes überprüft, wie reliabel die erfassten Indikatoren das entsprechende Konstrukt wiedergeben. Die modellierten Konstrukte erklärten hierbei zwischen 71.3 % und 85.5 % (AVE = .713 - .850) der Varianz und erreichten damit den geforderten Schwellenwert von .50 (Fornell & Larcker, 1981, S. 46). Folglich bestand kein weiterer Anpassungsbedarf. Die konvergente Validität des Messmodells ist somit als bedingt gegeben anzusehen. Die vollständige Auswertung der Daten mit dem Statistikprogramm RStudio in Verbindung mit dem PLS-PM-Anwendungspaket plspm im Anhang G beinhaltet die Übersicht der Kreuzladungen sowie die der durchschnittlich erfassten Varianz (AVE) der Konstrukte.

3.3.3. Emotionale Erschöpfung & Arbeitsengagement

Für die Überprüfung des Konstruktes der emotionalen Belastung und des Arbeitsengagements ergab sich im Zuge der Überprüfung der Homogenität und Eindimensionalität der Indikatoren eine akzeptable (Hair et al., 2017, S. 122) interne Konsistenz von Cronbach's Alpha zwischen .913 und .936. Zusätzlich wurden die Ladungen und Kommunalitäten des Messmodells überprüft. Hier fordern Hair et al. (2017, S. 114), dass Indikatoren mit einer Ladung $< .40$ aus dem Modell entfernt werden sollten. Dies war bei keinem der 18 Items der Fall (siehe Anhang B). Boßow-Thies und Panten (2009, S. 375) empfehlen darüber hinaus eine Kommunalität von $> .50$, was einer Faktorladung von etwa .70 entspricht. Die vier Items, die diesen Wert nicht erreicht haben, bleiben aufgrund der internen Konsistenz im Messmodell enthalten. Zur Überprüfung der konvergenten Validität werden die Kreuzladungen analysiert, also die Ladungen auf das ihnen zugeordnete Konstrukt. Hier ergab sich kein Anpassungsbedarf der Indikatorauswahl, da alle Items der jeweiligen Konstrukte am stärksten auf das eigene Konstrukt laden. Darüber hinaus sind alle Indikatoren des Konstruktes signifikant ($p \leq .05$). Mithilfe der durchschnittlich erfassten Varianz (AVE) wird auf der Ebene des latenten Konstruktes überprüft, wie reliabel die erfassten Indikatoren das entsprechende Konstrukt wiedergeben. Die modellierten Konstrukte erklärten hierbei zwischen 59.3 % und 66.7 % (AVE = .593 - .667) der Varianz und erreichten damit den geforderten Schwellenwert von .50 (Fornell & Larcker, 1981, S. 46). Folglich bestand kein weiterer Anpassungsbedarf. Die konvergente Validität des Messmodells ist somit als bedingt gegeben anzusehen. Die vollständige Auswertung der Daten mit dem Statistikprogramm RStudio in Verbindung mit dem PLS-PM-Anwendungspaket plspm im Anhang G beinhaltet die Übersicht der Kreuzladungen sowie die der durchschnittlich erfassten Varianz (AVE) der Konstrukte.

4. Ergebnisse

In diesem Kapitel erfolgt zunächst eine Darstellung der deskriptiven Statistik. Anschließend werden die Forschungshypothesen bewertet, bevor abschließend eine Gesamtevaluation des Strukturgleichungsmodells präsentiert wird.

4.1. Deskriptive Analyse

Das für die Studie verwendete Sample der Erhebung im Zeitraum vom 11. Januar 2022 bis 31. Januar 2022 bestand aus 110 Auszubildenden, von denen 78.18 % ($n = 86$) weiblich und 11.82 % ($n = 24$) männlich waren. Das Durchschnittsalter betrug 22 Jahre. Die Auszubildenden verteilten sich zum Zeitpunkt der Befragung über drei Ausbildungsjahre. Im ersten Ausbildungsjahr befanden sich 23.64 % ($n = 26$), im zweiten Ausbildungsjahr 40 % ($n = 44$) und im dritten Ausbildungsjahr 36.36 % ($n = 40$) Personen. Nach eigenen Angaben nutzen 60 % ($n = 66$) der befragten Auszubildenden die Möglichkeit des mobilen Arbeitens regelmäßig. Dieser Anteil setzt sich aus 78.79 % ($n = 52$) Frauen und 11.21 % ($n = 14$) Männern zusammen. Die durchschnittliche Anzahl der wöchentlichen Homeoffice-Tage der Probanden, die diese flexible Arbeitsform nutzen, beträgt drei Tage. Die berücksichtigten Teilnehmenden verteilten sich über

sechs unterschiedliche Ausbildungsberufe. Im Einzelnen waren 3.64 % ($n = 4$) Fachinformatikerinnen und Fachinformatiker; 2.73 % ($n = 3$) Gestalterinnen und Gestalter für visuelles Marketing; 0.91 % ($n = 1$) Industriekauffrauen und -männer; 49.09 % ($n = 54$) Kauffrauen und -männer für Büromanagement); 1.12 % ($n = 9$) Kaufmann/-frau im E-Commerce und 35.45 % ($n = 39$) Kauffrauen und -männer für Groß- und Außenhandel.

4.2. Evaluation der Forschungshypothesen

In Bezug auf die in Abbildung 2 dargestellten Pfade und die entsprechend formulierten Forschungshypothesen folgt hier eine Bewertung, wobei zunächst auf die beiden zentralen Hypothesen H1 und H8 eingegangen wird.

Durch die Wahl eines varianzanalytischen Verfahrens ist das Treffen von Verteilungsannahmen zunächst nicht möglich. Somit können keine Signifikanztests für die Pfadkoeffizienten durchgeführt werden. Aufgrund dessen wird das nicht-parametrische Bootstrapping genutzt, um die Möglichkeit zu eröffnen, für jeden Pfadkoeffizienten einen t-Wert zu ermitteln und somit Aussagen über Signifikanz der Koeffizienten zu treffen (Fuchs, 2011, S. 31). Insgesamt wurde das Resampling-Verfahren 1000-fach durchgeführt. Die entsprechende Übersicht der verwendeten Werte zur Beurteilung der Signifikanz findet sich im Anhang G. Die in Abbildung 3 dargestellten Pfeilrichtungen geben die Wirkungsrichtung der Kausalbeziehung an. Der Pfadkoeffizient dient dabei als Gradmesser für die Stärke der kausalen Beziehung. Das Fundamentaltheorem der Pfadanalyse besagt, dass sich die Wirkung der Kausalbeziehungen in direkte und indirekte kausale Effekte unterscheiden lässt. Der totale kausale Effekt kann berechnet werden, indem der Korrelationskoeffizient des direkten sowie des indirekten Kausaleffektes aufsummiert wird (Fuchs, 2011, S.6).

Hypothese 1 beinhaltete, dass die Intensität mobilen Arbeitens die emotionale Belastung der Auszubildenden erhöht. Anhand der operationalisierten Konstrukte und der erhobenen Daten muss diese Hypothese verworfen werden. Entgegen der Annahme zeigte sich ein insignifikanter Effekt. Hypothese 8 beinhaltete, dass die Intensität mobilen Arbeitens das Arbeitsengagement verringert. Diese Hypothese muss entgegen der Annahme ebenfalls verworfen werden, da sich wie bei der Hypothese 1 ein insignifikanter Effekt zeigte.

Die Hypothesen H2a - H14a beinhalteten, dass die Intensität mobilen Arbeitens die wahrgenommenen Arbeitsbelastungen (H2a - H7a) positiv und die wahrgenommenen Arbeitsressourcen (H8a - H14a) negativ beeinflusst. Entgegen den Erwartungen konnte bei keinem dieser Pfade ein signifikanter Effekt beobachtet werden. Bei vier Pfaden – H4a ständige Verfügbarkeit; H6a Technostress; H7a Entgrenzung und H13a interne Karriereentwicklung – ließen sich keine signifikanten Zusammenhänge beobachten. Bei den verbleibenden zehn Hypothesen zeigten sich gegenteilige Effekte durch die Intensität mobilen Arbeitens. Diese stellten sich im Einzelnen folgendermaßen dar: H2a Leistungsdruck ($\beta = -.28$, $p \leq .05$); H3a Arbeitsunterbrechung ($\beta = -.34$, $p \leq .05$); H5a Rollenambiguität ($\beta = -.22$, $p \leq .05$); H9a Partizipation ($\beta = .23$, $p \leq .05$); H10a Autonomie ($\beta = .32$, $p \leq .05$); H11a Lernmöglichkeit ($\beta = .26$, $p \leq .05$); H13a Soziale Unterstützung ($\beta = .28$, $p \leq .05$) und H14a Feedback ($\beta = .25$, $p \leq .05$).

Die Hypothesen H2b - H14b beinhalteten, dass sich die Arbeitsanforderungen positiv auf die emotionale Erschöpfung (H2b - H7b) und die Arbeitsressourcen positiv auf das Arbeitsengagement (H8b - H14b) auswirken. Allerdings konnten nur bei drei Pfaden signifikante Effekte beobachtet werden. Bei den Arbeitsanforderungen betraf dies H2b zum wahrgenommenen Leistungsdruck ($\beta = .21$, $p \leq .05$) und H6b zum Technostress ($\beta = .22$, $p \leq .05$). Bei den Arbeitsressourcen zeigte sich ein erwarteter signifikanter Effekt nur bei H11b zu Lernmöglichkeiten ($\beta = .45$, $p \leq .05$). Bei den anderen elf Pfaden ließen sich keine signifikanten Zusammenhänge beobachten.

Die Hypothesen H2c - H14c bezogen sich auf die Puffer-Hypothese des JDR-Modells und beinhalteten, dass die Arbeitsanforderungen das Arbeitsengagement (H2c - H7c) negativ und die Arbeitsressourcen die emotionale Erschöpfung (H8c - H14c) negativ beeinflussen. Entgegen den Erwartungen konnten diese Zusammenhänge nur bei Pfad H11c der wahrgenommenen Lernmöglichkeiten auf die emotionale Erschöpfung ($\beta = -.30$, $p \leq .05$) signifikant gemessen werden. Bei den anderen elf Pfaden ließen sich keine signifikanten Zusammenhänge beobachten. Die letzte Hypothese H15 beinhaltete, dass sich die emotionale Erschöpfung negativ auf das Arbeitsengagement auswirkt. Hier ließ sich ebenfalls ein signifikanter Zusammenhang beobachten ($\beta = -.38$, $p \leq .05$).

4.3. Evaluation des Strukturgleichungsmodells

Das Ziel des spezifizierten Strukturgleichungsmodells ist es, die statistischen Zusammenhänge zwischen den oben näher beschriebenen Variablen darzustellen. Dabei wird vor allem überprüft, inwiefern ein statistisch signifikanter Zusammenhang zwischen der Homeoffice-Nutzung und der emotionalen Erschöpfung sowie dem Arbeitsengagement durch die gemessenen Arbeitsanforderungen und -ressourcen vermittelt wird. Auf Grundlage eines validen Messmodells kann das Strukturmodell nachfolgend beurteilt werden. Hierfür sind zunächst die erklärte Varianz (R^2) der endogenen Konstrukte sowie die Höhe und Signifikanzen der Pfadkoeffizienten zu betrachten. Die Auswertung ergab für das Modell der emotionalen Erschöpfung ein Bestimmtheitsmaß (R^2) von 62 % und für das Arbeitsengagement ein Bestimmtheitsmaß (R^2) von 64 %. Die nachfolgende Analyse der Pfadkoeffizienten bei einem Signifikanzniveau von 5 % führte bei 14 von 39 Pfaden zu einem signifikanten Ergebnis. Die Darstellung des inneren Modells inklusive der Pfadkoeffizienten findet sich in Abbildung 3.

Ein globales Gütekriterium, wie der Goodness of Fit Index (GFI) könnte abschließend zur Evaluation herangezogen werden. Dieser ist allerdings nur als Vergleichsmaß zwischen Strukturgleichungsmodellen beziehungsweise kovarianzbasierten Verfahren heranzuziehen. Eine ganzheitliche Gütebeurteilung des Gesamtmodells, im Sinne einer Maßzahl, ist

daher nicht möglich. Um dennoch die Güte von Strukturgleichungsmodellen auf Grundlage des Partial Least Squares (PLS) Ansatzes überprüfen zu können, wird eine Gesamtbewertung verschiedener Gütemaße vorgenommen (Fuchs, 2011, S. 34). Unter Betrachtung der in Abschnitt 3.3 analysierten Messmodelle, der Höhe und Signifikanz der Pfadkoeffizienten sowie der erklärten Varianz, lässt das Strukturgleichungsmodell auf eine bedingt reliable Schätzung des inneren Modells schließen.

5. Diskussion

In diesem abschließenden Kapitel findet zunächst eine Diskussion der erhobenen Daten und eine entsprechende Einordnung in die verwendete Literatur statt. Darauf aufbauend werden praktische Implikationen für die Einführung und Beibehaltung des mobilen Arbeitens bei Auszubildenden festgehalten, bevor abschließend eine kritische Würdigung der Arbeit erfolgt.

5.1. Grundlegende Erkenntnisse

In der durchgeführten Studie wurde das JDR-Modell verwendet, um die Einflüsse mobilen Arbeitens auf das psychische Wohlbefinden Auszubildender zu untersuchen. Dabei wurde davon ausgegangen, dass die Intensität mobilen Arbeitens einerseits die Arbeitsressourcen negativ und andererseits die Arbeitsanforderungen positiv beeinflusst. Dieser Effekt führt aus Perspektive des JDR-Modells zu einem geringeren psychischen Wohlbefinden, was sich in einer erhöhten emotionalen Belastung und einem verringerten Arbeitsengagement widerspiegelt. Entgegen den Erwartungen liefern die Ergebnisse der Befragung keine Hinweise dafür, dass die Intensität mobilen Arbeitens das psychische Wohlbefinden der Auszubildenden über die Pfade der Arbeitsanforderungen oder der Arbeitsressourcen negativ beeinflusst. Wie bereits in dem systematischen Review von Charalampous et al. (2018) zu diesem Themenkomplex zeigte sich auch in der vorliegenden Studie ein ambivalentes Bild.

Nachfolgend werden die Ergebnisse diskutiert und in den Forschungsstand eingeordnet. Der Fokus liegt dabei auf den direkten Effekten der Intensität mobilen Arbeitens auf die Arbeitsanforderungen und -ressourcen. Zu den Hypothesen der Wirkungszusammenhänge des JDR-Modells erfolgt abschließend eine übergreifende Bewertung.

Der wahrgenommene Leistungsdruck bei Auszubildenden, die vermehrt mobil arbeiten, scheint sich entgegen diversen Studien (Ajzen & Taskin, 2021; Groen et al., 2018; Richardson & McKenna, 2014) zu reduzieren (-.27*). Ein Faktor, wie das Bedürfnis, sich im Homeoffice stärker unter Beweis stellen zu wollen, um das Vertrauen der Vorgesetzten zu erhalten (Richardson & McKenna, 2014, S. 730), ließen sich anhand des Samples und der verwendeten Drei-Item-Operationalisierung nicht erkennen. Diese konträren Beobachtungen könnten auf die eingeschränkte Sichtbarkeit während der Arbeit im Homeoffice und die damit einhergehenden reduzierten persönlichen Kontaktpunkte mit Arbeitskollegen zurückzuführen sein (Grant et al., 2013, S. 543). Sowohl die räumliche Distanz als auch die reduzierten Konfrontationsmöglichkeiten seitens der Führungskraft und Kollegen mit der Arbeitsleistung könnten in diesem Zusammenhang zu einer Reduktion des wahrgenommenen Leistungsdrucks geführt haben.

Die wahrgenommenen Arbeitsunterbrechungen scheinen sich bei Auszubildenden, die vermehrt mobil arbeiten, entgegen diversen Studien (Bergefurt et al., 2021; Charalampous et al., 2018; Chesley, 2014; Fonner & Roloff, 2012; Leroy et al., 2021; C. L. Ter Hoeven et al., 2016) zu reduzieren (-.34*). Gemeinhin als relevant angenommene Faktoren, wie erhöhtes Unterbrechungspotenzial durch das private Umfeld (Bergefurt et al., 2021, S. 9) oder die intensivere Nutzung der Informations- und Kommunikationstechnik (Charalampous et al., 2018, S. 17), ließen sich anhand des Samples und der verwendeten Drei-Item-Operationalisierung nicht erkennen. Diese konträren Beobachtungen könnten damit zusammenhängen, dass Auszubildende überwiegend noch bei ihren Eltern leben und im Homeoffice im Vergleich zum Büro mit weniger Unterbrechungen konfrontiert werden, da die Eltern Rücksicht auf ihre Kinder in der Ausbildung nehmen. Durch Informations- und Kommunikationstechnik bedingte Arbeitsunterbrechungen könnten Auszubildende als geringere Unterbrechung wahrnehmen, da sie gewohnt sind, über Smartphones täglich mit einer Vielzahl verschiedener Push-Benachrichtigungen konfrontiert zu werden (Pielot & Rello, 2015, S. 1765). Im Vergleich zum Büro könnte dies bedeuten, dass Unterbrechungen im Homeoffice oder durch Informations- und Kommunikationstechnik als weniger intensive Unterbrechungen wahrgenommen werden als im Fall des Kollegiums im Büro.

Die wahrgenommene ständige Verfügbarkeit scheint sich bei Auszubildenden, die vermehrt mobil arbeiten, entgegen diversen Studien (Derks et al., 2015; Grant et al., 2013; Lautsch et al., 2009; Vartiainen, 2021) nicht signifikant zu verändern. Ein Aspekt, wie das Bedürfnis, über Informations- und Kommunikationstechnik im Homeoffice ständig verfügbar zu sein, um potenziell unklaren Erwartungen der Führungskräfte, der Ausbildenden oder der Kollegschaft gerecht zu werden (Derks et al., 2015), ließen sich anhand des Samples und der verwendeten Drei-Item-Operationalisierung nicht erkennen. Stattdessen zeigte sich lediglich eine negative Tendenz (-.10), die vermuten lässt, dass die empfundene ständige Verfügbarkeit durch das mobile Arbeiten bei Auszubildenden eher reduziert wird. Die Situation, dass Auszubildende in der Regel noch keine umfassende Verantwortung für kritische Arbeitspakete haben und Ausbildende diese kritischen Ergebnisse nicht von Auszubildenden abhängig machen, könnte dazu führen, dass Ausbildende Auszubildende seltener im Homeoffice kontaktieren, um Arbeitsinhalte zu besprechen. Dies führt dazu, dass Auszubildende im Homeoffice keine gesteigerte Verfügbarkeitserwartung wahrnehmen. Die arbeitsrechtlichen Rahmenbedingungen durch den §8 des Jugendarbeitsschutzgesetzes (JarbSchG), können ebenfalls als Erklärungsansatz für diese Beobachtungen dienen.

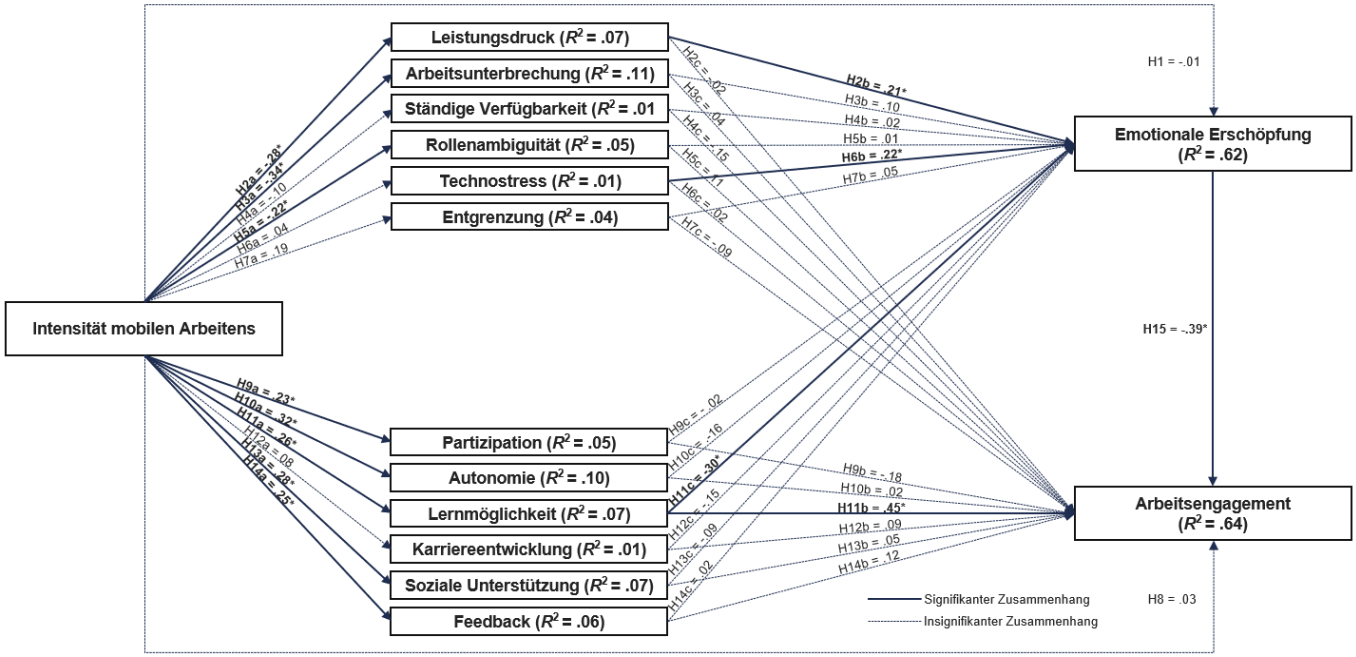

Abbildung 3: Strukturgleichungsmodell - Intensität mobilen Arbeitens & Job-Demands-Resources-Modell

Quelle: Eigene Darstellung
Anmerkung: $n = 110$; $* = p \leq .05$

Die wahrgenommene Rollenambiguität scheint sich bei Auszubildenden, die vermehrt mobil arbeiten, entgegen manchen Studien (Cooper & Kurland, 2002; Golden et al., 2008; Sardeshmukh et al., 2012) zu reduzieren (-.22*). Ein Faktor, wie die Schwierigkeit, Aufgaben und Erwartungen aufgrund eingeschränkter Medienreichhaltigkeit der Informations- und Kommunikationstechnik ausreichend zu deuten (Sardeshmukh et al., 2012), ließen sich anhand des Samples und der verwendeten Drei-Item-Operationalisierung nicht erkennen. Dies lässt sich eventuell darauf zurückführen, dass die Auszubildenden im Homeoffice eher nicht in alle Themen des Büroalltags integriert werden und dadurch seltener mit verschiedenen oder unklaren Aufgaben konfrontiert werden. Darüber hinaus könnten Ausbildungsbeauftragte und Kollegen, die mehrere Aufgaben zu bewältigen haben, dazu neigen, Auszubildenden im Homeoffice eher Aufgaben bzw. Lernpakete zu übertragen, die sie über einen längeren Zeitraum selbstständig bearbeiten können, um Unterbrechungen beziehungsweise Unklarheiten zu vermeiden. Zusätzlich könnte durch die verbesserte Informations- und Kommunikationstechnik, wie zum Beispiel bei Videokonferenzsystemen, das Problem der Medienreichhaltigkeit deutlich reduziert worden sein.

Der wahrgenommene Technostress scheint sich bei Auszubildenden, die vermehrt mobil arbeiten, entgegen diversen (Camacho & Barrios, 2022; Park et al., 2021; Suh & Lee, 2017; Taser et al., 2022) nicht signifikant zu verändern (.05). Aspekte, wie die durch Informations- und Kommunikationstechnologien bedingte höhere Arbeitsbelastung oder das Eindringen von Informations- und Kommunikationstechnologien ins Privatleben (Suh & Lee, 2017, S. 152), ließen sich anhand des Samples und der verwendeten Neun-Item-Operationalisierung nicht erkennen. Bei der vorliegenden Studie wurden die drei Facetten Techno-Overload, Techno-Invasion und Techno-Complexity berücksichtigt. Da die angewandten IT-Systeme im Homeoffice mittlerweile größtenteils identisch mit denen im Büro sind (MS Teams etc.), könnte es sein, dass es für Auszubildende keinen signifikanten Unterschied darstellt, ob sie mit ihren Kolleginnen und Kollegen im Büro über MS Teams zusammenarbeiten oder ob sie dies vom eigenen Zuhause aus tun. Dies könnte die geringen Effekte auf Techno-Overload und Techno-Complexity erklären. Hinsichtlich der Techno-Invasion lässt sich der geringe Effekt eventuell auf einen Gewöhnungseffekt bezüglich der mobilen Arbeit beziehungsweise der Nutzung von Informations- und Kommunikationstechnologien zurückführen, der durch das Homeschooling während der Schulzeit vor dem Ausbildungsstart, in der Berufsschule oder später im Betrieb entstanden ist.

Die wahrgenommene Entgrenzung scheint sich bei Auszubildenden, die vermehrt mobil arbeiten, entgegen diversen Studien (Allen et al., 2021; Kerman et al., 2022, S.17; Rigotti et al., 2021; Wang et al., 2020) nicht signifikant zu verändern (.19). Trotz der nicht vorhandenen Signifikanz des beobachteten Effekts deuten die Ergebnisse darauf hin, dass bei Auszubildenden, die vermehrt mobil arbeiten, eine erhöht wahrgenommene Entgrenzung zu erwarten ist. Ein Faktor, wie die häufigere Konfrontation mit Grenzüberschreitung

(Kerman et al., 2022, S. 17), ließen sich anhand des Samples und der verwendeten Vier-Item-Operationalisierung eingeschränkt erkennen.

Bei den Arbeitsressourcen zeigte sich ebenfalls ein unerwartetes Bild. So waren fünf von sechs Pfaden zwischen der Intensität mobilen Arbeitens und den erhobenen Konstrukten signifikant positiv. Lediglich bei der wahrgenommenen internen Karriereentwicklung zeigte sich keine signifikante Beeinflussung durch die Intensität mobilen Arbeitens.

Die wahrgenommene Partizipation scheint sich bei Auszubildenden, die vermehrt mobil arbeiten, entgegen den Ergebnissen zweier Studien (Golden et al., 2008; Vander Elst et al., 2017) zu erhöhen (.24*). Ein Aspekt, wie ein erschwerter Austausch mit der Kollegschaft aufgrund der reduzierten Face-to-Face-Kommunikation und damit einhergehenden verringerten Partizipationsmöglichkeiten (Vander Elst et al., 2017, S. 183) sowie ein erhöhtes Risiko arbeitsbezogener Isolation (Golden et al., 2008, S. 1417), ließen sich anhand des Samples über die verwendete Drei-Item-Operationalisierung nicht erkennen. Eine mögliche Erklärung könnte sein, dass es für Auszubildende einfacher ist, sich über Informations- und Kommunikationstechnologien (z. B. über MS Teams per Chat) oder auch anonyme Befragungstools an Entscheidungsprozessen zu beteiligen, da sie dann keine Angst vor Gruppendruck haben müssen (May, Gilson & Harter, 2004, S. 17).

Die wahrgenommene Autonomie scheint sich bei Auszubildenden, die vermehrt mobil arbeiten, zu erhöhen (.32*), auch wenn bisherige Studien (Molino et al., 2020; Santarpia et al., 2021) zu anderen Ergebnissen kamen. Ein Aspekt, wie die reduziert wahrgenommene Autonomie aufgrund der starken Abhängigkeit und der damit einhergehenden zunehmenden Mehrbelastung, ließen sich anhand des Samples über die verwendete Drei-Item-Operationalisierung nicht erkennen. Damit scheint das Phänomen des Autonomie-Paradoxons (Mazmanian et al., 2013, S. 17) bei Auszubildenden im Zusammenhang mit mobiler Arbeit nicht aufzutreten. Die zusätzliche Flexibilität scheint sich ebenso wie die Möglichkeit, vom eigenen Zuhause aus arbeiten zu können, positiv auf die wahrgenommene Autonomie auszuwirken, wie bereits in anderen Studien festgestellt wurde (Gajendran & Harrison, 2007; Sardeshmukh et al., 2012).

Die wahrgenommenen Lernmöglichkeiten scheinen sich bei Auszubildenden, die vermehrt mobil arbeiten, entgegen der Studie von Pretti et al. (2020) zu erhöhen (26*). Faktoren, wie die eingeschränkten Kollaborationsmöglichkeiten oder die Situation, dass Ausbildende und Kollegen weniger umfassend über den Entwicklungsstand der Auszubildenden Bescheid wissen und daher mit der Übertragung neuer Aufgaben und Entwicklungsmöglichkeiten Schwierigkeiten haben könnten, ließen sich anhand des Samples über die verwendete Drei-Item-Operationalisierung nicht erkennen. Für diese gegensätzlichen Beobachtungen könnten beispielsweise digitale Lernplattformen verantwortlich sein, die es Auszubildenden ermöglichen, selbstbestimmt Ausbildungsinhalte zu erarbeiten, ohne von Kolleginnen und Kollegen im Büro abhängig zu sein. Darüber hinaus erzeugen diese Plattformen möglicherweise ein stärkeres Gefühl der wahrgenommenen Lernmöglichkeiten, da sie autonomer bearbeitet werden können als beim klassischen Face-to-Face-Learning.

Die wahrgenommene interne Karriereentwicklung scheint sich bei Auszubildenden, die vermehrt mobil arbeiten, entgegen diversen Studien (Charalampous et al., 2018; Golden & Eddleston, 2020; Mann & Holdsworth, 2003) nicht signifikant zu verändern (.08). Aspekte, wie die Angst aufgrund mobilen Arbeitens weniger bei Vorgesetzten und Kollegen sichtbar zu sein und durch weniger Vernetzungsmöglichkeiten im Büro hinsichtlich der internen Karriereentwicklung vernachlässigt zu werden (Golden & Eddleston, 2020, S. 1), ließen sich anhand des Samples über die verwendete Drei-Item-Operationalisierung nicht erkennen. Diese Ergebnisse lassen sich eventuell darauf zurückführen, dass während der betrieblichen Ausbildungsphasen die weitere Karriereplanung eine eher nachgelagerte Bedeutung hat. Hinzu kommt, dass sich ein Großteil des Samples zum Zeitpunkt der Befragung im ersten und zweiten Ausbildungsjahr befand und die weitere Karriereplanung vermutlich erst zum Ende der Ausbildung im dritten Jahr an Bedeutung gewinnt.

Die wahrgenommene soziale Unterstützung scheint sich bei Auszubildenden, die vermehrt mobil arbeiten, entgegen einigen Studien (Gajendran & Harrison, 2007; Sardeshmukh et al., 2012; Vander Elst et al., 2017) zu erhöhen (.28*). Faktoren, wie eine durch Informations- und Kommunikationstechnologien verursachte geringere persönliche Face-to-Face-Interaktion, die das soziale Zugehörigkeitsgefühl und die wahrgenommene Unterstützung signifikant negativ beeinflussen könnte, ließen sich anhand des Samples über die verwendete Drei-Item-Operationalisierung nicht erkennen. Dies lässt sich eventuell darauf zurückführen, dass die Auszubildenden weniger Angst haben, virtuell mit Personen in Kontakt zu treten und sich digitale Unterstützung zu suchen. Dank der schnellen Möglichkeit zur Kontaktaufnahme mit einer Vielzahl von Personen an unterschiedlichen Orten ist die wahrgenommene Unterstützung im mobilen Arbeitsumfeld daher größer.

Das wahrgenommene Feedback scheint sich bei Auszubildenden, die vermehrt mobil arbeiten, entgegen diversen Studien (Cooper & Kurland, 2002; Golden et al., 2008; Rice & Gattiker, 2001; Sardeshmukh et al., 2012) zu erhöhen (.25*). Aspekte, wie eine erhöhte Anstrengung, um Feedback zu erhalten oder eine verringerte Qualität aufgrund der reduzierten Medienreichhaltigkeit (Sardeshmukh et al., 2012, S. 197), die das Erleben des Feedbacks potenziell mindert, ließen sich anhand des Samples über die verwendete Drei-Item-Operationalisierung nicht erkennen. Dies lässt sich, ähnlich wie beim Aspekt der sozialen Unterstützung, wohl darauf zurückführen, dass durch die virtuelle Vernetzung das Einholen von Feedback in gewisser Hinsicht vereinfacht wurde. Es muss nämlich nicht mehr stets ein Gesprächstermin vereinbart werden, vielmehr lassen sich Feedbacks auch spontan und kurzfristig einholen. Es könnte daher für mobil Arbeitende leichter sein, sowohl in der Häufigkeit als auch in der Qualität angemessenes Feedback zu erhalten.

Hinsichtlich der direkten Auswirkungen der Intensität

mobilen Arbeitens auf das psychische Wohlbefinden, operationalisiert durch die emotionale Erschöpfung und das Arbeitsengagement, zeigten sich keine relevanten Effekte. Diese Beobachtungen stimmen mit diversen, im Review von Charalampous et al. (2018) verwendeten Studien, überein.

Für die analysierten Zusammenhänge des JDR-Modells zeigten sich nur in wenigen Fällen signifikante Effekte. So waren es lediglich die Arbeitsanforderungen Leistungsdruck und Technostress, bei denen ein signifikanter Zusammenhang mit der emotionalen Erschöpfung messbar war. Bei den Arbeitsressourcen ließ sich ein solcher Zusammenhang nur bei den Lernmöglichkeiten feststellen. Hier trat neben dem direkten positiven Effekt auf das Arbeitsengagement auch ein negativer Effekt auf die emotionale Erschöpfung auf. Wie in der Studie von Demerouti und Nachreiner (2019, S. 124) postuliert, zeigte sich ein abmildernder Effekt des Arbeitsengagements auf die emotionale Erschöpfung (-39*). Bei allen verbliebenen untersuchten Hypothesen des JDR-Modells konnten keine signifikanten Zusammenhänge beobachtet werden. Dies könnte entweder durch die geringe Stichprobengröße und eine damit einhergehende Verzerrung erklärbar sein oder aber durch eine tatsächlich abweichende Wahrnehmung der Arbeitsanforderungen und -ressourcen bei Auszubildenden.

Angesichts der aktuellen wissenschaftlichen Studienlage und der intensiven Betrachtung des mobilen Arbeitens bei kaufmännischen Auszubildenden ist das auffälligste Ergebnis, dass die Nutzung mobilen Arbeitens mit steigender Intensität weder einen relevanten direkten positiven noch negativen Einfluss auf das psychische Wohlbefinden zu haben scheint. Die Bedeutung der Intensität mobilen Arbeitens im Kontext des JDR-Modells konnte insofern aufgezeigt werden, als sich bei acht von zwölf Pfaden ein signifikanter Effekt zwischen Intensität mobilen Arbeitens und Arbeitsanforderungen sowie -ressourcen beobachten ließ. Ein signifikanter Effekt ließ sich allerdings nur bei wenigen Pfaden zwischen den Arbeitsanforderungen und -ressourcen und der emotionalen Erschöpfung (H2b, H6b, H11c) beziehungsweise dem Arbeitsengagement (H11b) beobachten. Insgesamt lassen die Ergebnisse darauf schließen, dass neben den gemessenen Variablen weitere Faktoren für eine umfangreichere Evaluation notwendig sind (Schulte et al., 2021, S. 407; World Health Organization, 2019, S. 1), die die Varianz des psychischen Wohlbefindens bei Auszubildenden, die mobil arbeiten, besser erfasst. Dies umschließt ebenfalls die aufgeklärte Varianz der erhobenen Arbeitsanforderungen und -ressourcen. In dieser Studie wurden persönlichkeitsbezogene oder soziodemographische Faktoren nicht berücksichtigt.

Aufgrund der speziellen Kohorte trägt diese Studie zu einer Differenzierung der Validität des JDR-Modells bei jungen Berufstätigen bei. Da die Berufsausbildung in Deutschland ein besonderes Konzept des Berufseinstiegs im Vergleich zu anderen Ländern darstellt (Schultheis, Sell & Becher, 2021), ist an dieser Stelle auf die mögliche eingeschränkte Generalisierbarkeit im globalen Kontext hinzuweisen. Hinsichtlich der theoretischen Diskussion leistet diese Arbeit insofern einen Mehrwert, als sie dem Forschungsaufruf von Biebeler und Schreiber (2020, S. 36) nachgekommen ist und auf ein differenziertes Bild hinsichtlich möglicher relevanter psychischer Belastung hinweist, um einen Beitrag zu neuen gesetzlichen Regelungen bzw. praktischen Implikationen zu leisten. So wie die bisherigen Ergebnisse wissenschaftlicher Studien dazu, ob mobiles Arbeiten eher positive oder negative Konsequenzen mit sich bringt, ambivalent ausfallen, lautet die Antwort auch für die in dieser Arbeit untersuchte Kohorte, dass es keine pauschale Antwort gibt. Die individuellen Gegebenheiten müssen berücksichtigt werden, um auf der einen Seite mögliche Vorteile zu nutzen und auf der anderen Seite negative Auswirkungen gering zu halten.

5.2. Praktische Implikationen

Auf Grundlage der diskutierten Arbeitsanforderungen und -ressourcen mobil arbeitender Auszubildender lassen sich einige Vorschläge für die Praxis ableiten, die die Erhaltung des psychischen Wohlbefindens unterstützen können. Grundsätzlich sollte unabhängig von der Homeoffice-Nutzung auf die Balance zwischen Arbeitsanforderungen und verfügbaren Ressourcen geachtet werden, um das psychische Wohlbefinden zu fördern (Härtwig & Sapronova, 2021, S. 70). Wenn ausbildende Unternehmen mobiles Arbeiten aus rechtlichen und betrieblichen Gründen für Auszubildende einführen beziehungsweise fortführen, ist auf einige Aspekte hinzuweisen, die in der vorliegenden Studie auf besondere Relevanz hinweisen, um das psychische Wohlbefinden zu stärken. Da Auszubildende überwiegend zum ersten Mal in ihrem Leben mit dem Konzept des mobilen Arbeitens in Berührung kommen, ist es empfehlenswert, zu Beginn der Ausbildung über mögliche Chancen und Risken aufzuklären. Entsprechend sollte diesem Themenbereich ein eigener Abschnitt des Onboardings gewidmet werden. Zum einfacheren Verständnis und zur Adaption sollte auf Erfahrungsberichte und Empfehlungen gegenwärtiger oder ehemaliger Auszubildender zurückgegriffen werden, die gemeinsam mit Ausbildungsbeauftragten dazu referieren könnten. Gemeinsam mit der betrieblichen Ausbildungsleitung können so in den ersten Tagen der Berufsausbildung die unternehmensinternen Richtlinien, die gesetzlichen Rahmenbedingungen sowie Best Practices für mobiles Arbeiten vermittelt werden. Durch die intensive Beschäftigung mit der Thematik lassen sich neben aufklärenden Inhalten auch präventive Möglichkeiten und Anlaufstellen aufzeigen.

Anhand der Studienergebnisse zeigte sich, dass ein besonderer Fokus auf den Themen Entgrenzung, Technostress und Lernmöglichkeiten liegen sollte. Im Rahmen einer frühzeitigen Auseinandersetzung mit dem Thema Entgrenzung kann auf die Gefahren des psychologischen Detachments hingewiesen werden. Gleichzeitig können dadurch Maßnahmen aufgezeigt werden, um dem entgegenzuwirken. Neben der Schaffung eines Bewusstseins für mögliche Risiken bei Ausbildenden und Auszubildenden können durch praktische Handlungsempfehlungen wie eine räumliche Trennung zwischen Arbeits- und Privatsphäre im eigenen Zuhause und die Nutzung eines Arbeitszimmers Möglichkeiten aufgezeigt werden, mit denen aktiv eine Grenze gezogen, die

wahrgenommene Boundary Control erhöht sowie Arbeitsunterbrechungen zuhause reduziert werden können (Allen et al., 2021, S. 74). Darüber hinaus sollte zu Beginn einer neuen Ausbildungsstation explizit über die Regelungen zur „Nichtarbeitszeit“ gesprochen werden, um hier zusätzlich von Unternehmensseite, bei der Grenzziehung zu unterstützen und um mögliche Rollenambiguität und das Gefühl ständiger Verfügbarkeit zu reduzieren (Derks et al., 2015, S. 170). Praktisch ließe sich dies beispielsweise durch eine Meldung des Auszubildenden an die Ausbildungsbeauftragten umsetzen, dass sie ihren Arbeitstag jetzt beenden. Durch dieses Signal könnte eine zusätzliche Grenzziehung aus Perspektive der Auszubildenden vorgenommen werden. Die Kolleginnen und Kollegen könnten dies wiederum als Signal verstehen, die Freizeit der Auszubildenden zu respektieren und sie nicht mehr zu kontaktieren. Dadurch würde die Fürsorgepflicht berücksichtigt und gleichzeitig die Erholungsphase der Auszubildenden optimiert. Da Fähigkeiten im Umgang mit Informations- und Kommunikationstechnologien essenziell für die erfolgreiche Einbindung in den virtuellen Arbeitsalltag sind, sollte im Onboarding beziehungsweise zu Beginn der Ausbildung auf die Vermittlung entsprechender Grundkompetenzen geachtet werden. Dadurch könnte sich auch die mögliche Belastung durch Techno-Overload, Techno-Invasion und Techno-Complexity reduzieren lassen. Hierbei sollte auch die technische Ausstattung für das mobile Arbeiten berücksichtigt werden, da diese die Basis der virtuellen Zusammenarbeit darstellt. Um über den Ausbildungsstart hinaus die Remote-Work-Kompetenz zu forcieren und möglichen Technostress gering zu halten, sollten Ausbildungsbeauftragte regelmäßig Inhalte mit entsprechendem Bezug implementieren und Reflexionsmöglichkeiten schaffen.

Bezüglich der Auswirkungen auf die Arbeitsressourcen sollten Betriebe darauf achten, das übergeordnete Ziel der beruflichen Ausbildung – die berufliche Handlungsfähigkeit – nicht zu vernachlässigen. Auch wenn Ausbildungsfortschritte nicht Bestandteil der Befragung waren, zeigte sich die besondere Relevanz der wahrgenommenen Lernmöglichkeiten für die Auszubildenden. Im Einklang mit dem Ausbildungsziel nach § 1 Abs. 3 des Berufsbildungsgesetzes (BBiG) ließen sich bei wahrgenommenen Lernmöglichkeiten die größten positiven Effekte auf das Arbeitsengagement bei gleichzeitig stärkster Reduktion der emotionalen Erschöpfung feststellen. Ausbildende sollten darauf achten, dass Auszubildende, die vermehrt im Homeoffice arbeiten, während ihrer betrieblichen Einsatzzeiten im Blick behalten und ausreichend betreut werden. Hier sollten aufgrund der eingeschränkten Möglichkeiten in Bezug auf die Medienreichhaltigkeit solche Ausbildungsinhalte identifiziert und abgegrenzt werden, die sich besonders zur virtuellen Vermittlung eignen (Biebeler & Schreiber, 2020, S. 18). Die Nutzung digitaler Lernplattformen kann in diesem Zusammenhang positive Effekte mit sich bringen, die wahrgenommene Autonomie erhöhen und zu einem selbstgesteuerten Lernen beitragen.

Die Ergebnisse zeigen, dass aus Perspektive des JDR-Modells mobiles Arbeiten den Auszubildenden grundsätzlich nicht verwehrt werden sollte, solange nicht andere betriebliche oder gesetzliche Gründe dagegensprechen. Es zeigten sich vielmehr sogar zahlreiche positive Effekte auf die Arbeitsressourcen und negative Effekte auf die Arbeitsanforderungen, die in der Summe für eine Nutzung mobilen Arbeitens als mögliche Arbeitsform sprechen. Bei der Einführung oder Fortführung mobilen Arbeitens sollten allerdings über das psychische Wohlbefinden hinaus die rechtlichen und betrieblichen Rahmenbedingungen berücksichtigt werden, um die übergeordneten Ausbildungsziele nicht zu vernachlässigen. Dann kann weiterhin eine hohe Ausbildungsqualität gewährleistet werden.

5.3. Limitationen & Forschungsausblick

Abschließend wird auf diejenigen Aspekte dieser Arbeit hingewiesen, die in ihrer Validität kritisch zu beurteilen sind. Durch die Erhebung von Querschnittsdaten sind keine Rückschlüsse auf kausale Ursache-Wirkungsbeziehungen möglich. Aufgrund der geringen Stichprobengröße lassen sich ebenfalls keine statistisch repräsentativen Schlussfolgerungen auf die Grundgesamtheit der kaufmännischen Auszubildenden ziehen. In diesem Zusammenhang ist hervorzuheben, dass sich nur 23.64 % der Befragten im ersten Ausbildungsjahr befanden, sodass mögliche Lerneffekte hinsichtlich des Umgangs mit mobiler Arbeit nicht gleichmäßig berücksichtigt werden konnten. Zusätzlich könnten durch die geringe Stichprobengröße besonders Auszubildende aus denjenigen Unternehmen berücksichtigt worden sein, in denen mobiles Arbeiten bereits etabliert ist und eine fundiertere Einarbeitung stattgefunden hat. Auch andere soziodemographische Daten wie Alter, Geschlecht oder mögliche Vorerfahrung wurden nicht weiter einbezogen. Darüber hinaus wurde zur Vereinfachung des Modells angenommen, dass die Beziehungen zwischen den operationalisierten Konstrukten linear seien, obwohl bereits Golden (2006) auf einen invertierten u-förmigen Zusammenhang zwischen der Intensität mobilen Arbeitens und der Arbeitszufriedenheit hinwies. Des Weiteren ist auf einen möglichen Habituationseffekt (Thompson & Spencer, 1966) bezüglich homeofficebedingter Stressoren hinzuweisen. Dies könnte nachlassende negative Effekte hinsichtlich des Wohlbefindens erklären.

Es fand kein Vergleich von Strukturgleichungsmodellen statt, sodass keine bessere Passung hinsichtlich der gewählten Konstrukte vorgenommen werden konnte. Bezüglich der Operationalisierung der latenten Konstrukte ist darauf hinzuweisen, dass die Daten nur auf subjektiven Einschätzungen der Befragten beruhen und daher im Gegensatz zu objektiven Messungen den Abläufen eines psychologischen Frage-Antwort-Prozesses unterliegen. Dementsprechend ist, durch die Distanz des Online-Fragebogens, der Effekt der sozialen Erwünschtheit (Tourangeau & Rasinski, 1988, S. 307) geringer als er in persönlichen Befragungen sein sollte (Tourangeau, Rips & Rasinski, 2000, S. 277). Darüber hinaus kann es aufgrund der nicht verwendeten Randomisierung der Fragenreihenfolge und eines möglicherweise damit einhergehenden Halo-Effektes zu einer systematischen Verzerrung der Antworten gekommen sein (Schnell, Hill & Esser,

2011, S. 346). Außerdem ist bei der Validität der gemessenen Arbeitsanforderungen und -ressourcen zu erwähnen, dass diese überwiegend nur mit drei Items operationalisiert wurden und daher möglicherweise nicht alle Facetten der latenten Konstrukte vollständig erfasst wurden. Insgesamt ist daher auf eine gegebenenfalls eingeschränkte Konstruktvalidität hinzuweisen.

In Bezug auf die COVID-19-Pandemie ist zu berücksichtigen, dass damit einhergehende Faktoren als Störvariable die Messungen ebenfalls beeinflusst haben können. Darüber hinaus ist zu erwähnen, dass ein Teil der Stichprobe durch das pandemiebedingte Homeschooling bereits vor dem Ausbildungsstart Erfahrungen mit dem virtuellen Lernen sammeln konnte. Diese Faktoren sind in Bezug auf die Replizierbarkeit der Messungen zu berücksichtigen. Hinsichtlich einer generellen Aussage über den Einfluss mobilen Arbeitens auf das psychische Wohlbefinden Auszubildender ist zu erwähnen, dass individuelle Attribute, beispielsweise genetische und biologische Faktoren, oder Umweltfaktoren, beispielsweise der kulturelle Einfluss, nicht berücksichtigt wurden. Darüber hinaus wurden von insgesamt 37 möglichen Arbeitsanforderungen und -ressourcen des „Ressourcen und Anforderungen (ReA) in der Arbeitswelt“-Fragebogen nur 11 berücksichtigt. Insgesamt kann daher nur über eine sehr eingeschränkte Auswahl an möglichen relevanten Faktoren hinsichtlich des psychischen Wohlbefindens eine Aussage getroffen werden.

Somit gestaltet sich eine generelle Aussage über das mobile Arbeiten schwierig, da neben der Intensität auch andere Faktoren berücksichtigt werden müssten, um eine aussagekräftige Ableitung treffen zu können. Zu diesen Faktoren könnten beispielsweise die unterstützenden Rahmenbedingungen des Unternehmens, die Einarbeitung, die technische Ausstattung oder die räumlichen Rahmenbedingungen zuhause zählen.

Um sowohl neue Implikationen für die Praxis ableiten zu können als auch das JDR-Modell zusätzlich zu validieren, könnte das Thema der mobilen Arbeit bei Auszubildenden in weiteren Studien längsschnittlich untersucht werden. Besonders der Nutzen spezifischer Onboarding- und Trainingsmaßnahmen könnte so evaluiert werden. Darüber hinaus könnten durch Tagebuchstudien die möglichen Lerneffekte im Umgang mit mobiler Arbeit neue Erkenntnisse für die Kompetenzvermittlung und Stressprävention aufdecken.

6. Zusammenfassung

Diese Studie erweitert die Literatur zu den Auswirkungen mobilen Arbeitens unter den Bedingungen der COVID-19-Pandemie. Sie beleuchtet die Auswirkungen der neuen Arbeitsform auf das psychische Wohlbefinden kaufmännischer Auszubildender unter Verwendung des JDR-Modells. Die Studienergebnisse haben gezeigt, dass mobiles Arbeiten sowohl zu einer Verstärkung als auch zu einer Reduktion spezifischer Arbeitsanforderungen und -ressourcen führen kann. Die vorteilhaften Effekte des mobilen Arbeitens scheinen dabei zu überwiegen, da keine der erhobenen Arbeitsanforderungen in der Studie durch die Intensität dieser Arbeitsform signifikant positiv beeinflusst wurde.

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Enabling E-Mobility: How Electric Grids Can Support High EV Adoption with Residential PV and Battery Energy Storage Systems

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Abstract

Understanding the challenges electrical distribution grids will have to bear in the future is essential to take appropriate measures and ensure electrical grid infrastructure stability. This thesis deploys representative grid models for varying agglomeration scenarios and seasons to investigate the challenges and synergies that arise with high EV penetration rates, PV electricity generation and BESS. The central innovation lies in the developed large-scale model which considers time of year and agglomeration variation, all of which influence household and charging electricity demand, PV generation, as well as PV and EV penetration. Based on a large dataset on German mobility, a Markov chain is developed to sample a trip chain for each individual in the model. Based on the trip chain, EV energy demand and EV charging decisions are simulated. Household loads and PV generation are synthetically modelled to account for external influences. All load and generation profiles then interact with residential BESS and the resulting profile is deployed in three MATLAB MATPOWER grid models. An investigation of power flows showed that transformer thermal limits and feeder line thermal limits are the most critical components. Whilst rural grids are most vulnerable to increased loads through higher EV penetration rates, the mitigation potential with PV electricity generation and BESS is also highest. If every home that has an EV is equipped with a PV-BESS, the grid's capacity for maximum EV penetration increases by up to 50%.

Keywords: Electric vehicle charging; Photovoltaic systems; Electrical distribution grid; Battery energy storage system; Power flow analysis.

1. Introduction

Greenhouse gas emissions and energy supply insecurities necessitate a shift towards mobility and energy solutions without fossil fuel dependency. Recent geopolitical developments further highlighted the importance of energy independency. The transportation sector is responsible for 23% of the global energy related CO_2 emissions, with passenger road vehicles accounting for 44% of these emissions.[1] This has become an issue of great importance as the electrification of private transportation plays a significant role in achieving low-carbon targets. This introduces technical challenges for local power grids. Widespread integration of electrical vehicles (EV) in the distribution grid can lead to electrical equipment overloading and undervoltage issues. Furthermore, unpredictable energy price developments, energy dependencies, and carbon intensive energy generation might dampen the transition towards green mobility solutions and its environmental benefits. At the same time, prices for renewable power generation such as photovoltaic (PV) energy distinctly reduced over the last decades enabling the widespread adoption of PV systems.[2] These systems can have an opposite impact on electrical distribution grids – too much generation can lead to overvoltage issues and transformer overloading through reverse power flows. Together, the intense energy demand induced by EV charging operations and the surplus power generation by intermittent PV arrays might allow the mitigation of adverse effects on electrical distribution grids. This opportunity would forsake the need for costly infrastructure upgrades of the grid.

Understanding the loads electrical distribution grids will have to bear in the future is essential. Simulation models are needed to study the effect of high EV and PV penetration

[1] Cf. IEA (2021b); Cf. IEA (2022).

[2] Cf. Our World in Data (2020).; Cf. Umweltbundesamt (2021a, p. 7).

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on electricity networks to derive suitable measures. Electrical grids need to be operated within specified limits to ensure smooth operation and compliance with required power quality standards.[3] McKinsey & Company estimates that the total annual electrical energy demand in Germany increases 8% over the current energy demand in an adoption scenario with 16 million EVs.[4] To develop a greater understanding on the impact of charging EVs on electrical distribution networks a detailed model to forecast the charging demands and subsequently its impact on the electrical distribution grid is required. The total electricity demand for charging operations strongly depends on the charging power, the battery capacity, and the total number of EVs. The latter is greatly influenced by consumers' adoption rate. An increasing number of governments defined target penetration rates of electric vehicles and subsequently adopted pro-EV policies to foster EV adoption.[5] The current government of Germany now aims towards a rapid reduction of CO_2 emissions and agreed on reaching a stock of 15 million electric cars until 2030.[6] This represents a 30-fold increase in the number of EV stock over the current stock, shifting energy demand from fossil fuels to electricity.[7] Further, technological advancements and changing consumer preferences increase consumers' adoption towards EVs.[8] The rapidly decreasing costs of battery capacity made the mass production of EVs with greatly improved maximum driving ranges feasible.[9] To cope with enhanced battery capacities and to keep charging times moderately, charging standards with increasing power limits have been developed.[10] Thus potentially increasing peak charging loads in electrical distribution grids. As a result, thermal limits of electrical distribution equipment might be exceeded, and power quality standards cannot be ensured.

The mitigation of these non-negligible impacts has caused considerable interest due to its importance for policy makers and distribution system operators (DSO). On the network side, DSO would need to perform costly infrastructure side upgrades to enable such high EV penetration rates. On the consumer side, a multitude of approaches, such as controlled smart charging or vehicle to grid applications have been discussed in literature.[11] As these solutions poses restrictions on the charging behavior and battery service life reductions, alternative solutions are highly interesting. Deploying residential PV systems are another option to decrease grids loads induced by EV charging.[12] Due to the intermittent nature of PV generation, synergies of this approach are restricted towards day times only. An opportunity to increase the synergies between EV charging and PV generation is given by deploying battery energy storage systems (BESS) in residential buildings. Thus, increasing the PV self-consumption as well as reducing unwanted surplus generation. This might reduce loads on distribution networks and thus decrease the need for infrastructure side distribution network upgrades.

This thesis deploys representative grid models for varying agglomeration scenarios and seasons to model the synergy potential between high EV penetration rates, PV electricity generation and BESS. Mobility and charging behavior, PV yield profiles, and household load profiles are synthetically generated to account for time of the year and agglomeration characteristics. The resulting electrical profiles are then deployed, and a power flow analysis is conducted in MATLAB using MATPOWER to determine effects on the electrical grid.

The following chapter reviews relevant literature to model and analyze the effect of high EV and PV penetration rates in electrical distribution grids and its interaction with BESS. Having reviewed existing work, the problem statement and the research gap is derived in chapter three. This thesis then continues by introducing the employed data, how it is preprocessed and how it parameterizes the model in chapter four. Based on this data pool, the next chapter focusses on the specific model development and how entities in the model are simulated. Chapter six illustrates the power flow results and analyzes them. The final two chapters cover the discussion of the results and limitations of the work, as well as the conclusion and future research opportunities.

2. Literature review

This section reviews recent literature on the topic of EVs, EV charging, and PV electricity generation. A thematic disaggregation into two subtopics allows the identification of relevant literature and promising methodologies and simulation techniques. First, EV adoption, driving and charging behavior as well as the charging impact on electrical distribution grids are reviewed. Second, the integration of renewable energy generation with PV systems in distribution grids is investigated. This concerns the environmental impact, the impact on the power grid as well as the interaction with BESS. Finally, the novel contribution of this thesis is derived.

2.1. EV deployment characteristics and electrical grid interaction

2.1.1. EV adoption trends

The steadily growing amount of EV sales and registrations contribute towards the goal of emissions' reduction in the transport sector.[13] In existing literature, the EV adoption has been extensively investigated in an attempt to assess influencing factors and to understand EV adoption. However, fluctuating and diverging market growth rates make predictions about future adoption rates challenging. An understanding of these factors is important to assess the impact of

[3] Cf. DIN (1999).
[4] Cf. McKinsey & Company (2021).
[5] Cf. IEA (2021c).
[6] Cf. (Presse- und Informationsamt der Bundesregierung, 2021, p. 51).
[7] Cf. Kraftfahrt Bundesamt (2021b).
[8] Cf. Coffman, Bernstein, and Wee (2017, pp. 82–88).
[9] Cf. Our World in Data (2021).
[10] Cf. IEA (2021c).
[11] Cf. A. Dubey and Santoso (2015, pp. 1882–1890).
[12] Cf. ElNozahy and Salama (2014).
[13] Cf. Gohlke and Zhou (2021, p. 14); Cf. Kraftfahrt Bundesamt (2021a); Cf. Jochem, Rothengatter, and Schade (2016, p. 2); Cf. Jochem et al. (2016, p. 2).

charging EVs on electrical distribution grids, as the amount of total EVs greatly influences the demanded electrical energy. The following chapter will give an overview of recent EV adoption rate trends. Further, factors and characteristics influencing consumer's EV adoption rate are discussed.

In the past, the uptake of EVs grew steadily but remained relatively low and behind governmental expectations.[14] With sales shares in Germany below 3% until 2019 the EV share in total personal vehicle stock also remained very low and only reached a level of 0.64% in 2021.[15] This situation is predicted to change drastically as the growth of the EVs' sales share in Germany skyrocketed with more than 200% year over year growth, reaching 6.6% of total person vehicle sales in 2020.[16] With this rapid rise in consumers' EV adoption rate, the question arises which impacting factors exist and which shall be incorporated in the prediction of future penetration rates.

A review of major studies identified a multitude of factors that affect EV adoption rates.[17] Technological advancements such as decreasing plug-in electric vehicle (PEV) costs and range increases, as well as changing consumer preferences influence adoption rates significantly.[18] Additional factors include socio-demographics, mobility practices, policy interventions, and financial and non-financial incentives created by governmental institutions.[19] The latter are unpredictable in nature and thus an acknowledged constraint for forecasting models.[20] As many of these factors are country specific, significant discrepancies in the EV penetration of new vehicle sales across various countries emerged.[21]

Household-related factors have been extensively documented by existing research. The availability of home charging is suggested to influence PEV adoption, as many consumers prefer to charge at home.[22] This finding is backed by a field study of Patt et al. conducted in Switzerland.[23] Based on answers of 658 participants the relationship between the willingness to purchase a battery electric vehicle (BEV) and the ownership of a parking space was investigated.[24] The result indicates that residents who own their parking space are almost twice as likely to indicate a high willingness to purchase a BEV compared to those who park on the street.[25] This can have an influence on the spatial distribution of EV adoption, as urban areas tend to have significant less privately owned parking spaces then rural areas. To further understand spatial factors, Brückmann et al. investigated BEV adoption in Switzerland, where governmental support for EV adoption is low.[26] Minimizing the influence of political jurisdictions allows for a more precise analysis on spatial patterns of EV adoption. A combination of revealed preference data with the car holder's area of residence links consumer characteristics with spatial characteristics.[27] Their findings suggest that BEV adoption is neither driven by population density of residential areas nor by a higher availability of charging infrastructure.[28] Home-ownership, however, is a significant driver of current BEV adoption.[29] Even though home-ownership is strongly associated with parking space ownership, this finding might be explainable by the strong relationship between the individuals' level of income and their likeliness to adopt a PEV.[30] In other words, people owning homes are more likely to have a higher level of income and thus they are more likely to adopt a PEV. This theory is supported by Chen et al.[31] In their study 4,885 individuals from Denmark, Finland, Iceland, Norway, and Sweden were investigated according to their preferences and their willingness to adopt a PEV.[32] Their findings suggest that there is no significant difference in PEV adoption rates of non-rural and rural residents.[33]

Collectively, these studies suggest that the uptake of EVs will increase greatly driven by a multitude of factors such as technological advancements and decreasing costs. As financial incentives play a major role, significant discrepancies in the EV penetration of new vehicle sales across various countries emerged. Regardless of this, no significant spatial differences in the EV adoption between rural and non-rural residents were identified. Forecasting future penetration rates is important to understand when charging operations of EVs might lead to non-negligible impacts on electrical distribution grids. To further understand the impact of charging EVs it is important to ask when and where charging occurs, and what energy demands to expect. This is covered in the next section.

2.1.2. Driving and charging behavior

Literature that investigated the driving or charging behavior of individuals, or both, is mainly based on mobility data, time of use data, or charging point data. Depending on the deployed data source, current work mainly embodies two types of simulation frameworks: Agent-based electromobility simulations and charging point-based load simulations. First, agent-based electromobility simulations often entail socio-economic, behavioral, and spatial factors and can be implemented using various modelling techniques. Mobility and

[14] Cf. IEA (2021c); Cf. Deutsche Bundesregierung (2009, p. 46).
[15] Cf. IEA (2021a).; Cf. Kraftfahrt Bundesamt (2021b).
[16] Cf. IEA (2021a); Cf. Kraftfahrt Bundesamt (2021b).
[17] Cf. Coffman et al. (2017).
[18] Cf. Coffman et al. (2017, pp. 82–88).
[19] Cf. Coffman et al. (2017, pp. 89–91); Cf. C.-f. Chen, Zarazua de Rubens, Noel, Kester, and Sovacool (2020, pp. 3–6).
[20] Cf. Ensslen, Will, and Jochem (2019, p. 85).
[21] Cf. Graham and Brungard (2021, p. 304).
[22] Cf. van der Kam, van Sark, and Alkemade (2020); Cf. Morrissey, Weldon, and O'Mahony (2016); Cf. Tal, Lee, and Nicholas (2018); Cf. Hardman et al. (2018).
[23] Cf. Patt, Aplyn, Weyrich, and van Vliet (2019).
[24] Cf. Patt et al. (2019, p. 3).
[25] Cf. Patt et al. (2019, p. 6).
[26] Cf. Brückmann, Willibald, and Blanco (2021).
[27] Cf. Brückmann et al. (2021, p. 2).
[28] Cf. Brückmann et al. (2021, p. 8).
[29] Cf. Brückmann et al. (2021, p. 10).
[30] Cf. C.-f. Chen et al. (2020, p. 11).
[31] Cf. C.-f. Chen et al. (2020).
[32] Cf. C.-f. Chen et al. (2020, p. 5).
[33] Cf. C.-f. Chen et al. (2020, p. 11).

time of use data can be used to extract temporal or spatial information to build models, such as Hidden Markov chains or other deterministic models. Second, charging point-based load simulations employ charging data to identify temporal or spatial charging patterns and to predict charging demands. In the past, simulations have been realized with a wide variety of modelling techniques, such as Monte Carlo simulations, decision trees, or multinomial logit models. The following chapter gives an overview of identified charging preferences derived from both data types as well as their chosen simulation frameworks. Further, novel contributions in literature with enhanced methodologies are discussed. These are built on these two simulation frameworks and refine or combine them to develop a model embracing multiple empirical data sources and to account for as many influential factors as possible.

A stochastic bottom-up modelling approach for predicting residential EV use, charging behavior, and resulting electrical load profiles was presented by Fischer at al.[34] Based on a large German mobility dataset, a Markov chain including the most significant influencing factors on residential charging behavior was developed.[35] The results suggest that car-type, charging infrastructure, day of the week and the agent's working times have the strongest influence on EV usage.[36] The agent-based electromobility simulation indicates peak electricity loads at 6:00 p.m. which can, depending on the charging power, increase the overall peak load of a household up to a factor of 3.6 compared to a household without EVs.[37] These findings are in line with the demand predictions of a conference paper based on the UK National Travel Survey and a study based on UK 2000 time of use survey data.[38] Both works were able to predict and observe temporal charging patterns with peak demands in the early evening. Recent work by Habib et al. extends the stochastic modelling approach based on mobility data by including various external factors, such as type of EVs based on market trends.[39] A subsequent Monte Carlo simulation was then carried out to develop the stochastic charging profiles.[40] The results confirm previous findings and suggest high peak loads by uncontrolled EV charging.[41] A partly acknowledged natural limitation of that approach is given by superimposing mobility behavior of internal combustion engine vehicles (ICEV) to EVs. A study in Norway's maturing electric vehicle market identified a stronger change in driving behavior after buying a BEV.[42] However, results also suggest that buyers of a BEV are in a stage of life, in which travel changes are more likely to occur, therefore clear conclusions cannot be drawn.[43]

An analysis of charging-point data was employed by Schäuble et al. They analyzed the charging behavior patterns of EV based on electric mobility studies of early adopters.[44] Empirical load profiles on data covering over 30,000 recorded charging operations between 2011 and 2015 in Germany and France are observed and subsequently synthetic load profiles are generated.[45] Results indicate that 60% of charging operations are completed at home with clear charging patterns differentiating weekdays and weekends.[46] Weekday charging peaks occur at 6:15 p.m., while charging load decreases to nearly zero from 2:30 a.m. to 5:30 a.m. in presence of fast charging.[47] Work based on Irish charging data from the years 2012 to 2015 also observed an accumulation of home charging events during evening times, highlighting temporal charging patterns.[48] However, dated data accommodating EVs with significantly smaller battery capacities than today's vehicles and the potentially unique charging behavior of early adaptors might lead to hardly generalizable results of both studies.[49] Therefore, more recent data should be employed.

Figenbaum analyzed data from two fast charging station providers with a total network of more than 1,500 stations in Norway.[50] Norway provides a great research environment as their EV fleet share is among the highest with 9.4% EVs of total passenger vehicles.[51] The results suggest, that only 4-6% of the total EV energy demand is provided by fast chargers.[52] Furthermore, a survey of Norwegian EV owners indicated that only 12% of owners charge at least once per week at public facilities and that 93% have access to charging at home.[53] These findings are supported by multiple other contributions which suggest, that most of the charging is done at home.[54] Nevertheless, public charging might play an indispensable role in urban areas, as less than 60% of urban US households can park on their own property.[55] First predictions in Germany estimate an out-of-home charging probability of 33% in metropolitan areas.[56] The majority of public charging points do not provide fast charging power.[57] A study conducted by van der Kam et al. based on more than one million charging operations at approximately 25,000 unique

[34] Cf. Fischer, Harbrecht, Surmann, and McKenna (2019).
[35] Cf. Fischer et al. (2019, p. 10).
[36] Cf. Fischer et al. (2019, p. 17).
[37] Cf. Fischer et al. (2019, p. 14).
[38] Cf. Crozier, Apostolopoulou, and McCulloch (2018, p. 5); Cf. Wang and Infield (2018, p. 93).
[39] Cf. Habib et al. (2020, p. 301).
[40] Cf. Habib et al. (2020, p. 301).
[41] Cf. Habib et al. (2020, p. 305).
[42] Cf. Figenbaum and Nordbakke (2019, p. 53).
[43] Cf. Figenbaum and Nordbakke (2019, p. 20).
[44] Cf. Schäuble, Kaschub, Ensslen, Jochem, and Fichtner (2017).
[45] Cf. Schäuble et al. (2017, pp. 7–10).
[46] Cf. Schäuble et al. (2017, pp. 16–25).
[47] Cf. Schäuble et al. (2017, pp. 26–28).
[48] Cf. Morrissey et al. (2016, p. 263).
[49] Cf. Schäuble et al. (2017, pp. 17–18); Cf. Electric Vehicle Database (2021).
[50] Cf. Figenbaum (2020).
[51] Cf. Figenbaum (2020, p. 42).
[52] Cf. Figenbaum (2020, p. 48).
[53] Cf. Figenbaum and Nordbakke (2019, p. 26).
[54] Cf. Lee, Chakraborty, Hardman, and Tal (2020, p. 11); Cf. Thingvad, Andersen, Unterluggauer, Træholt, and Marinelli (2021, p. 10); Cf. Kleiner, Brokate, Blaser, and Friedrich (2018, p. 218); Cf. Baresch and Moser (2019, p. 388).
[55] Cf. Traut, Cherng, Hendrickson, and Michalek (2013, p. 143).
[56] Cf. Kleiner et al. (2018, p. 218).
[57] Cf. Chargemap (2022).

charge points in the Netherlands investigated public charging behavior.[58] Contrary to the findings of Chen et al., their results suggest a smaller charging impact induced by public charging.[59] The charging profile is smoother and does not include high gradients. Peak loads are observable at 9:00 a.m. and 6:00 p.m. and a base load by public charging piles is observable throughout the day.[60] Hence, public charging load peaks, based on this data, are not as pronounced as private home charging.

This section has illustrated a review of techniques used to simulate driving and charging behavior and discussed charging preferences. Both simulation frameworks lead to similar results regarding identified charging patterns. Most of the charging operations are executed between 6:00 p.m. and 9:00 p.m. on weekdays, while home charging plays a major role in providing most of the EV energy demand. These temporal patterns in charging demands raise the question of how the increased electricity consumption influences electrical distribution grids. This will be discussed in the next chapter.

2.1.3. Charging impact on distribution grids

Academic research investigated the EV charging impact on electrical grids for a considerable period of time, ranging from the early work of Taylor et al. over a decade ago to most recent work published this year.[61] It has been extensively evaluated in an attempt to characterize, classify and measure potential effects and to derive recommendations for grid operators and policy makers. Existing work differs significantly regarding the complexity and assumptions made to model the EV charging load, the network topology, and the investigated metrics of the charging impact. The following section provides an overview of chosen metrics and findings regarding the charging impact on electrical distribution grids.

Initial work by Clement-Nyns et al. investigated the impact of charging plug-in hybrid electric vehicles (PHEV) on a residential distribution grid. Based on home arrival times the impact of home charging 8.8 kWh PHEV batteries with a 4 kW charger in an IEEE 34-node test feeder grid topology is simulated.[62] Therefore, they undertook a feeder level analysis as proposed by Taylor et al.[63] Different scenarios are realized by varying the EV adoption rate and subsequently, power losses and maximum voltage deviations are calculated.[64] The results suggest that the uncoordinated charging of batteries of PHEVs has a non-negligible impact on the distribution grid.[65] A lack of complexity in the simulation model for PHEV loads as well as the low battery capacity of PHEVs limit the work of Clement-Nyns et al. Nevertheless, later work, which explicitly focused on voltage deviations induced by additional EV charging loads, were able to confirm these results.[66] These papers by Ul-Haq et al. and Ma et al. both examined voltage characteristics of single nodes in more complex distribution networks: IEEE30 node system and a CIGRE low-voltage European distribution benchmark system respectively.[67]

Beside voltage deviations, a great extent of literature studied the influence of EV charging on distribution grid peak loads.[68] Wang and Infield simulated the charging impact predicted by a Markov Chain Monte Carlo simulation of vehicle use patterns in a single phase distribution network layout.[69] They employ load profiles for domestic households alongside the predicted EV charging profiles for both weekdays and weekends.[70] The results suggest that the EV charging loads occur at the same time as domestic base peak loads and thus total peak loads increase significantly for a single household with an EV.[71] Further, the voltage profile for the household in the distribution network, which suffers the most from the network impact due to its location, is investigated. All power flow analyses have been conducted with the dedicated network simulator "Open Distribution System Simulator" (OpenDSS).[72] An analysis of voltage bound violations predicts violations during weekdays with EV penetration rates of 30% and above.[73] Additionally, the thermal performance of the substation feeder is examined. The substation feeder is part of the distribution equipment. Distribution equipment is rated until a specific power load in kVA. Exceeding this power load can lead to shortened lifespans of the equipment or in extreme cases to thermal overloading and damage.[74] In the simulated scenario with EV penetration rates of 70% and above the specified line limit of 50 kW might be exceeded.[75] Applicability of results to a European environment might be difficult due to the simplified single phase distribution network layout, as most European distribution networks are based on three phase networks. Further limitations might be given since the chosen EV characteristics of a 2013 vehicle with a battery capacity of 18.8 kWh are already outdated compared to battery capacities of newly sold EVs.[76]

Habib et al. extended the model for the network load by developing a stochastic EV model incorporating additional

[58] Cf. van der Kam et al. (2020, p. 7).
[59] Cf. van der Kam et al. (2020); Cf. J. Chen, Li, Yang, and Ma (2020).
[60] Cf. J. Chen et al. (2020, p. 9); Cf. van der Kam et al. (2020, p. 8).
[61] Cf. Taylor, Maitra, Alexander, Brooks, and Duvall (2009); Cf. Rahman, Khan, Khan, Mallik, and Nadeem (2022).
[62] Cf. Clement-Nyns, Haesen, and Driesen (2010, pp. 371–372).
[63] Cf. Taylor et al. (2009, p. 6).
[64] Cf. Clement-Nyns et al. (2010, p. 373).
[65] Cf. Clement-Nyns et al. (2010, p. 378).
[66] Cf. Ul-Haq, Cecati, Strunz, and Abbasi (2015, p. 56); Cf. Ma, Jiang, Chen, Dai, and Ju (2017, p. 503); Cf. Habib et al. (2020, p. 313).
[67] Cf. Ul-Haq et al. (2015, p. 54); Cf. Ma et al. (2017, p. 501).
[68] Cf. Muratori (2018); Cf. Zhang, Yan, Liu, Zhang, and Lv (2020); Cf. Pagani, Korosec, Chokani, and Abhari (2019); Cf. Calearo, Thingvad, Suzuki, and Marinelli (2019); Cf. Haider and Schegner (2021); Cf. Wang and Infield (2018).
[69] Cf. Wang and Infield (2018, pp. 86–92).
[70] Cf. Wang and Infield (2018, p. 92).
[71] Cf. Wang and Infield (2018, p. 93).
[72] Cf. Wang and Infield (2018, p. 92).
[73] Cf. Wang and Infield (2018, p. 93).
[74] Cf. Haque, Shafiullah, Nguyen, and Bliek (2016, p. 3).
[75] Cf. Wang and Infield (2018, p. 93).
[76] Cf. Wang and Infield (2018, p. 91); Cf. Electric Vehicle Database (2021).

parameters, such as varying EV types or charging powers.[77] Subsequently, households are differentiated by their size and a predefined number of EVs is assigned for each adoption rate scenario.[78] Households between 125 and 250 square-meters are simulated with one EV each, while the biggest categorized household with 500 square-meters is simulated with two EVs.[79] Household type dependent residential demands alongside charging demands are deployed in an extended version of the IEEE 13-node test feeder network.[80] Network characteristics are then analyzed in the power flow tool "DigSilent Power Factory" for different scenarios.[81] The investigated metrics include: Thermal limits of transformers, feeder losses, voltage behavior, and voltage unbalance factor.[82] The former two metrics address the distribution equipment in the network while the latter two are energy quality related measures. The simulation results illustrate that thermal limits of transformers are exceeded in case of 7.2 kW charging with a 40% penetration rate.[83] Furthermore, voltage drops exceed regulatory voltage limits in the 40% penetration rate scenario at around 7:00 p.m. for both scenarios with either a 1.9 kW charger or a 7.2 kW charger.[84]

In summary, existing literature analyzed the charging impact in simulated distribution networks by investigating peak charging loads, voltage deviations, and thermal power limits of grid components. The overall results suggest that there is a significant impact of EV charging on distribution grids in scenarios with higher EV penetration rates. Therefore, possibilities to mitigate this impact should be evaluated.

2.2. Charging with renewable energy sources

One possibility to mitigate the impact of EV charging on distribution grids, which is discussed in scientific research, is to employ distributed and renewable electricity generation.[85] The most common and economically feasible form of household level distributed electricity generation is provided by PV arrays. Latest advancements in PV modules efficiency and economies of scale led to a sharp decline in prices for PV systems.[86] This might render the widespread installation of PV arrays feasible for owners with EVs. Furthermore, PV as sustainable and emission free energy source can support the decarbonization of the transport sector. The following section will discuss the environmental impact charging of EVs with PV arrays. Further, the potential to charge EVs with the support of decentralized PV electricity as well as implications of widespread distributed and intermittent electricity generation and their impact on distribution grids is reviewed. Finally, research on the interaction of EV charging, PV arrays, and BESS is examined.

2.2.1. Environmental impact

The environmental impact of driving an EV mainly depends on the energy source used to generate the energy for the charging operation.[87] The energy mix describes the fraction of energy fed-in, based on a specific energy source divided by the total amount of fed-in energy in a year. The energy mix varies greatly between countries due the availability of natural resources.[88] In Germany, most of the produced energy currently relies on fossil fuels such as coal or natural gas.[89] Fossil fuel-based energy generation is known to emit a great extent of CO_2 and other emissions which are harmful to the environment. Calculations involving traded electricity as well as electricity in- and exports estimate, that 1 kWh of electrical energy consumed in Germany is responsible for 366 g of CO_2 emissions.[90] This value decreased steadily as the share of emission free renewable energy sources in the energy mix increased significantly over the past years.[91] Despite this, a great discrepancy in predicted CO_2 emissions over the lifetime of a EV between Germany and countries with comparatively lower emission energy production emerged.[92] Therefore, an acceleration of the decarbonization in the transport sector by exploiting the potential of renewable energy sources such as PV to charge EVs might be feasible.

Yang et al. conducted a comprehensive benefits analysis of an EV charging station with PV arrays.[93] They conducted a case study of an electric bus charging station in Beijing, China with a total charging output power of 354 kW, a 445 kW PV system, and an additional battery with a capacity of 616 kWh. The results suggest that, in addition to benefits for grid operators in terms of lower transmission losses, there is also a major environmental benefit.[94] The environmental benefit is calculated by considering the environmental cost of pollutants emitted during the energy generation process.[95] This implies a great reduction in emissions, however, the study did not provide exact figures.

Overall, results suggest that emission free PV energy has the potential to further accelerate the decarbonization of the transport sector. Existing studies, however, employed simplified models without considering grid interaction effects. Grid interaction is important as the amount of energy which can be fed back into the grid might be limited. How PV arrays interact with the grid and why fed-back of energy is limited is discussed in the next chapter.

[77] Cf. Habib et al. (2020, p. 302).
[78] Cf. Habib et al. (2020, p. 302).
[79] Cf. Habib et al. (2020, pp. 303–305).
[80] Cf. Habib et al. (2020, p. 306).
[81] Cf. Habib et al. (2020, pp. 307–308).
[82] Cf. Habib et al. (2020, pp. 309–310).
[83] Cf. Habib et al. (2020, p. 311).
[84] Cf. Habib et al. (2020, p. 313).
[85] Cf. ElNozahy and Salama (2014); Cf. Mancini, Longo, Yaici, and Zaninelli (2020); Cf. Good, Shepero, Munkhammar, and Boström (2019).
[86] Cf. Our World in Data (2020).
[87] Cf. Hawkins, Singh, Majeau-Bettez, and Strømman (2013, pp. 56–59).
[88] Cf. eurostat (2022).
[89] Cf. Statistisches Bundesamt (2022).
[90] Cf. Umweltbundesamt (2021a, p. 10).
[91] Cf. Umweltbundesamt (2021a, p. 10).
[92] Cf. Gómez Vilchez and Jochem (2020, p. 10).
[93] Cf. Yang, Zhang, Zhao, and Wang (2021).
[94] Cf. Yang et al. (2021, p. 10).
[95] Cf. Yang et al. (2021, p. 6).

2.2.2. Impact on the power grid

Initial work published by ElNozahy and Salama focussed on the aggregated system-level impact of using PV electricity to charge PHEVs.[96] They deployed their model in a IEEE 123 node test feeder and simulated the impact of adding a 10 kW PV array to each household with a PHEV.[97] PV electricity generation, PHEV charging demands, and residential as well as commercial loads where stochastically modelled with Monte Carlo simulations.[98] This Monte Carlo based benchmark system allows to investigate the resulting impacts when PV arrays are used to charge PHEVs. Further, they investigated the probability of overloading different distribution equipment classes.[99] Analyzed equipment includes primary feeder, 25 kVA transformers, 50 kVA transformers, single phase laterals, and service drops. The results suggest that the inclusion of PV arrays reduces the probability of transformer overloading significantly while primary feeder, single phase laterals, and service drops are not likely to be overloaded even in the studied worst-case scenario.[100]

The introduction of distributed electricity generation can lead to power flows, which can change their direction. Reverse power flows can occur if a household produces more electricity than it consumes. For the electrical network this household now behaves like an electrical supply and no longer like an electrical sink. The household becomes an electrical prosumer. The feed-in of electrical energy by the household can lead to issues such as voltage rises or voltage phase imbalances.[101] As effects on distribution equipment by reverse power flows can be more severe, many DSOs limit the occurrence of reverse power flows.[102] High PV penetration rates in distribution networks increase the probability of reverse power flows, therefore, ElNozahy and Salam also investigated the occurrence of reverse power flows.[103] In the studied scenario with a PHEV and PV penetration rate of 52%, the simulated reverse power flow exceeded tolerable limits of transformers.[104] Excessive reverse power flows cannot only lead to overloading of distribution equipment but also to a rise of voltage above limits. To mitigate this effect, overvoltage prevention mechanisms, such as active power curtailment of the PV inverter, can be used.[105] In this scenario, power curtailment would have been necessary to avoid damages or a significant loss in lifespan of the transformers. This finding is reinforced by a later study which concluded that energy demand by both public and at home EV charging, does not significantly reduce the need of active power curtailment of widespread distributed generation with PV systems.[106] Nevertheless, overall findings of ElNozahy and Salama imply that PV arrays can meet part of the PHEV charging demand.[107] However, a weak chronological coincidence between PHEV charging demand and PV electricity production might reduce potential synergies.[108]. This is due to the fact that PV generation is strongest during daytimes where solar irradiation is strongest while PHEV charging demands peak in evenings.

This relationship was further supported by recent studies, which showed that the chronological coincidence between EV charging demand and solar energy availability can be weak and is influenced by seasonal dependencies.[109] Good et al. explicitly investigated the potential of PV energy for charging EVs during different seasons and calculated the solar fraction, which describes how much of the electrical load can be covered by solar power.[110] In their study approach, a solar fraction of 1 would imply that the complete energy demand of charging EVs can be supplied with PV energy. Their simulation results suggest a significant higher solar fraction during the month of July compared to the month of March.[111] This can be explained by the high latitude of the chosen research environment in Scandinavia, where day length differences between June solstice and December solstice are especially large. Thus, making the potential for EV charging with PV electricity season and latitude dependent. Further investigations are necessary to understand if it is feasible to charge EVs with PV electricity during the winter months in locations of high latitude.

Together, these studies outline that distributed PV electricity generation can play a role in mitigating EV charging demands. However, a weak chronological coincidence between PV electricity generation and EV charging demands as well as the influence of seasonality effects on solar irradiance can limit the mitigation potential. Furthermore, reverse power flows can occur, and active power curtailment measures might be necessary to avoid negative effects on the grid. Current literature is sparse and employed simulation models lack complexity and variability in EV type, time of the year, or PV penetration rates.

2.2.3. Interaction with battery energy storage systems

Having discussed how PV electricity impacts the power grid in scenarios with high EV adaption, this section addresses how energy storage systems (ESS) can support the integration of intermittent renewable energy sources.

Energy storage systems are a mean of storing excess electrical energy produced during periods of high electrical generation and low electrical loads. The stored energy can then be converted back to electricity to be used at times of high demand. ESS are increasingly used to balance electrical grids

[96] Cf. ElNozahy and Salama (2014).
[97] Cf. ElNozahy and Salama (2014, p. 137).
[98] Cf. ElNozahy and Salama (2014, pp. 134–136).
[99] Cf. ElNozahy and Salama (2014, pp. 139–140).
[100] Cf. ElNozahy and Salama (2014, p. 140).
[101] Cf. Scott, Atkinson, and Morrell (2002, p. 510).
[102] Cf. Hatta, Asari, and Kobayashi (2009); Cf. von Appen, Braun, Stetz, Diwold, and Geibel (2013, p. 57).
[103] Cf. Hasheminamin, Agelidis, Salehi, Teodorescu, and Hredzak (2015, p. 1158); Cf. ElNozahy and Salama (2014, p. 140).
[104] Cf. ElNozahy and Salama (2014, p. 141).
[105] Cf. Tonkoski and Lopes (2011).
[106] Cf. Luthander, Shepero, Munkhammar, and Widén (2019, p. 715).
[107] Cf. ElNozahy and Salama (2014, p. 139).
[108] Cf. ElNozahy and Salama (2014, p. 139).
[109] Cf. Mancini et al. (2020, p. 21); Cf. Munkhammar, Widén, and Rydén (2015, pp. 140–141); Cf. Good et al. (2019).
[110] Cf. Good et al. (2019, p. 116).
[111] Cf. Good et al. (2019, p. 119).

and play a crucial role in the energy management of intermittent energy sources.[112] However, limited capacities of electrical distribution grids limit the load balancing capabilities of centralized ESS.[113] Therefore, power feed-in management measures of renewable sources are required to avoid negative effects on distribution grids.[114] In 2019 approximately 4% of feed-in wind and PV energy were curtailed in Germany.[115] This number is expected to increase with a rapidly growing share and distribution of renewable energy generation.[116] To further enhance the transition towards renewable energy sources residential ESS might be pivotal. Residential ESS are compact distributed ESS installed at the individual's household often coupled with devices connected to them such as energy management devices, control devices, and supervision devices.[117] Together, these can help shaving electrical peak loads of households and thus reduce loads on distribution grids while increasing the efficiency of renewable generation due a reduction of required power feed-in management measures.[118]

Figure 1 illustrates an classification of common distributed energy storage systems. Chen et al. provided an assessment of promising ESS systems.[119] Reviewed characteristics include the technical maturity, power rating, discharge time, storage duration, capital cost, cycle efficiency, energy density as well as life time.[120] A thorough analysis of these aspects did not yield a superior technology for energy storage, instead the technology should be chosen based on the application.[121] For small-scale and distributed PVs the application of battery energy storage systems (BESS) proved most promising.[122] In this category, lithium-ion cells provide the best combination of energy density, energy efficiency and power performance.[123] This is supported by the fact that lithium-ion cells experienced a sharp decline in price per kWh.[124]

To understand how the coupling of a BESS with distributed PV electricity generation affects the impact of uncontrolled EV charging in varying network topologies, Mancini et al. simulated multiple EV and PV penetration rates and employed the load curves in different distribution networks.[125] A 300 kWh battery with an 50 kW inverter was employed in low voltage distribution grids.[126] The DigSilent Power Factory simulation findings indicate that PV electricity and energy storage can increase the maximum feasible EV penetration in rural networks from 40% to more than 60%.[127] Further, EV induced peak charging loads are more critical in urban compared to rural networks.[128] Issues not addressed in this study include time of the year dependent variability in both EV loads and PV generation, as well as individual household level BESS. The latter should play a major role in mitigating charging loads.

A passively integrated residential BESS implies a charging process of the BESS whenever there is an energy surplus between produced PV electricity and consumed electricity or discharging when there is an energy deficit. Hong et al. studied how EV charging affects distribution transformer aging and how this can be mitigated with two integration approaches of PV energy.[129] This contribution modelled the EV mobility and different charging habits and powers based on the EV's battery's state of charge (SOC) in an apartment complex with 1,000 households.[130] The BESS is assumed to provide a capacity of 2 MWh while the PV arrays' modelled peak generation capacity equals 310 kW which is lower than the apartments base load during the day.[131] Integrating the PV energy without a BESS led to no reduction of simulated peak loads in the evening while BESS interaction enabled a 20% reduction of peak loads in an 30% EV penetration scenario.[132] This simulation demonstrates the supporting role of an BESS towards PV electricity to mitigate EV charging impacts. However, limited complexity in the employed simulation, undersized PV arrays, and no investigation of grid metrics limit the explanatory power of the study.

Overall, energy storage systems and especially BESS show a great potential in increasing synergies between PV electricity generation and EV charging loads by reducing peak loads, increasing PV self-consumption, and enhancing power quality. Employed simulations in current literature lack complexity in modelled EV loads, an investigation of residential BESS, and an impact assessment on electrical distribution grids.

2.3. Contribution

As the market of EV is rapidly developing with a 43% year-over-year increase in 2020 in global electric car stock the impact of wide range EV charging on electrical distribution grids is inevitable.[133] EV charging is characterized by temporal patterns, where individuals' charging activities cluster together such that peak loads coincide. Existing literature suggests that the most pertinent points are voltage drops below regulatory limits as well as electrical distribution grid equipment overloading induced by these peak demands. One

[112] Cf. Rehman, Al-Hadhrami, and Alam (2015, p. 593); Cf. H. Chen et al. (2009, pp. 291–292).
[113] Cf. Hatta et al. (2009). Cf. Hawkins et al. (2013, p. 57); Cf. Scott et al. (2002, p. 510)
[114] Cf. Bundesnetzagentur (2022).
[115] Cf. Bundesnetzagentur (2021).
[116] Cf. Umweltbundesamt (2021b, p. 10).
[117] Cf. IEEE (2015).
[118] Cf. Novoa and Brouwer (2018, pp. 175–176).
[119] Cf. H. Chen et al. (2009).
[120] Cf. H. Chen et al. (2009, pp. 306–309).
[121] Cf. H. Chen et al. (2009, pp. 309–310).
[122] Cf. H. Chen et al. (2009, pp. 309–310).; Cf. Nair and Garimella (2010), p. 2126.
[123] Cf. Hall and Bain (2008, pp. 4353–4354).
[124] Cf. Our World in Data (2021).
[125] Cf. Mancini et al. (2020).
[126] Cf. Mancini et al. (2020, p. 12).
[127] Cf. Mancini et al. (2020, pp. 18–19).
[128] Cf. Mancini et al. (2020, pp. 14–16).
[129] Cf. Hong, Lee, and Kim (2020).
[130] Cf. Hong et al. (2020, pp. 11–12).
[131] Cf. Hong et al. (2020, pp. 11–12).
[132] Cf. Hong et al. (2020, p. 15).
[133] Cf. International Energy Agency (2021).

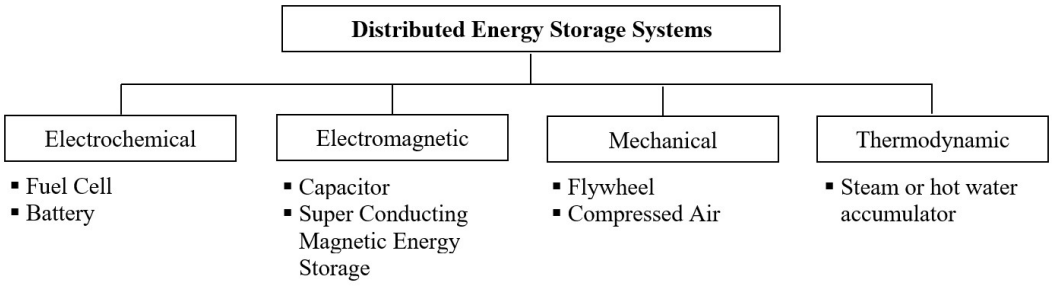


Figure 1: A classification of distributed energy storage systems.

potential approach to mitigate the impact of EV charging is widespread distributed PV electricity generation. Moreover, PV as a sustainable and emission free energy source decreases overall CO_2 emissions in the production of the required electrical energy. However, challenges such as the occurrence of reverse power flows and a weak chronological coincidence between PV electricity generation and EV charging demands could limit potential synergies. These challenges might be overcome by integrating BESS for prosumer households. Prosumer households with such a system of a PV array and BESS have a great a great potential in supporting electrical distribution grids and allowing widespread EV adoption. Despite this, current literature is lacking a thorough understanding of the role of BESS supported PV generation to charge EVs. Thus, understanding the real potential of decentralized power generation with PV systems is crucial to prepare electrical distribution grids for soaring energy demands induced by EV charging operations.

Table 1 provides an overview of the most important forementioned literature in terms of features chosen for simulations and evaluated metrics. These features play a major role in the chosen degree of simplification for the model and thus have a significant impact on the simulation results. In earlier studies, reasonable assumptions were made to model the EV penetration, charging load of EVs, and generation capacity of PVs, while few significant aspects were not covered. For instance, fixed PV penetration and sizing was presumed in ElNozahy and Salama, whereas the model of Mancini et al. assumes an uniform distribution of employed EV and PV units.[134] Both models employ stochastic modelling techniques to simulate charging and generation loads, nonetheless they do not account for different EV types or seasonal fluctuations in solar irradiance or energy consumption. Mancini et al. modelled a centralized BESS to store excess electrical energy generated by PV array but did not consider household level BESS.[135] Varying EV types were considered in the work of Habib et al., in which the impact of distributed PV electricity generation on distribution grids was not studied.[136] Simulations accounting for seasonal fluctuations in solar irradiance were presented by Good et al., however, no impact on electrical grids have been investigated.[137] Overall, no thorough analysis on the role of distributed PV systems in combination with BESS to mitigate the charging impact of high EV adoption rates on electrical distribution grids exists.

Therefore, this thesis contributes to existing research by enhancing the modelling approach and by considering all identified features of importance. First, an enhanced model of EV charging demands is employed. It comprises seasonality characteristics, EV fleet developments, and consumers' charging preferences, therefore combining, and applying findings of existing research. Second, varying household load profiles by aggregating demand with PV generation and a BESS are realized. Third, varying household load profiles are deployed in different network topologies and grid interaction metrics are investigated. So far, there is no existing literature that conduced a comprehensive distribution grid level analysis of all these system parameters.[138] This approach identifies the potential of PV arrays in combination with a BESS to support widespread EV adoption. Furthermore, the feasibility of this approach depending on the type of agglomeration can be deducted. This thesis will enable DSOs and policy makers to set the right course to prepare electrical distribution grids for a widespread EV adoption. The baseline developed by this thesis will help decision makers to identify promising solutions. These can eliminate or reduce the need for expensive infrastructure-side grid expansions.

3. Problem statement and scenarios

Having reviewed related work, this section now presents the main body of research of this thesis. First, the problem statement is described, and research questions are formulated. Next, the chosen simulation scenarios of this thesis and how they help to answer the research questions at hand are elaborated.

3.1. Research question

Existing work shows the importance of understanding EVs' charging impact on electrical distribution grids since this

[134] Cf. ElNozahy and Salama (2014); Cf. Mancini et al. (2020).
[135] Cf. Mancini et al. (2020).
[136] Cf. Habib et al. (2020).
[137] Cf. Good et al. (2019).
[138] To the best of the authors knowledge.

Table 1: Summary of relevant literature.

Author	Year	Country[a]	A	B	C	D	E
Clement-Nyns et al.	2010	BE	✓			✓	
ElNozahy and Salama	2014	US	✓	✓		✓	
Good et al.	2019	NO, SE	✓	✓			✓
Habib et al.	2020	PK	✓			✓	
Hong et al.	2020	CN		✓	✓		
Mancini et al.	2020	IT	✓	✓	✓	✓	
Mazzeo	2019	IT		✓	✓		
Novoa and Brouwer	2018	US	✓		✓	✓	
Schäuble et al.	2017	DE	✓				
Wang and Infield	2018	UK	✓			✓	
Yang et al.	2021	CN		✓	✓		
This thesis	2022	DE	✓	✓	✓	✓	✓

A: Charging behavior modelled
B: Distributed household level PV electricity generation modelled
C: BESS modelled
D: Grid impact investigated
E: Time of the year variation investigated
[a]Country code based on ISO 3166 Alpha-2

can have a serious impact on grid stability and power quality. Electrical grids can be supported by the extensive integration of decentralized power generation with PV systems and BESS to enable widespread EV adaption. Current literature is lacking an understanding of household-level PV systems with BESS. In particular, its impact throughout the seasons in mitigating distribution grid overloading in various network topologies induced by EV charging loads. Therefore, the following research questions are investigated:

1. ***How can the employment of residential PV generation support EV charging to mitigate charging impacts on the distribution grid in varying network topologies?***
2. ***How can the employment of passive residential PV-BESS support EV charging to mitigate charging impacts on the distribution grid in varying network topologies?***

Answering these research questions establishes a better understanding on the role of distributed electricity generation in supporting electrical distribution grids. Furthermore, it will allow policy makers and DSOs to derive suitable measures to prepare distribution grids for the increased electrical demands induced by the charging of EVs. Depending on the suitability of distributed PV electricity generation to mitigate the charging impact, consumers can be incentivized to adopt PV arrays. These incentives might be regional specific as different agglomeration types will reach infrastructure limits with varying EV penetration rates. As these research questions require a detailed analysis with varying assumptions, multiple simulation scenarios are proposed.

3.2. Simulation scenarios

To understand if and how distributed electricity generation with PV arrays can mitigate potential charging impacts multiple simulation scenarios with varying EV and PV penetration rates are deployed in three network architectures. The chosen scenarios reflect different short and long-term projections of EV penetration rates. A future case in 2030 with an EV vehicle stock of 15 million EVs is assumed. This aligns with the PEV adoption goal of the German government and results in an EV share of approximately 30% if the total vehicle stock of 48.2 million remains unchanged.[139] Further, variation in EV penetration and PV penetration are analyzed, to investigate the sensitivity of results. Urban, semi-urban, and rural grid architectures are employed to investigate if population density can have a significant impact on the availability of PV electricity generation. This might be due to spatial limitations in cities with high-rise buildings.

Owing to the fluctuations in solar irradiance based on the time of the year, different calendar weeks (CW) are considered.[140] These solar irradiance scenarios address the following four cases: First, average case solar insolation scenarios in between both solstices are deployed during CW12 in March and CW38 in September. Second, a best-case for PV electricity generation on the northern hemisphere during the June solstice in CW 26 is determined. And last, a worst-case scenario during the December solstice in CW51 is studied. With these four scenarios, the model covers the PV energy

[139]Cf. Presse- und Informationsamt der Bundesregierung (2021); Cf. Kraftfahrt Bundesamt (2021a).
[140]All calendar weeks based on the year 2019.

generation under the most common solar insolation conditions. The paper is limited to these four conditions, as current research has recognized them as most information-intensive edge cases.

4. Employed data and identification of model parameters

This section describes what data is necessary to answer the research question at hand, how it is preprocessed and how it parameterizes the developed model.

4.1. Employed data to model charging loads

To enable the modeling of realistic charging loads, agents' mobility behavior needs to be simulated as well. The following section will describe the employed dataset to model the mobility behavior. Further, the characteristics of the simulated EVs and their charging characteristics are defined.

4.1.1. Mobility dataset and preprocessing

This thesis assumes that peoples' driving behavior does not depend on the propulsion type of the vehicle. Therefore, the following section will introduce, analyze, and preprocess a mobility dataset where personal vehicle trips are based on ICEVs.

The German Mobility Panel "Deutsches Mobilitätspanel" (MOP) conducted by the Karlsruhe Institute of Technology and the Federal Ministry of Transportation and Digital Infrastructure builds the foundation of the mobility behavior.[141] This dataset contains 70,796 recorded trips by 3,191 persons who live in 1,853 households. Each participant recorded all trips conducted during a time span of one specific week between September 2019 and March 2020. No influence of COVID-19 on the mobility dataset is expected as the last recorded trip was conducted on the 06/03/2020, a week before the German Government declared COVID-19 as pandemic. The recorded trips, inter alia, include detailed information of the trip purpose, start and arrival times as well as person and household related information. Of these recorded trips 32,223 trips have been conducted mainly by car with the person as main driver and are thus the only trips of interest. Further, residential information such as the community size of the household and the number of cars in the household is available.

Pre-processing of the data was necessary before employing it to parametrize the mobility model. Recorded departure and arrival times have an accuracy of 1 minute, which allows accurate tracking of mobility behavior. However, as all recordings are self-reported most arrival and departure times show a rounding bias resulting in approximately 75% of datapoints with a right-hand digit of 0 or 5. Therefore, all data points are rounded to 5-minute steps such that no 0-minute trips exit. Then, 305 trips to holiday flats or hotels as well as the corresponding household were removed as subsequent trips of members of the household would skew data. 31,942 car only trips remain where an explorative data analysis was conducted. Focusing on the travelled distance and the trip time it was observable that maximum values show a great deviation by multiple standard deviations of the mean values. As this thesis focuses on the average daily travel patterns, unreasonable long trips got excluded. Chosen thresholds for exclusion were the corresponding 99^{th} percentiles, resulting in a cutoff time duration of 130 minutes and above and a travelled distance of 200 km and above in one trip. Records based on the average speed of the trip were not excluded, as "stop&go" traffic can cause average speeds below 5 km/h and unreasonably high speeds are not present.[142] The final dataset contained 22,803 trips. 18,383 trips have been conducted on weekdays and 4,420 trips on weekends. The separation allows an independent identification of use patterns. Figure 2 illustrates selected probability distribution functions (PDF) for the vehicle trips differentiated by weekdays and weekends. Data for weekdays are denoted by solid red lines and weekends are shown as solid blue lines. Figure 2a. and 2b. depict the rolling average of the probability of departing and arriving at a specific timestep, respectively. A morning and evening driving peak can be observed during weekdays as portrayed by Figures 2a. and b. Furthermore, weekend driving patterns peaks around 11:00 a.m.

Considering all trips of an individual person results in individuals' mobility behavior for the period of one week. Each trip in the dataset essentially represents a transition between one location state to another. The MOP dataset contains twelve different trip purpose categories and thus spatial information can be derived from each trip purpose. To accurately depict the agents' charging behavior it is important to derive spatial information of the vehicle. This thesis assigns four states to each individual: Driving (D), Home (H), Work (W), Other (O).

Figure 3 demonstrates the pseudo code for the algorithm used to determine the state of each individual at each timestep. First, the initial state of an individual before conducting the first trip had to be determined as this was not part of the data. It was assumed that most individuals were at home at the beginning of their recording at 12:00 a.m. of a randomly chosen day of the week. Thus, the initial state was set to home except for the 29 individuals' whose first recorded trip had the purpose "homewards". These got initialized with the state other. After the initialization step, the trip information was employed to determine the subsequent states. Between departure and arrival time the state is set to driving. The state from the current trip until the beginning of the next trip was determined based on the purpose of the current trip. The trip purpose was encoded as follows:

1. **Work:** Way to work; way to training facility
2. **Home:** Homewards; way to second home
3. **Other:** Run an errand; leisure route; pick someone up/ drop someone off; other; other personal purpose

[141] Cf. Karlsruhe Institute of Technology and Federal Ministry of Transportation and Digital Infrastructure (2020).

[142] Cf. Ohde, Ślaski, and Maciejewski (2016, p. 32).

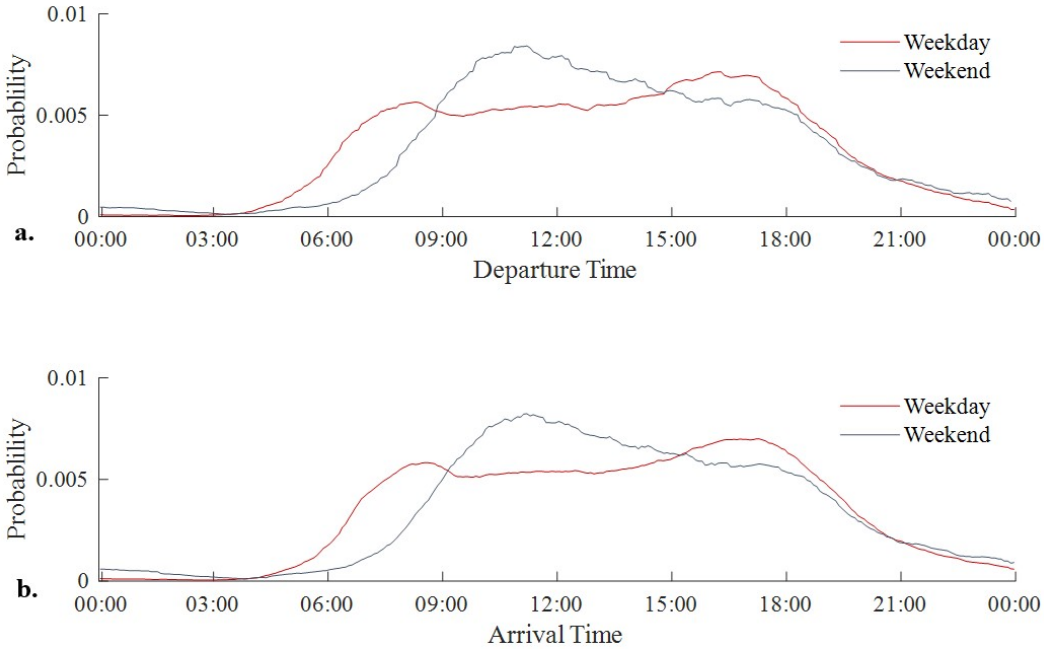


Figure 2: PDFs of vehicle trips differentiated by weekday and weekend. **a.** Departure time; **b.** Arrival time.

4. **Same state as the previous state:** Round-trip

The resulting state chain depicts the state of each individual at each timestep and allows to derive a mobility schedule of the vehicle. Figure 4 depicts the average state distribution for all individuals during an average weekday. Driving peaks in the morning and in the evening can be observed which confirms beforehand identified vehicle use patterns during weekdays. Furthermore, it is worth noting that the share of people in a working state during daytimes appears to be relatively low. This is due to the fact that the dataset represents the general public and includes the non-employable population as well.

4.1.2. EV characteristics

The following section describes EV characteristics and EV specifications used to model the energy consumption of electric vehicles. Further, different charging standards are introduced, and the charging power is specified. EV characteristics are defined on battery electric vehicles as presented in Table 2. This is due to two reasons: The most pertinent point is that their battery capacity is significantly larger compared to PHEVs. Moreover, this kind of vehicle already has predominant share in sales of non-ICEVs in Germany while showing a considerable growth in share.[143] Even though commercial vehicles and buses are considered crucial to the wider uptake of EVs, these vehicle categories scheme are not considered in this thesis.[144]

The battery capacity of EVs varies strongly and depends on the specific vehicle model. Segments group vehicles according to their size, vehicle structure or intended purpose and allow a better comparability between vehicles.[145] As each segment represents vehicles of a specific size and weight the battery capacity strongly correlates within segments. EVs in segments representing smaller vehicles such as “Mini” or “Small car” usually contain batteries of smaller capacities than EVs in segments for larger cars and thus require more frequent charging. Figure 5 exhibits newly registered personal vehicles in Germany in 2020 grouped by segment. Particularly striking is that segments for smaller cars prevail for newly registered EVs as 46% of these are small or mini cars, while these two segments only account for 20% of all newly registered personal vehicles.[146] This difference might be explainable by the fact that most of the offered EV models are still in higher price classes. Therefore, consumers with the intention to buy an EV might chose vehicles of smaller size as these suit their willingness to pay. For the chosen simulation, this thesis assumes that differences between EV and the overall segment mix level out and that the EV segment distribution equals the current distribution of overall vehicle sales. The segment “Other” is excluded, as it represents a great variety of vehicle types and assigning specific characteristics to this segment would not be reasonable.

Literature suggests that the average energy consumption per km of an EV generally increases with both weight and power but still varies a lot depending on the specific vehicle model.[147] This scattering of rated energy consumptions can

[143] Cf. Kraftfahrt Bundesamt (2021a).
[144] Cf. United Nations (2017, pp. 6–8). Excluded categories include N, M2, and M3 according to the European Union classification of vehicles.
[145] Cf. Kraftfahrt Bundesamt (2021c, p. 9).
[146] Cf. Kraftfahrt Bundesamt (2021b); Cf. Kraftfahrt Bundesamt (2021e).
[147] Cf. Weiss, Cloos, and Helmers (2020, p. 11).

```
function createStateChain
    sample person
        for all trips from person do
            sample departure_time, arrival_time, purpose, transport_type
            for departure_time to arrival_time
                assign state driving
            end for
            if first recorded trip then
                for 0 to departure_time
                    if purpose = homeward then assign state other
                    else assign state home
                end for
            else
                for arrival_time to next trip departure_time
                    if purpose = work or purpose = training facility then assign state work
                    else if purpose = homeward or purpose = second home then
                        assign state home
                    else if purpose = round trip then assign previous state
                    else assign state other
                end for
        end for
end function
```

Figure 3: Pseudo code to derive states from trip information.

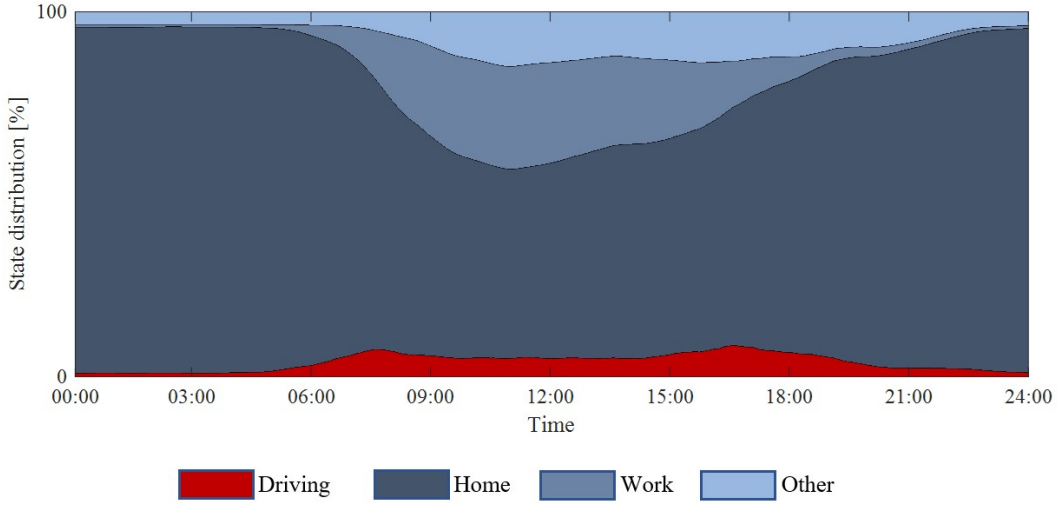


Figure 4: Average state distribution during a weekday.

Table 2: A classification of personal transport vehicles by type.

Type	Internal combustion engine vehicle (ICEV)	Fuel cell electric vehicle (FCEV)	Hybrid electric vehicle (HEV)	Plug-in hybrid electric vehicle (PHEV)	Battery electric vehicle (EV)
Power source	Fossil Fuel	Hydrogen	Fossil Fuel	Fossil Fuel & Electricity	Electricity
Battery	-	-[a]	1-5 kWh	5-30 kWh	15-110 kWh
Example	Volkswagen Golf Mk7	Toyota Mirai 2019	Toyota Prius	Mercedes C 300 e	Tesla Model S

[a]Usually non-plug-in batteries included for recapturing breaking energy and smoothing power delivery.

also be seen in Table 4, where the selected EV models for this thesis are presented. As rated energy consumptions tend to represent the best-case scenario, real life energy consumption results of the ADAC Ecotest are chosen.[148] For each segment the top selling EV model in Germany of the year 2021 was

[148]Cf. ADAC (2022).

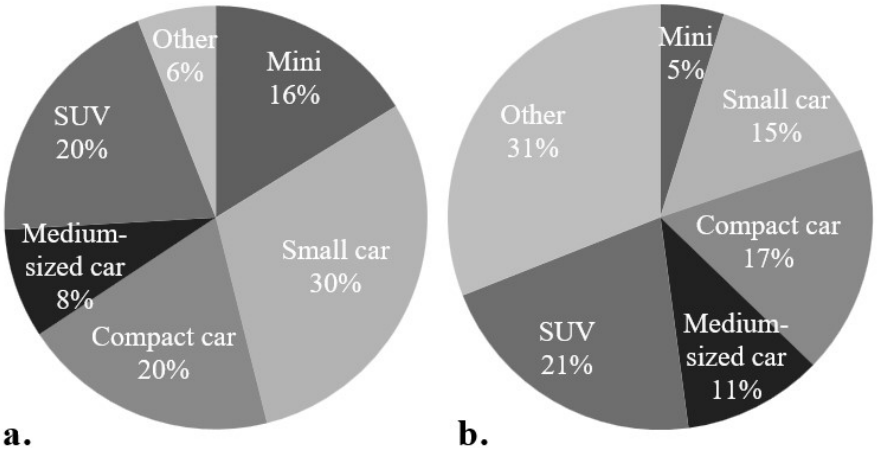


Figure 5: Registration of new vehicles in Germany 2020 grouped by segment. **a.** EV only; **b.** All vehicle types. Own illustration based on Kraftfahrt Bundesamt.

Cf. Kraftfahrt Bundesamt (2021b); Cf. Kraftfahrt Bundesamt (2021e).

Table 3: Share of households with private car by agglomeration type.

	Rural [%]	**Semi-urban [%]**	**Urban [%]**
Share of households with private car	89	86	77

Cf. Karlsruhe Institute of Technology and Federal Ministry of Transportation and Digital Infrastructure (2020).

chosen.[149] To prolong life expectancy and to avoid harmful under- or overcharge events of the battery, vehicle manufacturers limit the amount of total battery capacity which can be used. The simulation of the battery charge in this thesis is built upon the usable battery capacity only.

An additional factor which has a significant influence on the average energy consumption of an EV is the ambient temperature.[150] Ambient temperature affects energy efficiency of an EV by influencing both auxiliary loading, such as cabin and battery thermal management, and battery output energy losses.[151] Existing work suggests that the total energy consumption increases significantly with decreasing ambient temperatures.[152] Most recent literature identified that the trip range at low temperatures from 0°C to 15°C is 28% lower than driving at moderate temperatures from 15°C to 25°C.[153] The simulation scenarios in this thesis cover different seasons, implying varying ambient temperatures. To model the effect of the additional energy consumption during colder months a consumption factor is introduced. This consumption factor represents a simplification of actual temperature dependencies, as the ambient temperature influences various other mechanical factors such as the air density, air resistance, rolling resistance, or tire pressure. Based on average ambient temperatures, a consumption factor of 1.25 is assumed for the December scenario, implying an additional energy consumption of 25%.[154] The March and September cases include a consumption factor of 1.15, while the June case assumes unaltered rated energy consumption. Further, a temperature and state of charge independent self-discharge rate of 1% per day is assumed to account for the energy consumed by electronics. Other potentially influencing factors on energy consumption such as the trip distance, individual driving styles, average speed, or the batteries state of charge are excluded in the context of this thesis.[155]

4.1.3. Charging characteristics

The core metric influencing the charging load on electrical distribution grids is the charging power. This section describes common charging standards and locations and defines the underlying characteristics of EV charging.

A wide range of charging technologies and power levels based on either 1-phase AC, 3-phase AC or DC power supplies exist. For each technology, different standardized connector types are used in the European Union, such as the EN 62196

[149] Cf. Kraftfahrt Bundesamt (2021d).
[150] Cf. Al-Wreikat, Serrano, and Sodré (2022, p. 1); Cf. Liu, Wang, Yamamoto, and Morikawa (2018); Cf. Qi, Yang, Jia, and Wang (2018, p. 371).
[151] Cf. Liu et al. (2018, p. 331).
[152] Cf. Iora and Tribioli (2019, p. 12); Cf. Liu et al. (2018, p. 329).
[153] Cf. Al-Wreikat et al. (2022, p. 1).
[154] Cf. Climate-Data (2022).
[155] Cf. Qi et al. (2018, p. 371); Cf. Bingham, Walsh, and Carroll (2012, p. 34).

Table 4: Selected EV specifications by segment.[a]

Segment	Mini	Small car	Compact car	Medium-sized car	SUV
Selected model	Volkswagen e-UP	Renault Zoe ZE40 R110	Volkswagen ID.3 Pro	Tesla Model 3 Long Range Dual Motor	Audi e-tron 55 quattro
Battery capacity [kWh]	36.8	54.7	62	82	95
Battery usable [kWh]	32.3	41	58	76	86.6
Rated energy consumption[b] [kW/100 km]	14.5	17.5	15.5	14.7	22.4
ADAC Ecotest energy consumption [kW/100 km]	17.7	20.3	19.3	20.9	25.8

[a]Cf. Electric Vehicle Database (2021); Cf. ADAC (2022).
[b]Based on the Worldwide Harmonised Light Vehicle Test Procedure (WLTP).

Type 2 for regular AC charging.[156] The "Ladesäulenverordnung" of the German Federal Ministry for Economic Affairs and Climate Action adopted on 17th March 2016 laid down the requirement to adopt the EU standard.[157] This regulation enforced the European connector standard EN 62196 Type 2 in Germany for AC charging. The Type 2 connector provides between 3.6 kW and 43 kW power.

Literature identified home charging as the prevalent mode of charging.[158] Fast chargers and high power chargers for range extensions are excluded, as they only account for 1-2% of the charging operations and many EV types still do not support maximum charging powers.[159]

Table 5 provides an overview of charging locations that are either in scope or out of scope for the modelling of EV charging demands in this thesis. The charging location home includes privately owned garages or parking spaces, as well as parking spaces for residential buildings. As an 11 kW 3-phase AC charger provides a good compromise between moderate charging times and economical CAPEX, this thesis assumes that chargers installed at home provide a charging power of 11 kW. The charging power demanded by the EV is not constant, as it depends on the SOC.[160] Furthermore, the charging efficiency also tends to decrease with higher SOCs, reaching maximum charging losses of 20% for SOCs above 80%.[161] As both these factors strongly depend on the specific EV model and literature regarding these is sparse, this thesis excludes these factors and assumes a constant grid side charging power of 11 kW. Average charging losses are considered and an average in literature identified charging efficiency of 90% is assumed for the whole charging process.[162]

4.2. Employed data to model household and house loads

The following section will provide an overview of impacting variables on household electricity consumption, and what assumptions and underlying data sources are chosen to model the household load profiles. Subsequently, characteristics of a house depending on the type of agglomeration are presented.

4.2.1. Household load characteristics

Household electricity consumption is mainly determined by human activities.[163] Thus, the temporal and spatial ordering of human activities have a huge influence on the electricity demand of a household. This has implications on the formation of temporal patterns as some energy intensive activities cluster together, such as the preparation of food, and therefore peak electricity demands occur.[164] Further, the electricity consumption is determined by climate conditions as it varies between cold and hot climates mainly due to the use of air conditioning and heating devices.[165] To forecast and account for the energy demand of electrical consumers, averaged load profiles, such as standard load profiles, based

[156]Cf. International Electrotechnical Commission (2014); Cf. International Electrotechnical Commission (2016).
[157]Cf. Bundesanzeiger Verlag (2016).
[158]Cf. Baresch and Moser (2019, p. 388).
[159]Cf. Baresch and Moser (2019, p. 393); Cf. Kleiner et al. (2018, p. 218); Cf. Lee et al. (2020), p. 11; Cf. Thingvad et al. (2021, p. 10).
[160]Cf. Figenbaum (2020, p. 41).
[161]Cf. Kostopoulos, Spyropoulos, and Kaldellis (2020, p. 423).
[162]Cf. Sears, Roberts, and Glitman (2014, p. 256).
[163]Cf. Torriti (2017, p. 46).
[164]Cf. Torriti (2017, p. 46).
[165]Cf. Park, Yang, Miller, Arjunan, and Nagy (2019).

Table 5: Charging locations.

	In scope	**Out of scope**			
Charging location	Home	Public fast and high power charger	Commercial parking	Curbside	Workplace
Electrical power range [kW]	3.6 - 22	50 - 350	11 - 50	11 - 22	3.6 - 43
Selected EV charging power [kW]	11	-	-	-	-

on past data are mainly used. Figure 6 depicts standard load profile curves for a week in December and June of the consumption type household (H0). Temporal patterns are visible with pronounced load peaks each evening.

To accurately model household loads, it is important to consider different household sizes and their distribution. The average household size in Baveria, Germany tends to increase with decreasing community size.[166] This implies that households in rural areas are on average larger than in urban areas. Table 6 illustrates the household size distribution according to the type of agglomeration.

4.2.2. House parameters

Having reviewed the electrical load of a single household the electrical load at a supply point needs to be determined. To define the electrical load of a house, the number of households per building needs to be considered. Table 7 gives an overview on the distribution of the number of households depending on the type of agglomeration. The data suggests that the share of single family homes is significantly higher in rural areas while the share of multifamily buildings is higher in urban areas. This is expected and can have a significant influence on the PV generation potential.

4.3. Employed data to model PV generation

The potential PV electricity generation capacity can be expressed in different ways. This thesis focusses on the technical potential, which accounts for the generation potential given technical constraints as well as geographical depending solar irradiance data. The economic potential – the share of houses with the capacity to invest in a PV system – is not considered. The following section introduces the underlying statistical data to determine the PV generation potential per residential house.

4.3.1. Available rooftop area

The core metric influencing the PV generation potential is the area of the PV arrays and therefore the available area to install PV arrays is crucial. Large rooftop PV installations can reach peak power generation capacities of up to 10 MWp.[167] For single residential households, photovoltaic systems below 10 kWp are most common and average installation capacities increased over the last years and reached 7.5 kWp for all newly installed systems below 10 kWp.[168] At the same time the number of PV systems between 10 and 15 kWp showed a YoY growth of 248%.[169] This is further supported by the reform of the German renewable energy act (EEG) which increased the exemption limit of the EEG apportionment from 10 kWp to 30 kWp.[170] Estimates of the PV installation potential based on the available rooftop area in German residential areas showed the need to distinguish between different types of buildings.[171] This thesis considers residential buildings only and differentiates between single family buildings, double family buildings, and multifamily buildings. Because the rooftop area was calculated based on, inter alia, the average size of an apartment, an analysis of average apartment sizes depending on the type of agglomeration was conducted.[172] This analysis separated apartment sizes depending on residential building type and type of agglomeration. Results suggested no significant differences in apartment sizes. Therefore, the average German roof area was used for all agglomeration types and is given in Table 8 for slanted and flat roofs. Flat roofs are defined as roofs with an inclination below 5° and its share is roughly 10% of residential rooftop construction types.[173]

Next, a reduction in available rooftop area for PV installations due to constructional constraints such as existing solar thermal systems, ventilation systems or chimneys was considered. Unsuitable azimuth angles of the direction of slanted roofs further reduce the available area. This is expressed by a utilization factor which determines the share of the roof area that is suitable for an PV array. Multiplying the roof utilization factor for photovoltaic systems with the average rooftop area results in the average available rooftop area for PV in-

[166] Cf. Bayrisches Landesamt für Statistik (2021).

[167] Cf. Bundesnetzagentur (2021).

[168] Cf. EUPD Research (2020); Cf. Bundesnetzagentur (2021).

[169] Cf. EUPD Research (2020).

[170] Cf. Bundesministerium für Wirtschaft und Klimaschutz (2021).

[171] Cf. Mainzer et al. (2014).

[172] Cf. Mainzer et al. (2014, p. 719); Cf. Statistisches Bundesamt (2011); Cf. Bundesamt für Bauwesen und Raumordnung (2010).

[173] Cf. Fechner (2020, p. 16).

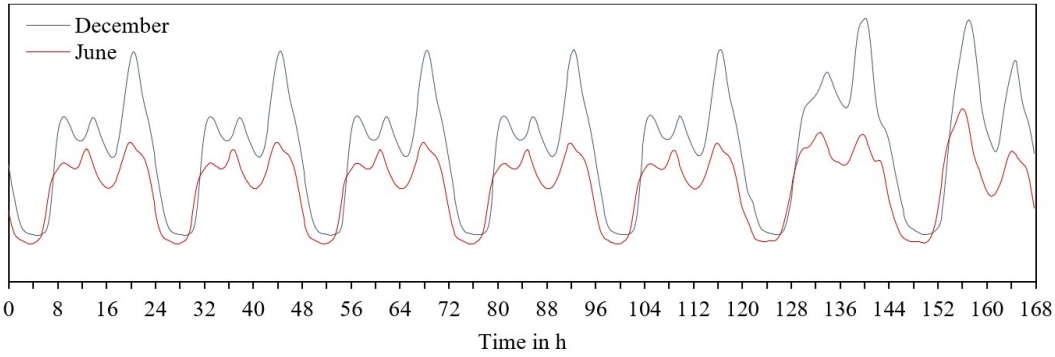


Figure 6: Standard load profiles for households, where a time of 0 equals Monday 12:00 a.m. Own illustration.

Cf. Stadtwerke Groß-Gerau (2021).

Table 6: Household sizes depending on agglomeration types.[a]

Persons per household	Rural [%]	Semi-urban [%]	Urban [%]
1	35	40	54
2	35	33	27
3	14	12	10
4	12	11	7
5 or more	4	4	2

[a]Cf. Bayrisches Landesamt für Statistik (2021); Cf. Bundesamt für Bauwesen und Raumordnung (2010).

Table 7: House types depending on agglomeration types.[a]

Households per building	Rural [%]	Semi-urban [%]	Urban [%]
1	68	57	48
2	10	13	10
3-6	14	20	14
7-12	7	7	17
13 or more	1	3	11

[a]Cf. Statistisches Bundesamt (2011); Cf. Bundesamt für Bauwesen und Raumordnung (2010).

Table 8: Average German rooftop area.[a]

	Flat roof [m^2]	Slanted roof [m^2]
Single family buildings	141.4	113.7
Double family buildings	143.9	130.2
Multi-family buildings	135.7	207.3

[a]Cf. Mainzer et al. (2014, p. 720).

stallations, which is given in Table 10.

This thesis does not consider façade PV installations as these are usually only considered for new- or reconstructions and a lower economical yield as well as security constraints do not render them suitable for most building owners.[174]

[174]Cf. Fechner (2020, p. 24).

Table 9: Average roof utilization factor and share of rooftop types.[a]

	Flat roof [%]	Slanted roof [%]
Roof utilization factor for photovoltaic systems	27	29
Rooftop type of residential buildings	10	90

[a]Cf. Mainzer et al. (2014, p. 720); Cf. Fechner (2020, p. 16).

Table 10: Average available rooftop area for PV installations.

	Available rooftop area for PV installation	
	Flat roof [m^2]	Slanted roof [m^2]
Single family buildings	38	33
Double family buildings	38	38
Multi-family buildings	36	60

4.3.2. PV generation capacity

Based on the available rooftop area the potential peak power capacity of the PV system can be calculated. The average module efficiency increased over the past years and newly sold silicon-based PV systems reach nominal module efficiencies of more than 20%.[175] This implies that 20% of the exposed solar irradiation can be converted to electricity. Even though the efficiency negatively correlates with the operating temperature, temperature dependencies are not considered in the context of this thesis.[176] Based on system power densities of 200 W/m^2 for modern PV arrays the average potential PV peak power as given in Table 11 is achievable for rooftop solar installations.[177]

The potential yield of the PV system depends on a multitude of additional factors, such as other performance losses, the tilt angle, azimuth angle, and solar irradiance. These factors need to be parametrized before the PV generation profiles can be simulated.

The overall efficiency of the PV system is further reduced by conversion losses as well as obscuration through soiling or other objects and buildings.[178] This performance loss is set to 10% for this thesis. The tilt angle influences both the possible yield of a PV system as well as the required surface area to install multiple PV panels.[179] Optimal tilt angles for latitudes between 40°N and 70°N range between 29° and 40°.[180] Higher tilt angles require greater spacing between multi row PV array installations. This required spacing between PV systems is already considered with the utilization factor for the rooftop area calculation. The tilt angle is set to 30° while the azimuth angle is set to 180° (facing perfectly southwards) which is in line with the mean for most PV systems as identified by Pfenninger and Staffell.[181]

The solar irradiance strongly depends on meteorological events as well as the location. Larger latitudes lead to a strong occurrence of seasonality patterns. Figure 7 illustrates the PV generation capacity in Munich simulated with MERRA-2 data from 1980 until 2019.[182] The MERRA-2 data contains satellite imagery-based information and assimilation of, inter alia, aerosol and meteorological data.[183] The illustration confirms both the occurrence of seasonality patterns in potential PV yield as well as the strong influence of meteorological events. The latter is unpredictable and can lead to huge fluctuations in the electric energy generated as depicted by the light blue area.

4.4. Parameters of the BESS

Literature investigated varying BESS capacities and their feasibility to deploy them in residential buildings. While some literature investigated the potential of used EV batteries as BESS, this thesis will select a battery configuration based upon currently available products.[184] The "Tesla Powerwall" was selected with an energy capacity of 13.5 kWh and an overall charging efficiency of 90%.[185] This efficiency was set for a charging cycle, while discharging was assumed to be without any significant losses.

5. Model development

This chapter presents the selected modelling methodology. For each scenario a suitable simulation is developed. Multiple partial models are required to conduct an in-depth analysis of the individual factors. These partial models cover the following aspects: (1) Model of EV charging loads, (2)

[175]Cf. Fraunhofer Institute for Solar Energy Systems ISE (2020, p. 44).
[176]Cf. S. Dubey, Sarvaiya, and Seshadri (2013).
[177]Cf. Trinasolar (2020).
[178]Cf. Fraunhofer Institute for Solar Energy Systems ISE (2020, p. 44).
[179]Cf. Fraunhofer Institute for Solar Energy Systems ISE (2020, p. 44).
[180]Cf. Yunus Khan et al. (2020, pp. 520–521).
[181]Cf. Pfenninger and Staffell (2016, p. 1254).
[182]Cf. Pfenninger and Staffell (2016).
[183]Cf. NASA (2022).
[184]Cf. Heymans, Walker, Young, and Fowler (2014).
[185]Cf. Tesla (2022).

Table 11: Rooftop PV installation potential.

	PV installation potential rooftop	
	Flat roof [kWp]	**Slanted roof [kWp]**
Single family buildings	7.6	6.6
Double family buildings	7.6	7.6
Multi-family buildings	7.2	12

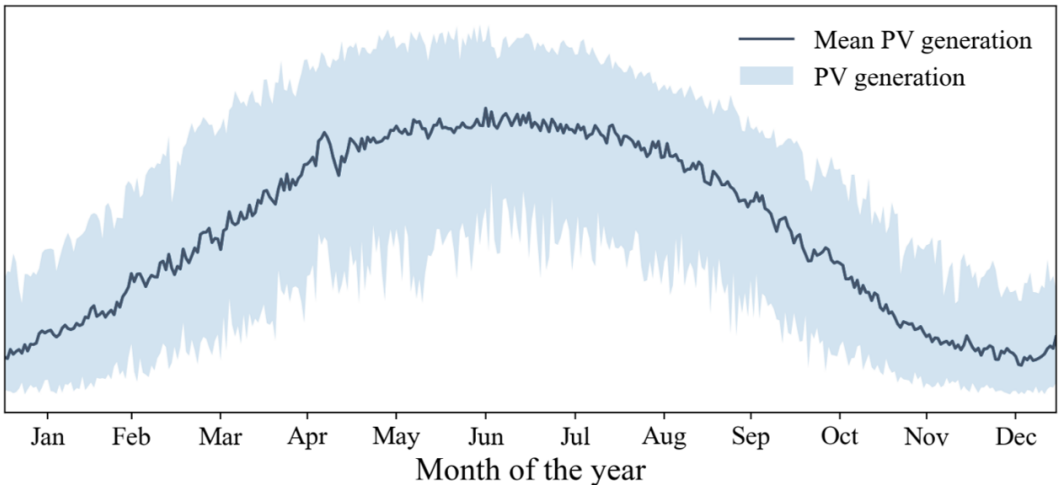


Figure 7: Yearly PV power generation over 40 years in Germany. Based on Pfenninger and Staffell. Own illustration.

Cf. Pfenninger and Staffell (2016).

Model of house load profiles, (3) Model of PV generation capacity, and (4) Model of the BESS. The results of the former three partial models represent the electrical load profile of an individual house which then represents a node in the low voltage (LV) distribution grid. For specific simulation scenarios a further forth model of the BESS interacts with the load profile.

Figure 8 illustrates the flowchart and the relationship between the input data in yellow boxes and the final output in red. Boxes colored in blue represent significant intermediate results. A simulation period of one week is chosen to account for day of the week dependencies in behavior. First, a Markov chain state and trip sequence is generated. Based on this, EVs and their charging behavior are simulated. An aggregation of household load profiles, EV charging profiles, PV generation profiles as well as a simulation of the BESS results in the electrical profile of a house. This house is then deployed as a node in selected grid topologies. The power flow problem is solved with MATLAB MATPOWER to investigate the resulting grid metrics.

5.1. Model of EV charging loads

Chapter 2.1.2 provided an overview on approaches to simulate EV charging loads. In general, both charging load simulation frameworks, namely agent-based electromobility simulations and charging point-based load simulations led to similar results. However, charging point-based load simulations are comparatively more limited, as charging point data is sparser and the inclusion of external factors is limited. Literature has shown that external factors, such as ambient temperature, EV types, or spatial and temporal mobility behavior can have a significant impact on the energy demand of EVs.[186] In contrast, the inclusion of external factors in agent-based electromobility simulations follows a simpler logic and spatial charging locations can be modelled. Therefore, this thesis simulates EV charging loads by carrying out this methodology.

5.1.1. Model of mobility behavior

To enable the modeling of realistic charging behavior, agents' mobility behavior needs to be simulated as well. An accurate depiction of travel behavior can be achieved by scheduling the activities of an agent in both time and space with suitable methodologies such as trip chaining. Trip chaining is a common approach applied in traffic modelling.[187] A trip chain consists of two or more trips linked to each other. Hence, a household usually begins the day by a home to non-home trip. Subsequently several non-home trips can be linked to this initial trip whereas each trip has an assigned time and space variable. This allows to identify

[186] Cf. Fischer et al. (2019, p. 14); Cf. Tal and Dunckley (2016, 54); Cf. Hu, Wu, and Schwanen (2017, p. 6).
[187] Cf. McGuckin and Nakamoto (2004).

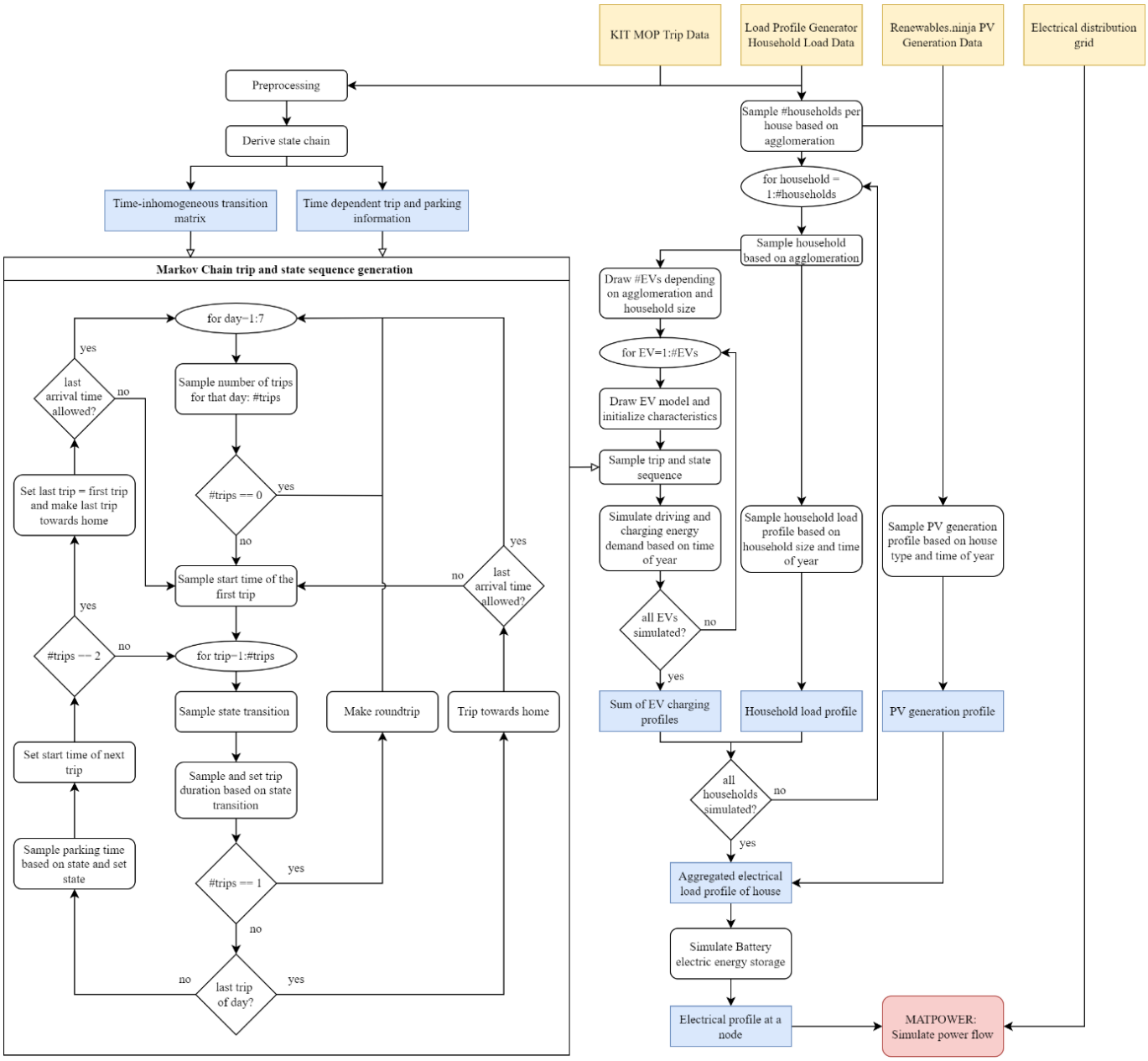


Figure 8: Flowchart of model.

the agents' daily mobility schedule. Related work usually employed probability distributions for mobility related time data, space data or both, to randomly sample and simulate single agents.[188] By employing this approach Fischer et al. were able to create probability distribution functions of weekday departure and arrival times as well as activities. Synthetic driving schedules were then created with time-inhomogeneous Markov Chains.[189] This approach allows to simulate the vehicle state at each time step.

This thesis employs Markov Chain simulations, as a numerical approach, to create synthetic mobility schedules. A Markov Chain can be defined as a stochastic memoryless process, where the specific state x at the point in time t only depends on the state at time t-1. This is expressed by Equation (1).

$$P(x_t \mid x_{t-1}, x_{t-2}, \ldots, x_0) = P(x_t \mid x_{t-1}) \tag{1}$$

The Markov Chain is mainly characterized by the transition operator $T(x_{t+1}|x_t)$ which provides the probability of arriving at state x_{t+1} at time $t+1$ given the chain state x_t at time t. As the associated transition operator is not constant and depends on the given timestep a time-inhomogeneous Markov Chain is necessary. The transition operator can be converted to a matrix form in $C \times S \times S$ scale, where C describes the

[188] Cf. Habib et al. (2020, p. 303); Cf. Wang and Infield (2018, p. 87); Cf. ElNozahy and Salama (2014, pp. 135–136).
[189] Cf. Fischer et al. (2019, pp. 10–11).

chain length which equals the number of timesteps, and S describes the number of possible states. To accurately depict the agents' behavior the following spatial states were considered: Home (H), Work (W), Other (O). This results in the transition matrix as depicted in Equation (2).

$$T_c = \begin{bmatrix} P^c_{H\to H} & P^c_{H\to W} & P^c_{H\to O} \\ P^c_{W\to H} & P^c_{W\to W} & P^c_{W\to O} \\ P^c_{O\to H} & P^c_{O\to W} & P^c_{O\to O} \end{bmatrix} \tag{2}$$

The agents state transition probability of arrival at work in $c+1$ given being at home in c is now given by $P^c_{H\to W}$. During any time step in the chain C, the sum of probabilities given a specific state is always 1. Furthermore, it is assumed that each person only has one workplace and one home. This is reflected in the transition matrix as the state transition probability from home to home and work to work are 0 for all timesteps. To generate the car usage and locations the algorithm proposed by Fischer et al. is used and slightly adopted.[190] First, for an agent and each day of the week, the number of trips is randomly sampled depending on car usage data. In a second step, the time of the first departure for the current day is sampled. The time-inhomogeneous Markov Chain now constructs a sequence of trips and determines the spatial transitions between each trip. The parking durations at each spatial location are randomly sampled based on a state and time of week depending on parking probability distribution. Trip durations of the first and the last trip of a day are equal if the total number of trips for this day equals two. The last trip of the day ends at home and the trip sequence for an agent on that day is accepted if the last arrival time is before a predefined time. The predefined time is sampled from a fitted distribution to the final homewards trips of each day. For this a Burr Type XII distribution was chosen. To ensure that arrival times are not too restricting and to account for differences in agents' daily schedules only arrival times after 4:00 p.m. are considered to fit the distribution. Figure 9 shows the probability distribution which sets the predefined times for weekdays and weekends. The weekday distribution with a solid blue line and is more restricting regarding the latest arrival time and peaks at around 17:00 while the weekend distribution shows a higher variance.

Benchmarking the generated trips chains with the input data trip chains yielded results showing only slight deviations of average trip duration and frequency. This is displayed in Table 12. Temporal driving patterns are observable in the resulting average state distribution for a weekday as depicted in Figure 10.

5.1.2. Model of EV charging behavior

Based on the mobility behavior the energy demand of the EV and subsequently the charging operations of a household can be modelled. Depending on the household size, the type of agglomeration, and the EV penetration rate the number of EVs for a single household is sampled.

Each EV of the household then gets a random mobility schedule assigned. An affine relationship between the distance travelled and the energy consumed is used to estimate the energy consumption of an EV. The travelled distance is modelled by sampling a time of the day dependent speed from the original trip dataset for each timestep during the duration of the trip. The energy consumed during one timestep is calculated with Equation (3).

$$P_{consumed} = v * P_{car} * C * \frac{1}{60} \tag{3}$$

where v equals the sampled velocity for that timestep in km/h, P_{car} the energy consumption of the car in kW/km, and C the consumption factor based on the time of the year. Based on the consumed energy and the self-discharge of the EV the batteries SOC gets adjusted accordingly. The self-discharge also applies when the EV is not used.

The likelihood of a charging operation depends on multiple factors. This thesis considers: (1) the availability of a charging station, (2) the parking duration and, (3) the agent's behavior depending on the current SOC. In the context of this thesis only charging at home is assumed. This is done as it represents a worst-case scenario for the residential distribution grid as all the required energy is drawn from that grid. Therefore, charging is only feasible if the EV is parked at home.

In the next step the parking period is considered. The probability to plug in an EV is only considered if the parking time exceeds a certain period. This period is set to 10 minutes. Finally, the agent's behavior depending on the current SOC is modelled based on range anxiety, the fear of running out of energy, as a core metric. A study showed that most individuals start to feel uncomfortable at a 25% SOC or less.[191] To account for larger battery capacities of modern EVs the range anxiety is parametrized with 20% in the context of this thesis. Therefore, agent's whose EV have a SOC below 20% are almost 100% likely to connect their EV to a charger given that the former two conditions are fulfilled. This behavior is modelled with a logistic function.[192] Equation (4) and Figure 11 depict the logistic function that represents the connection probability depending on the state of charge. The point of indifference is set to 60%, based on the empirically observed median SOC at the beginning of a charging operation.[193] The SOC at the beginning of the week is randomly initialized with a SOC value obtained after one week of simulation.

$$p_{charge}(SOC) = \min\left(1, 1 - \frac{1}{1 + e^{-0.15*(SOC-0.6)}}\right) \tag{4}$$

$$P_{charged} = P_{charger} * \eta * \frac{1}{60} \tag{5}$$

[190] Cf. Fischer et al. (2019, p. 11). Specifically algorithm 1 and 2.

[191] Cf. Philipsen, Brell, Brost, Eickels, and Ziefle (2018, pp. 488–489).

[192] Cf. Fischer et al. (2019, p. 11).

[193] Cf. Schäuble et al. (2017, pp. 16–17).

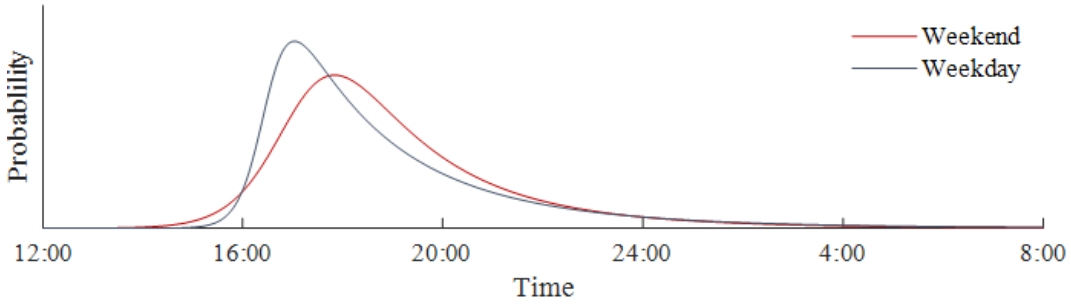


Figure 9: Burr Type XII probability distributions to draw predefined maximum arrival times.

Table 12: Benchmarking of driving time and trip frequency of data against model.

		Model	Data	Deviation
Average daily driving time [min]	Total	40.37	40.2	0.17 (0.4%)
	Weekday	45.35	45.27	0.08 (0.2%)
	Weekend	27.93	27.5	0.43 (1.6%)
Average trip frequency [trips/day]	Total	2.08	2.09	-0.01 (-0.5%)
	Weekday	2.34	2.36	-0.02 (-0.8%)
	Weekend	1.42	1.42	0 (0%)

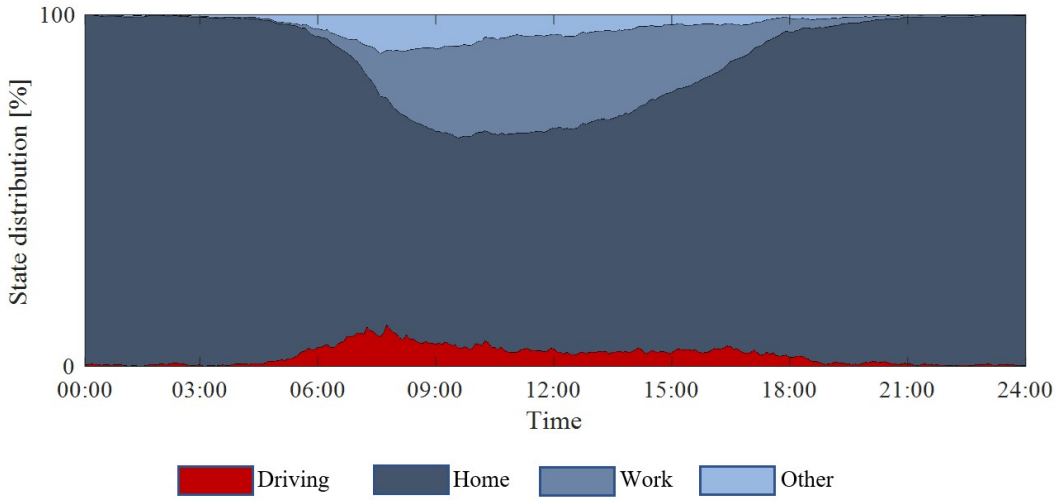


Figure 10: Average simulated state distribution of agents during a weekday.

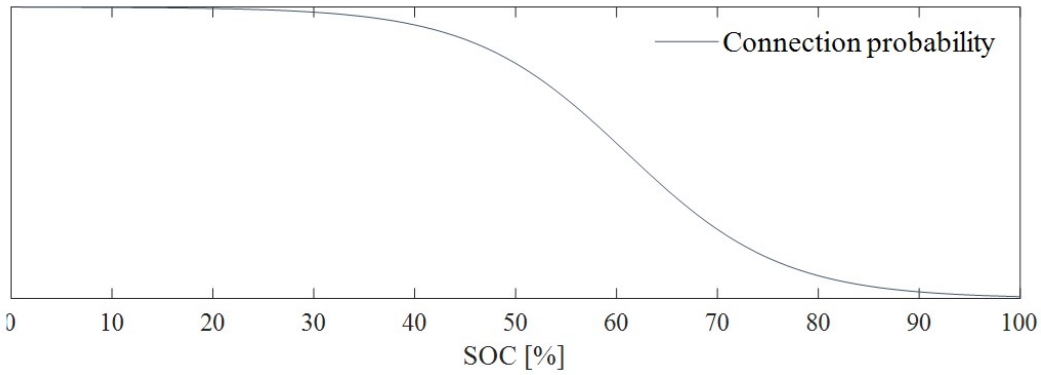


Figure 11: Connection probability with a=1.

The energy charged at one timestep for the EV is calculated with Equation (5), where $P_{charger}$ is the rated power of the charger in kWh and η is the charging efficiency of the overall charging operation. The resulting charging loads equal $P_{charger}$. Aggregation of all charging loads for each EV of a household results in the overall charging loads of this household.

5.2. Model of house load profiles

Standard load profiles have been widely used for research in energy systems. However, recent literature suggests that the use of such profiles yields misleading results especially in settings with intermittent energy sources.[194] Alternatives are provided by reference load profiles or synthesized residential load profiles. The former usually depicts reference data of one specific household. Unfortunately, publicly available reference load profiles are spare and thus empirical sampling of households to simulate multiple households is not feasible. On the other hand, synthesized residential load profiles allow the generation of random household behavior as well as the definition of household characteristics and desired activities and behaviors. Due to these benefits, this thesis realizes the modelling of household load profiles with synthetic load profiles.

Pflugradt and Muntwyler developed a synthetic load profile generator that simulates the behavior and activities of the residents to generate the load profiles for the whole household.[195] Their load profile generator is available free of charge and has been widely used and validated in a great extent of literature.[196] The energy consumption can be simulated in time intervals down to 1 minute for self-defined households. Further, it includes 60 predefined and validated German households based on a survey, measurements, and appliance use statistics. These predefined households are used to generate a set of 1, 200 households for each time of the year while incorporating meteorological data for the location Munich. This thesis assumes that all households do not rely on electricity as source of heating, as only roughly 5% of households in Germany use this source of heating energy.[197]

To develop the electrical load profile of a house, the loads of individual households are aggregated. First, depending on the agglomeration type, household load profiles based on the number of residents per household are sampled. Second, the number of households per house are selected based on the type of agglomeration. Then, household load profiles of the houses' residents (including EV charging demand) are aggregated to obtain the electrical load profile of the house.

5.3. Model of PV generation profiles

To model the PV generation profiles the PV profile generator provided by Pfenninger and Staffell is used.[198]

Figure 12 illustrates the model of PV generation in two different stages. In the first stage, the PV capacity per residential building type is estimated. This parametrization of the PV model has been done in section 5.3. In the second stage, the PV generation simulator provided by Pfenninger and Staffell is parametrized accordingly to generate time of the year and building type depending on PV generation profiles. The generated PV profiles apply on a building level. In total PV profiles for 40 years are generated which are then later randomly drawn to capture variation in PV electricity generation.

PV systems with peak powers above 7 kWp need to have active power curtailment measures in Germany to ensure grid stability.[199] This can be implemented with additional smart meters or alternatively with limiting the maximum output power to 70% of the theoretically achievable peak power. As smart meter installations are often not economically feasible for such small PV installations, most residential PV systems in Germany are curtailed to 70% of peak power.

To estimate reasonable PV penetration rates, it is important to consider the share of EV owners with suitable rooftop areas, that own or are willed to invest in PVs. Empirical results suggest that PV owners in Austria are 21% more likely to purchase an EV in the next five years compared to non-EV owners. Moreover, 43% of EV drivers in the UK already own solar panels and 14% plan to buy solar panels in the near future.[200] This increases the overall likelihood that EV drivers are simultaneously owners of PV arrays. Latest results suggest that the conditional probability of owning a PV system is 31% higher when the owner also owns an EV.[201] This conditional probability is applied in this thesis while holding average PV penetration rates constant.

Average PV penetration rates shows great spatial differences in Germany. While rural areas in south Germany show penetration rates above 20% for small PV installations, some areas in north Germany have penetration as low as 3%.[202] Latest analysis suggest great development potentials due to many unused rooftop areas with suitable azimuth angles and rooftop geometry.[203] Therefore, PV penetration rates of 30% are assumed as reasonable for a future 2030 scenario.

5.4. Model of the battery energy storage system

The BESS integration mainly depends on the total power energy demand of the house. The calculation of the total energy profile of the house at a specific timestep is given in

[194] Cf. Linssen, Stenzel, and Fleer (2017, p. 2024).
[195] Cf. Pflugradt and Muntwyler (2017).
[196] Such as Cf. Huang, Sun, Lovati, and Zhang (2021); Cf. Haider and Schegner (2020); Cf. Lopez, Rider, and Wu (2019).
[197] Cf. BDEW Bundesverband der Energie- und Wasserwirtschaft e.V. (2019).
[198] Cf. Pfenninger and Staffell (2016).
[199] §9 EEG.
[200] Cf. Cohen, Azarova, Kollmann, and Reichl (2019, p. 575); Cf. CleanTechnica (2019).
[201] Cf. Cohen et al. (2019, p. 574).
[202] Cf. EUPD Research (2022).
[203] Cf. EUPD Research (2022).

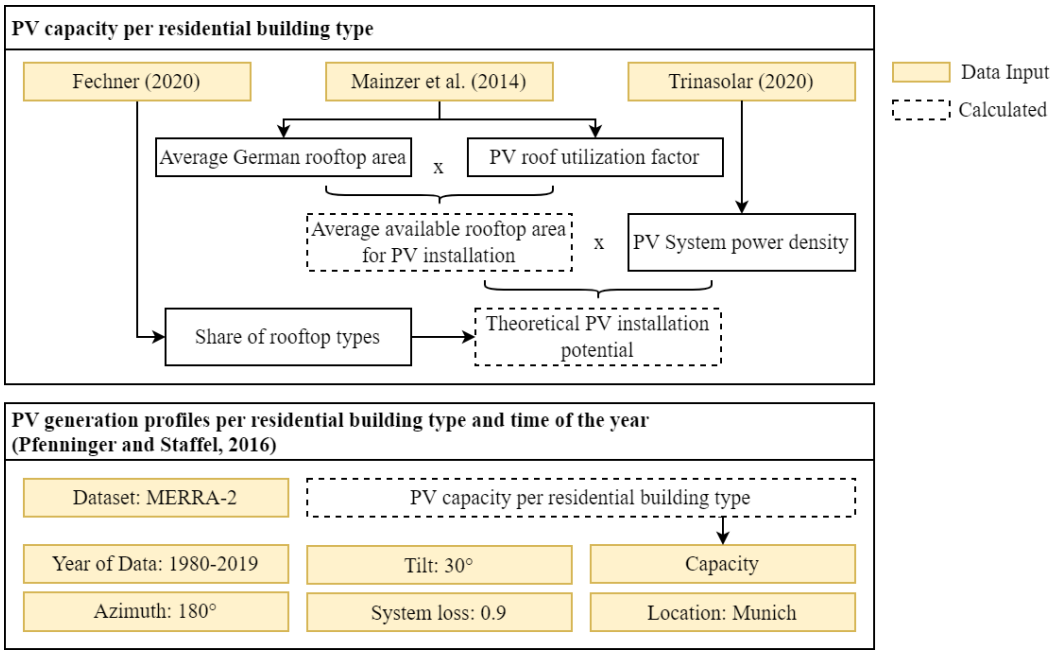


Figure 12: Model of PV generation.

Equation (6).

$$P_{house} = P_{PV} - P_{HH} \tag{6}$$

where $P_{HH} = \sum_{j}^{h} P_{HH}^{j}$ equals the sum of all household loads including EV loads in this specific house. P_{PV} represents the electrical PV yield of the PV system. All values only represent a specific timestep.

In a passive integration approach the following strategy is applied: If P_{house} at a given timestep is greater 0, the excess energy is used to charge the BESS. If the BESS already has a SOC of 100% then the house acts as an electrical supply and provides energy to the grid. If P_{house} is smaller 0, energy from the BESS is consumed to supply the house loads. If the SOC of the BESS is 0% then the house acts as an electrical sink and draws power from the grid. The SOC at the beginning of the week is initialized with a random SOC, which is obtained after one week of simulation.

5.5. Model of the distribution grids

This section describes the selected grid models, how simulated loads are integrated into the grid and the power flow methodology.

Representative networks grid model based on street maps and DSOs data are employed for varying agglomeration types to model electrical distribution grids.[204] SimBench distribution grids are based on typical German LV grid topologies and statistically represent average German grids.[205] The node layout of the selected grid is displayed in Figure 13 and Table 13 illustrates corresponding grid characteristics. All lines are realized as cables with diameters ranging between 150 mm^2 and 240 mm^2. In the power flow model, each supply point is realized as a simulated house. An exception is the urban grid, where more than one house can be connected to a supply point. Average grid lines differ greatly with an average feeder length of 367.5 m in the rural grid, 298.3 m in the semi-urban grid and 154.3 m in the urban grid respectively. Therefore, it is expected that voltage deviations are highest in the rural grid.

The load flow simulation is carried out with MATLAB MATPOWER.[206] All power flows in the context of this thesis are solved with Newton's method while all reactive limits are enforced. As the time horizon is very large the analysis is conducted semi-dynamically by parametrizing and solving a static grid power flow problem for each individual timestep. Investigated grid metrics are: (1) Maximum transformer loading and reverse power flows, (2) line loadings, and (3) voltage deviations. The maximum transformer loading is specified by the individual transformer's characteristics. Excess PV generation can lead to undesired reverse power flows, resulting in the transformer feeding energy from the LV grid to the MV grid. Maximum line loadings are calculated based on the maximum specified current of the line which mainly depends on the conductor material, the line diameter and the type of installation. All lines are installed in earth resulting in maximum current of 270 A for the NAVY 4x150 mm^2 line and 357 A for the 4x240 mm^2 line. Maximum power loadings of the line can then be calculated with Equation (7).

$$P = V * I * \sqrt{3} \tag{7}$$

[204] Cf. Meinecke, Thurner, and Braun (2020); Cf. Sarajlic and Rehtanz (2019).
[205] Cf. Meinecke, Sarajlić, et al. (2020, p. 9).
[206] Cf. Zimmerman, Murillo-Sanchez, and Thomas (2011).

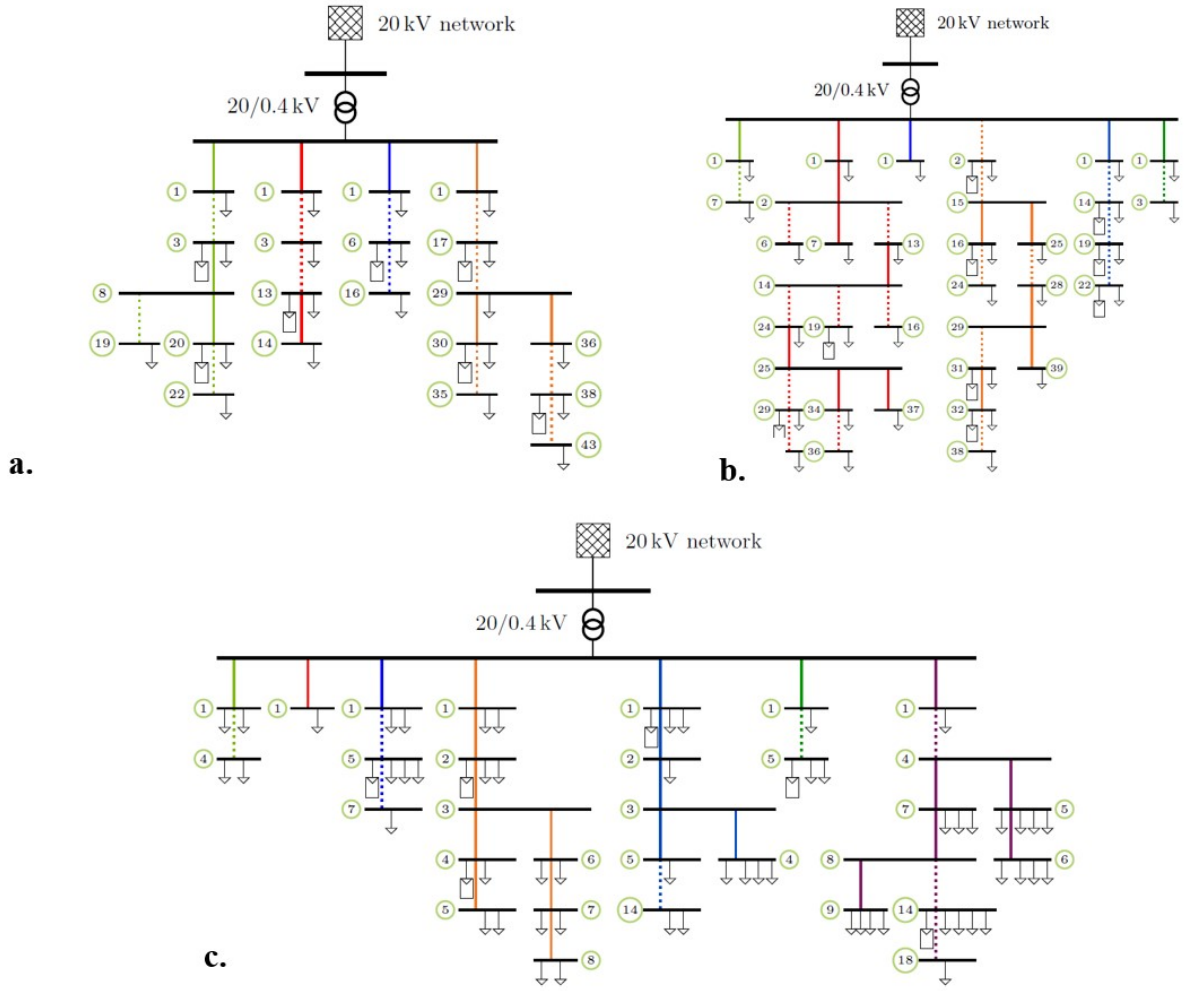


Figure 13: Illustration of selected grid topologies. **a.** Rural LV grid13 model; **b.** Semi-urban LV grid model; **c.** Urban LV grid model.

Cf. Sarajlic and Rehtanz (2019, p. 4).

Table 13: Characteristics of selected 0.4 kV distribution grids.[a]

	Rural grid (LV02)	Semi-urban grid (LV05)	Urban grid (LV06)
Transformer Sr	1x250 kVA	1x630 kVA	1x630 kVA
Line type	NAVY 4x150 mm^2	NAVY 4x240 mm^2	NAVY 4x240 mm^2
Overall line length	1.47 km	1.79 km	1.08 km
Number of supply points	93	104	53
Number of feeders	4	6	7

[a]Cf. Prettico, Gangale, Mengolini, Lucas, and Fulli (2016, pp. 40–48).

where P is power in Watt, V is the voltage of the line in Volts and I is the specified current of the line in Ampere. Line overloads mainly occur in feeders near the transformer. Maximum voltage deviations are defined in EN 50160 for German power grids. Voltage levels below 0.9 p.u. and above 1.1 p.u. are unsatisfactory and 95% of the 10-minute mean values for a week must obtain these limits.[207] Grid loads are deployed with a fixed power factor $cos(\varphi)0.93$ for individual loads,

[207]Cf. DIN (2020).

while PV generation is assumed to have a power factor of 1.0.[208]

6. Impact of EV charging on distribution grids

Electrical load profiles are realized with the model such that each agglomeration scenario is populated with the respective number of households. This results in an average of 189 simulated households for the rural grid, 420 households in the semi-urban grid and 444 households in the urban grid. Solving the power flow problem allows an analysis of the grid metrics of interest. Owing to the natural fluctuations of the simulation results each scenario is simulated for 200 iterations. Based on this information, percentiles on how likely it is that a specific metric is violated, can be derived. This is important as distribution grids are not designed to withstand concurrent peak loads of all consumers in the grid. Instead, maximum capacities are calculated with a concurrency level and thus very small probabilities of grid metric violations are tolerated.[209]

The following section presents the results of the power flow analysis. First, results in the rural grid are introduced, influences of time of year variation and chosen grid metrics are discussed. Subsequently, the semi-urban power flow and the urban power flow are analyzed based on selected cases.

6.1. Rural grid

In this case a mean of 189 households is simulated for a period of one week. Figure 14 illustrates the median value of the deployed electrical profiles for the March case with an assumed EV and PV penetration level of 30%. The solid blue line depicts household loads, while the solid orange line illustrates the sum of household and EV charging loads. Household loads peak at 202 kW, which is 80.8% of the transformers capacity and in line with the grid load specifications of Sim Bench.[210] Results align with existing literature and indicate strong temporal patterns in household and EV charging loads. Load profiles show a great deviation between weekdays and weekends. While overall household loads are higher during weekends, additional EV charging loads during weekends are not as pronounced. Weekday peak loads increase by 25% due to EV charging and by 16% during weekends.

a. PV generation and reverse power flows

The solid yellow line in Figure 14 indicates the PV yield. Comparing this profile with load profiles confirms literature findings of weak chronological coincidences between PV generation and electrical peak loads, especially during weekdays. This leads to excess PV electricity generation which is fed back into the grid by the house supply point. This can be beneficial when neighboring supply points still demand electrical energy. However, if total PV yield surpasses total loads in the distribution grid, reverse power flows in the transformer occur. This is illustrated in Figure 15. The shaded area depicts the energy which is fed back into the medium voltage grid. The extend of excess energy strongly depends on the time of year, as shown by 15a, 15b, 15c, and 15d. The occurrence of these reverse power flows is not desired and might be limited by DSOs. Besides already considered curtailment measures, such as limiting PV generation to 70% of the peak power, further curtailment can be necessary. In the case without BESS, PV generation between 9:15 a.m. and 2:45 p.m. needs to be curtailed in June to eliminate the occurrence of reverse power flows. By introducing household BESS part of the excess energy can be stored. This is illustrated in Figure 16 which indicates the power flow into the battery as negative values and the power output of the battery as positive values. This additional energy storage and exchange significantly reduces the occurrence of reverse power flows as illustrated in the worst-case June scenario in Figure 16. First, the BESS are charged beginning at 7:00 a.m. when the net sum of generated electricity is higher than the electrical demand. During afternoon the average electrical demand of the houses start to surpass the PV generation. The overall sum of power outflow is higher than the power inflow as early as 3:00 p.m. and peaks at 7:15 p.m. Afterwards, the BESS is still able to supply the houses with energy, which indicates that the capacity of the BESS can sufficiently support electrical loads in the rural grid.

b. Transformer loads

An investigation of transformer limits for varying EV penetration rates indicates that maximum transformer loadings can be exceeded in certain simulation iterations. Figure 17 illustrates the mean transformer use factor for a weekday with varying EV penetration rates. The use factor is calculated with Equation (8).

$$Usefactor = \frac{P_{actual}}{P_{max}} \tag{8}$$

where P_{actual} represents the actual load in Watt and P_{max} equals the specified maximum power limit in Watt. A use factor of 1 indicates a load equal to the specified maximum load and is thus the critical threshold.

Based on mean values transformer limit violations are observable with 60% EV penetration as depicted with the yellow line. Grid loads can be of high volatility. Therefore, individual simulation iteration results are analyzed. Figure 18 illustrates the use factor of the transformer for all simulation iterations with an 30% EV penetration. The solid black line depicts the median value of all simulation iterations of the selected scenario. The red shaded area equals the respective percentiles where each shade represents a 5-percentile step. The simulation result shows that 20-percentile of simulations exceed the transformer limits with 30% EV penetration on Sunday. Limit violations occur during a very short period during weekdays in case of grid loads without PV and BESS interaction. Figure 18(b) and 18(c) illustrate the effect of additional PV arrays and BESS interaction respectively. The

[208] Cf. Meinecke, Sarajlić, et al. (2020, p. 5).
[209] StromNEV §16 II Anlage 4.
[210] Cf. Sarajlic and Rehtanz (2019, p. 3).

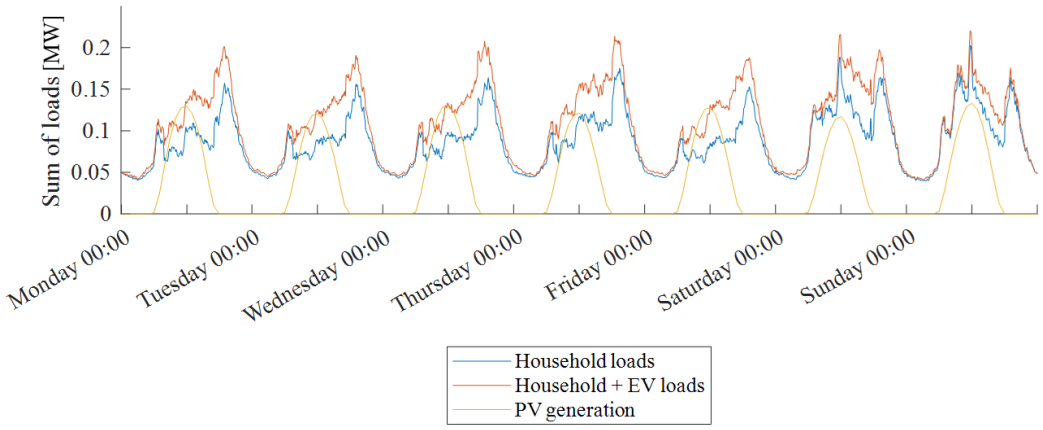


Figure 14: Median of deployed electrical load profiles for the rural grid in March with 30% EV and PV penetration.

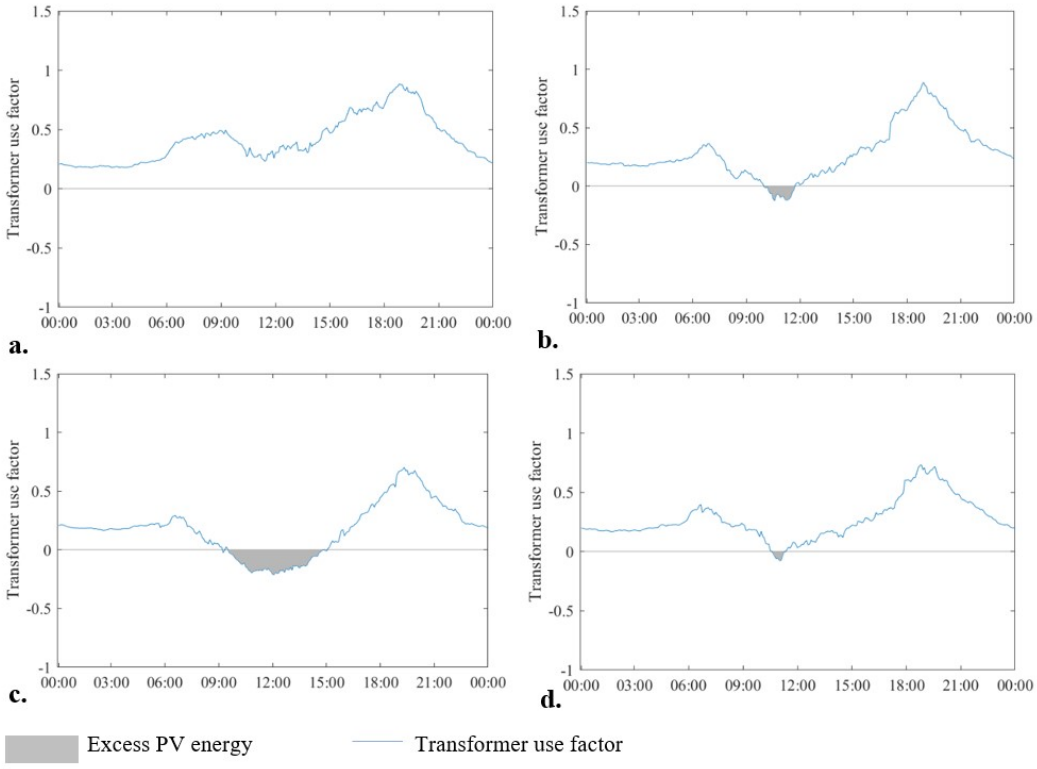


Figure 15: Excess PV energy with 30% PV penetration **a.** December; **b.** March **c.** June, **d.** September.

results demonstrate two things: First, the mitigation potential of solely adding PV generation is limited during weekdays but very effective on weekends. This is in line with findings of existing literature. Second, BESS can shave peak loads during time of days with little to no PV yield. This is visible in Figure 18c, where no transformer limit violations are observable.

c. Line loads

Next, loads of feeder lines depending on the EV penetration rate and time of year are investigated. Line limits can be exceeded at EV penetration rates of 40%. Most critical are the lines after the step-down transformers in long branches, as these must bear the load of all following houses in this feeder branch. Line limit violations in general are considered more critical than transformer overloading, as line temperatures cannot be precisely monitored and thus line limits are conservatively sized.[211] The line use factor of the most critical branch in the rural grid with 30% EV penetration is illustrated in Figure 19 for a period of one week. The lines still have enough capacity to cope with additional EV charging loads.

[211] Cf. Nesti, Nair, and Zwart (n.d.).

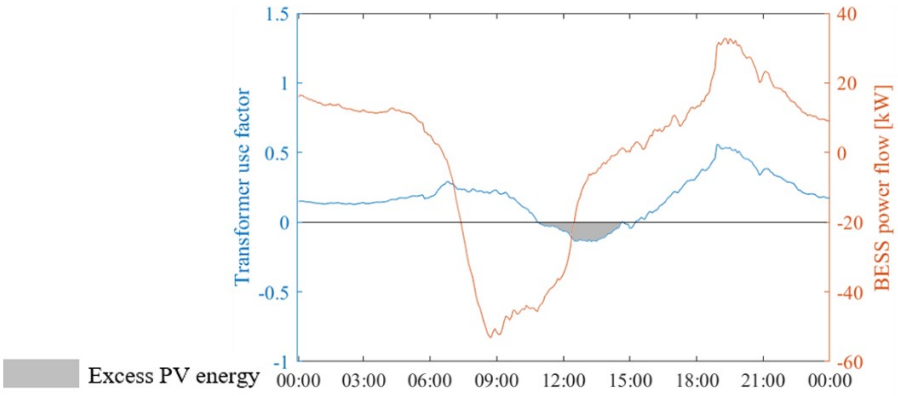


Figure 16: BESS interaction and transformer use factor in the rural grid in June.

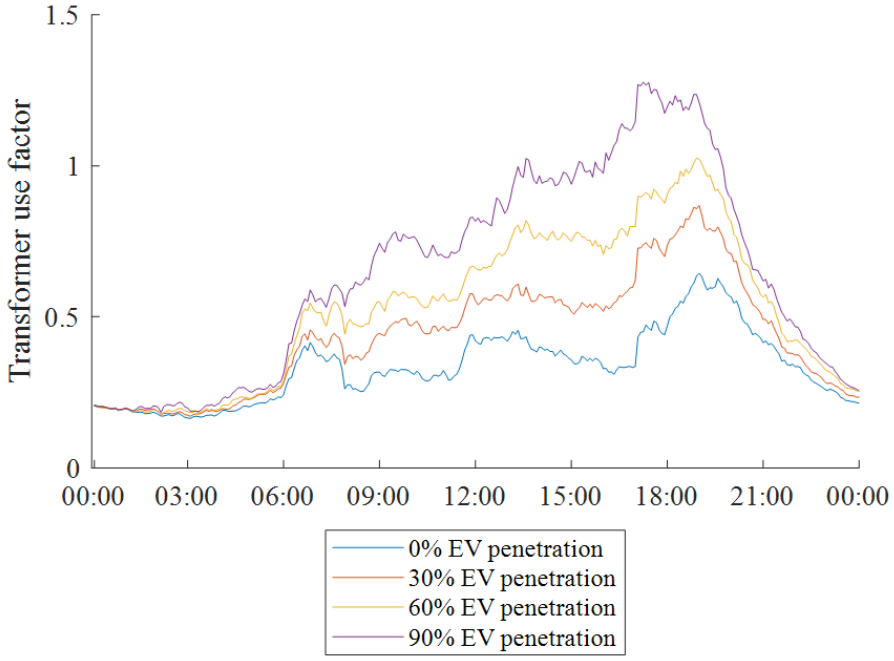


Figure 17: Mean transformer use factor for a weekday in the rural grid with varying EV penetration rates.

d. Bus voltages

Minimum bus voltages have been monitored and are presented in Figure 20 for an 30% EV penetration scenario in March. Under voltage issues are most likely to occur in the last line of the feeder branch with the highest overall line length. In general, voltage deviations appeared to be moderate and increasingly an issue with very high EV penetration rates. During the simulation period the moments of under voltage occurrences were counted. For investigated EV penetration rates of up to 75% no under voltage occurrences were observable.

e. Sensitivity of load mitigation

To understand the full potential of EV charging load mitigation with PV and BESS, simulations are carried out for varying time of years, PV penetration, and EV penetration. Figure 14 illustrates the sensitivity of the line limit violations in case of PV and BESS interaction. Numbers indicate the percentile of simulations where a limit violation occurred. December represents the worst-case scenario, as PV generation is low and electrical consumption by households and EVs is larger. Higher PV penetration rates as well as seasons with high solar irradiation significantly improve the mitigation potential of residential PV arrays with BESS. Figure 14 also indicates that rural lines in the SimBench grid are generously dimensioned for transmitting a high amount of power. Compared to Figure 15 where the sensitivity of transformer limit violations in case of PV and BESS interaction is displayed, violations of line limits are much rarer than transformer limit violations. Figure 15 indicates that with 40% EV penetration most simulated iterations exceed line limits in the December case, while this share significantly reduces with higher PV penetration rates and more solar irradiation in June. Limit

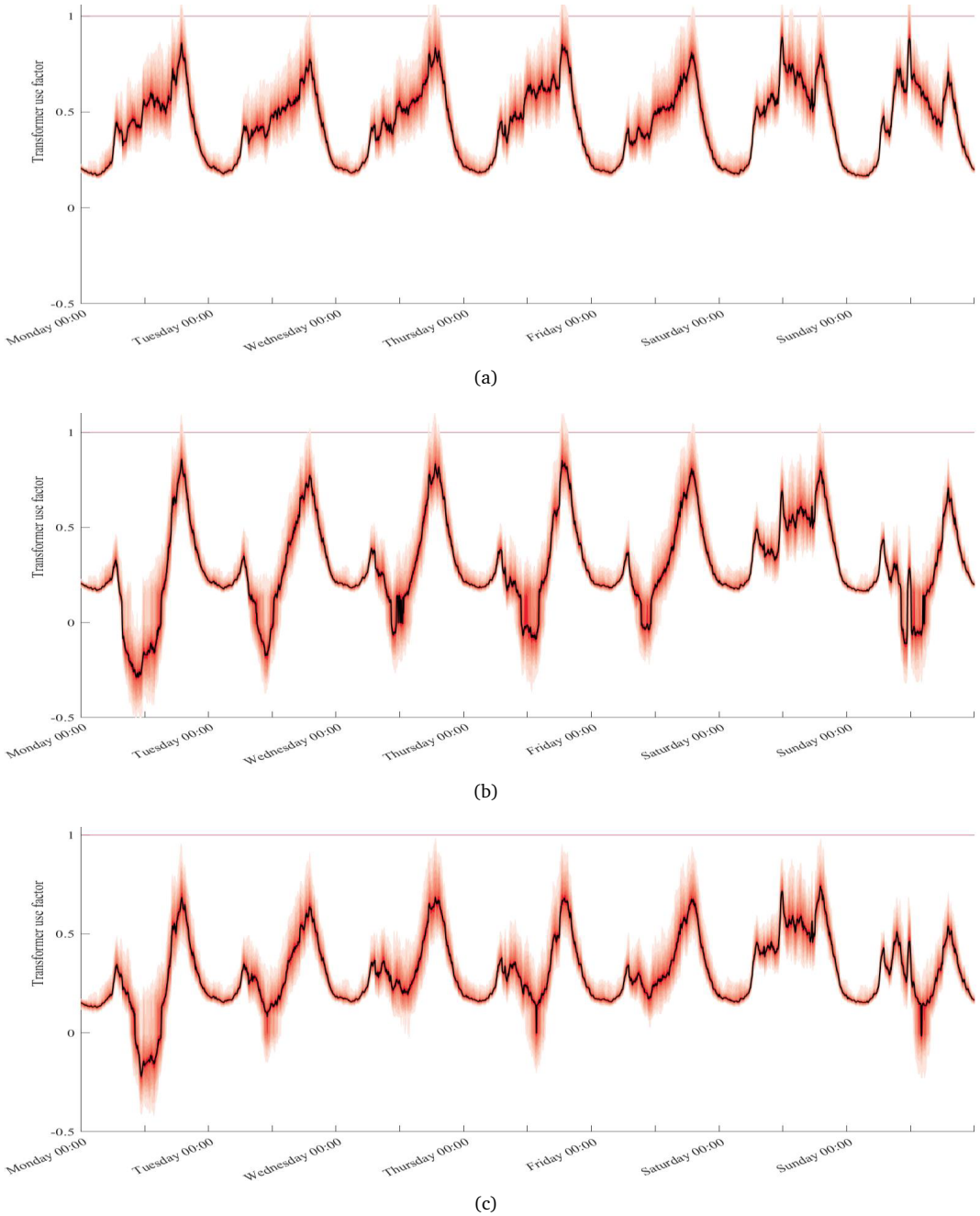


Figure 18: Rural transformer use factor in March. **a.** Household and 30% EV penetration; **b.** Household and 30% EV + PV penetration; **c.** Household and 30% EV + PV + BESS penetration.

violations occur for lower EV penetration rates mainly on weekends while for EV penetration rates above 50% the most critical violations occur during weekday evenings.

Together, these simulations suggest that the rural grid cannot reliably withstand EV penetration rates above 30%. Limit violations occur in the rural MV-LV transformer. Line limits as well as undervoltage limit violations only occur at higher EV penetration rates. Additional PV generation is not able to mitigate the loads effectively due to weak chronological coincidence. Paring a PV system with BESS greatly increases the mitigation potential. However, low solar irradiation in months with shorter daytimes limit the effect. Higher PV penetration increases the supporting potential but on the other hand introduces stronger reverse power flows.

6.2. Semi-urban grid

The semi-urban grid loads are realized with 420 simulated households containing approximately 1,530 individuals. Figure 21 illustrates the median value of the deployed electrical profiles for the March case with an assumed EV and

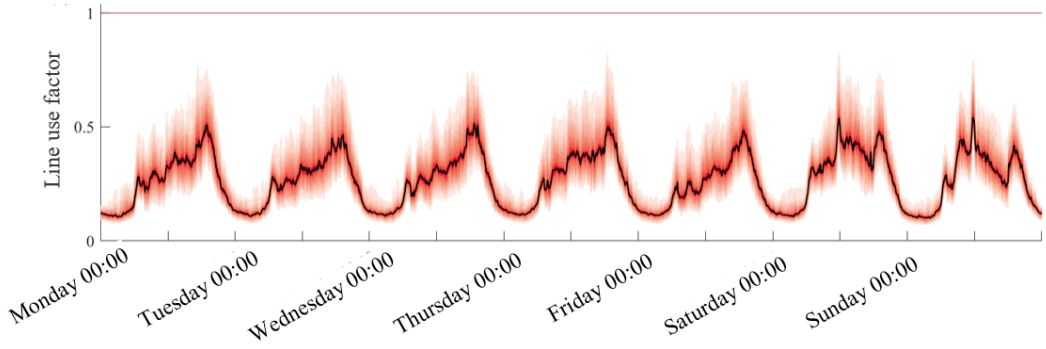


Figure 19: Use factor of critical line in rural grid with 30% EV penetration.

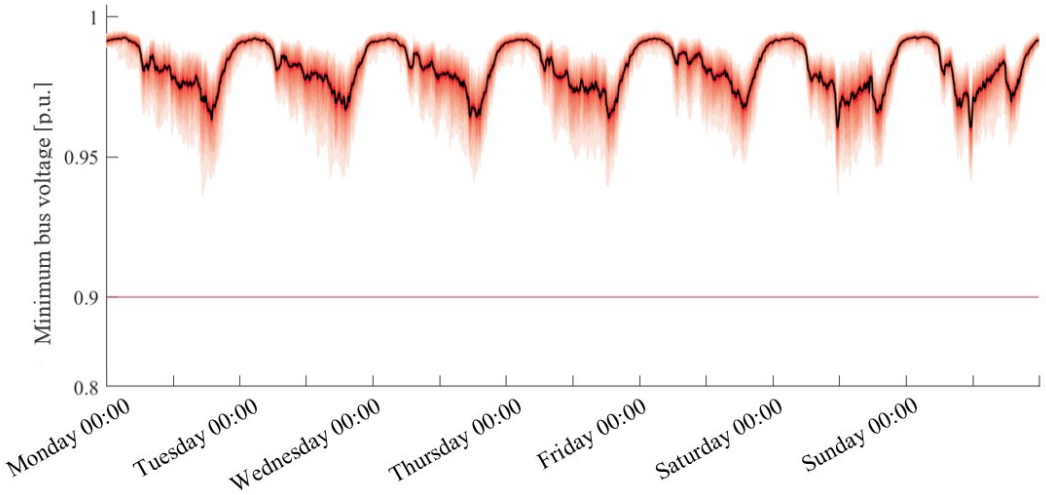


Figure 20: Minimum bus voltages in rural grid with 30% EV penetration.

Table 14: Percentile of simulation iterations with rural line limit violations with PV and BESS. **a.** December; **b.** March; **c.** June; **d.** September.

PV and BESS penetration [%]

EV penetration [%]	0	30	60	90
0	0	0	0	0
10	0	0	0	0
20	1	0	0	0
30	2	0	0	0
40	4	3	0	0
50	7	5	1	0
60	11	6	4	1
70	20	19	11	8

a.

EV penetration [%]	0	30	60	90
0	0	0	0	0
10	0	0	0	0
20	0	0	0	0
30	0	0	0	0
40	5	2	0	0
50	9	4	1	0
60	14	5	3	0
70	21	16	9	2

b.

EV penetration [%]	0	30	60	90
0	0	0	0	0
10	0	0	0	0
20	0	0	0	0
30	0	0	0	0
40	1	0	0	0
50	2	0	0	0
60	4	0	0	0
70	6	0	0	0

c.

EV penetration [%]	0	30	60	90
0	0	0	0	0
10	0	0	0	0
20	0	0	0	0
30	0	0	0	0
40	5	1	0	0
50	9	3	1	0
60	14	5	2	0
70	20	16	7	1

d.

PV penetration level of 30%. Household loads peak at 433 kW which is 69% of the transformer's capacity. Therefore, the semi-urban grids' household base load is not as high as the rural grids' load. 30% EV penetration leads to an approximately 23% increase in peak loads during weekdays and is comparable to the peak load increase in the rural grid.

a. PV generation and reverse power flows

The PV generation per household is significantly smaller compared to the rural grid. This is due to the conditional probability on the number of households per house. Therefore, reverse power flows do not occur in the median case in March with 30% EV and PV penetration. This is an important finding in the understanding of the maximum feasible PV penetration rate to minimize the occurrence of reverse power flows.

b. Line loads

Table 15: Percentile of simulation iterations with rural transformer limit violations with PV and BESS. **a.** December; **b.** March; **c.** June; **d.** September.

PV and BESS penetration [%]

EV penetration [%]

	0	30	60	90
0	0	0	0	0
10	25	7	1	0
20	43	21	7	3
30	54	39	24	12
40	64	45	36	30
50	71	51	45	41
60	74	59	52	49
70	85	67	59	55

a.

	0	30	60	90
0	0	0	0	0
10	3	0	0	0
20	9	0	0	0
30	17	0	0	0
40	35	19	9	7
50	51	34	26	21
60	64	43	38	34
70	74	55	49	45

b.

	0	30	60	90
0	0	0	0	0
10	1	0	0	0
20	9	0	0	0
30	24	0	0	0
40	37	0	0	0
50	47	3	0	0
60	54	8	0	0
70	63	11	1	0

c.

	0	30	60	90
0	0	0	0	0
10	3	0	0	0
20	8	2	0	0
30	17	6	0	0
40	34	20	8	6
50	50	33	25	19
60	63	41	36	31
70	73	52	46	41

d.

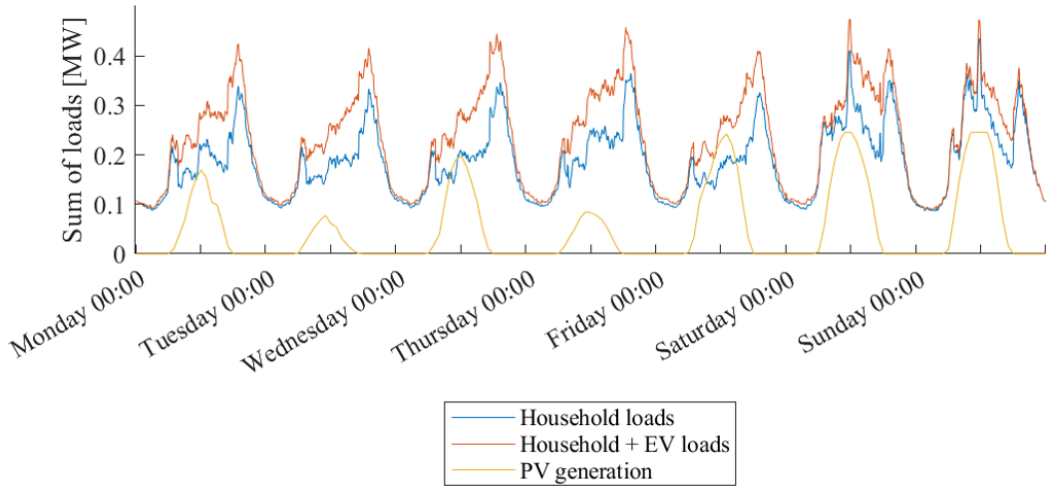


Figure 21: Median of deployed electrical load profiles for the semi-urban grid in March.

The relatively higher transformer capacity influences results such that transformer overloading's are not as likely to occur. On the other hand, line limit violations increase earlier in frequency with higher EV penetration rates. Line limits are illustrated in Figure 22 for an EV penetration rate of 30%. The mitigation impact of additional PV and BESS are not as pronounced as in the rural grid. While peak line loadings are slightly reduced, the influence is weaker.

c. Bus voltages

Undervoltage issues were not observable for all investigated EV penetration rates. This is most likely due to the high number of feeders and relatively low line length in combination with generously dimensioned line diameters.

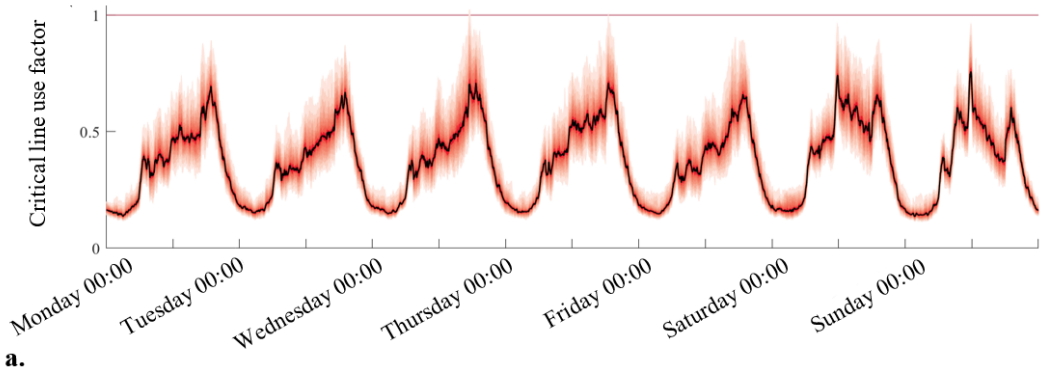
d. Sensitivity of load mitigation

Figure 16 illustrate the percentile of simulation iterations where line limits got violated. First violations occur with EV penetration rates as low as 10% in December. Higher PV penetration rates as well as seasons with higher solar irradiance significantly reduce the likelihood of limit violations for low EV penetration rates. Compared to the rural grid, the semi-urban grid step down transformer is not as likely to be overloaded, as shown in Figure 17. First limit violations occur at 20% EV penetration. Further, the June scenario mitigates transformer limit violations due to additional charging loads, completely for investigated EV penetration rates of up to 70%.

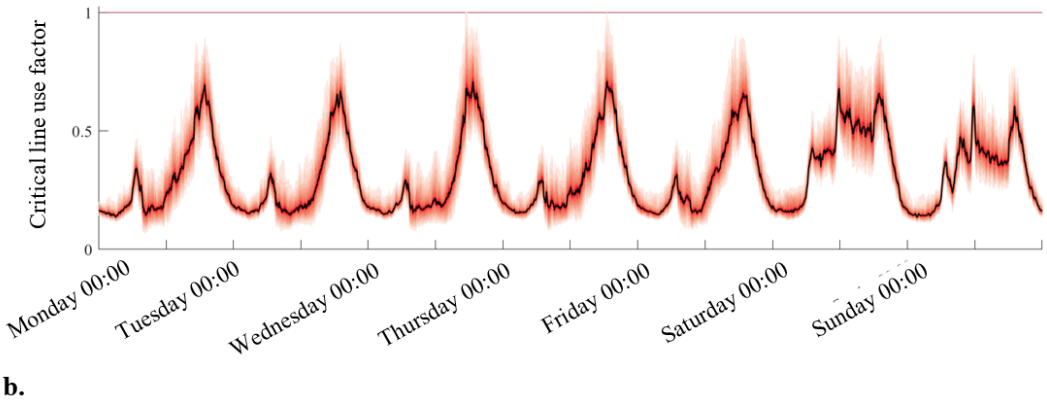
Overall, the semi-urban grid seems more robust dimensioned compared to the rural grid. Critical components are primarily lines. Transformer limits as well as undervoltage limit violations only occur at higher EV penetration rates. PV arrays with BESS help to reduce loads on grids. 30% penetration of the forementioned increases the maximum feasible EV penetration rate by 10% in the worst-case in December and 40% in the best case in June.

6.3. Urban grid

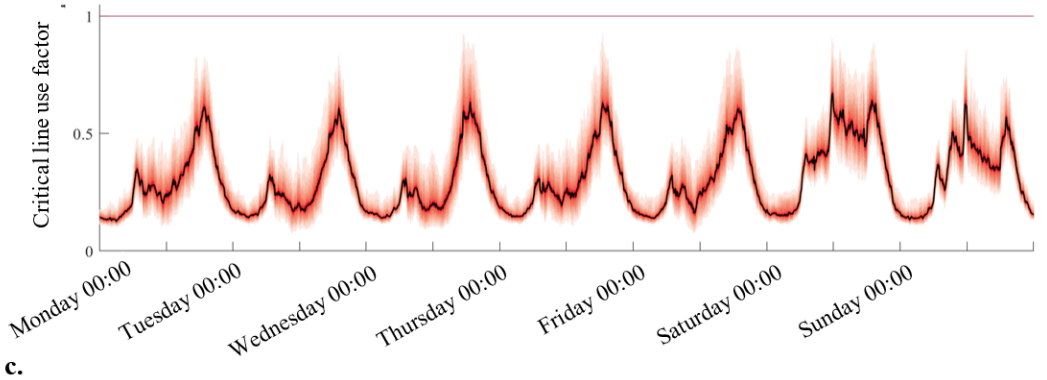
The urban grid loads are realized with 444 individual simulated households connected to 53 supply points of the grid. Therefore, this grid is the most complex in terms of number of simulated individuals. At the same time loads are spatially concentrated on a smaller number of supply points with short line distances in between. Figure 23 illustrates the median value of the deployed electrical profiles for the March case with an EV and PV penetration level of 30%. House-



(a)



(b)



(c)

Figure 22: Semi-urban line use factor in March. **a.** Household and 30% EV penetration; **b.** Household and 30% EV + PV penetration; **c.** Household and 30% EV + PV + BESS penetration.

Table 16: Percentile of simulation iterations with semi-urban line limit violations with PV and BESS. **a.** December; **b.** March; **c.** June; **d.** September.

PV and BESS penetration [%]

EV penetration [%]

	0	30	60	90
0	0	0	0	0
10	3	0	0	0
20	7	2	0	0
30	12	5	0	0
40	21	8	5	0
50	35	24	22	16
60	55	53	49	48
70	64	62	58	55

a.

	0	30	60	90
0	0	0	0	0
10	0	0	0	0
20	2	0	0	0
30	5	0	0	0
40	12	5	1	1
50	19	10	6	4
60	26	17	13	11
70	47	38	34	28

b.

	0	30	60	90
0	0	0	0	0
10	1	0	0	0
20	3	0	0	0
30	5	0	0	0
40	12	0	0	0
50	18	2	0	0
60	25	5	0	0
70	40	10	0	0

c.

	0	30	60	90
0	0	0	0	0
10	0	0	0	0
20	2	0	0	0
30	5	0	0	0
40	12	5	1	1
50	18	10	5	4
60	25	16	12	9
70	46	37	33	26

d.

Table 17: Percentile of simulation iterations with semi-urban transformer limit violations with PV and BESS. **a.** December; **b.** March; **c.** June; **d.** September.

PV and BESS penetration [%]

EV penetration [%]

	0	30	60	90
0	0	0	0	0
10	0	0	0	0
20	1	0	0	0
30	3	1	0	0
40	18	8	5	2
50	33	24	21	16
60	50	49	46	43
70	61	60	58	55

a.

	0	30	60	90
0	0	0	0	0
10	0	0	0	0
20	0	0	0	0
30	0	0	0	0
40	3	0	0	0
50	9	3	2	1
60	17	8	5	2
70	45	27	21	17

b.

	0	30	60	90
0	0	0	0	0
10	0	0	0	0
20	0	0	0	0
30	0	0	0	0
40	1	0	0	0
50	5	0	0	0
60	12	0	0	0
70	21	0	0	0

c.

	0	30	60	90
0	0	0	0	0
10	0	0	0	0
20	0	0	0	0
30	0	0	0	0
40	2	0	0	0
50	7	3	1	0
60	16	8	4	1
70	45	26	19	15

d.

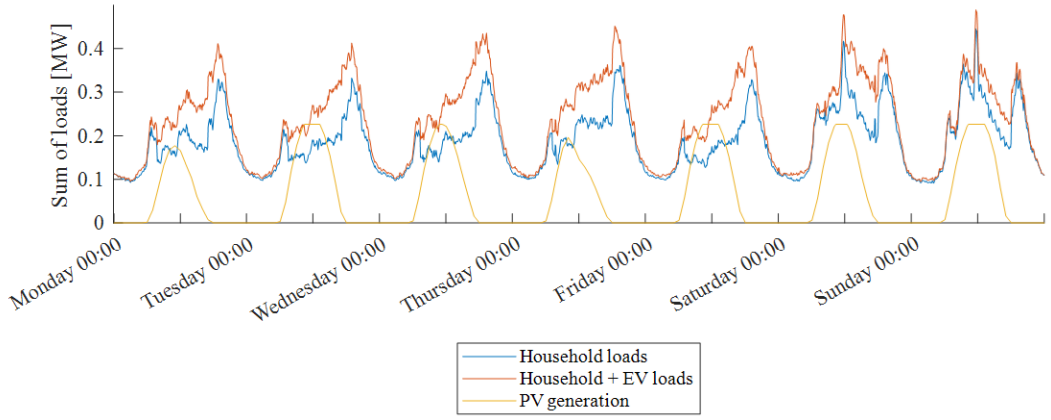


Figure 23: Median of deployed electrical load profiles for the urban grid in March.

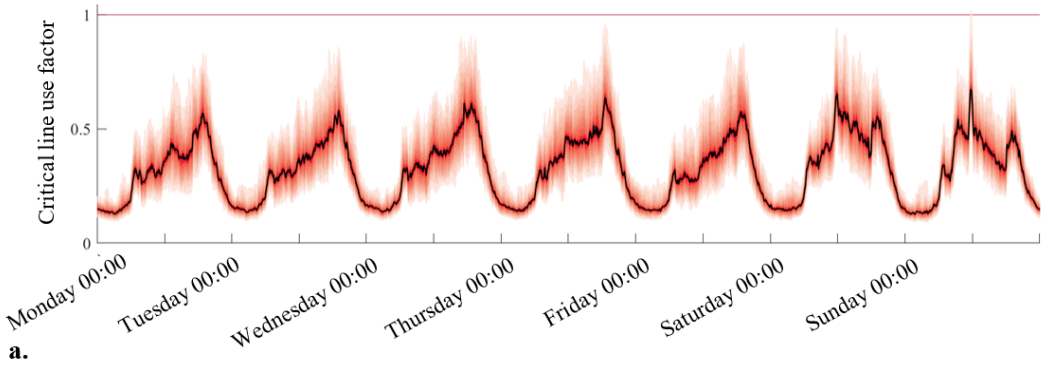
hold loads peak at 440 kW which is 70% of the transformer's thermal capacity.

a. PV generation and reverse power flows

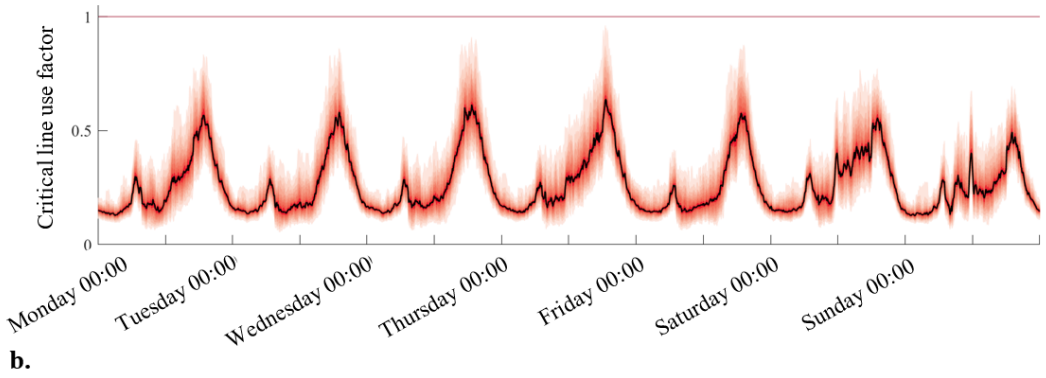
The overall PV yield per household in this type of grid is the smallest. This is due to the high number of multifamily homes. Integrating additional EV charging loads leads to no reverse power flows in the March case even without a BESS. This is beneficial as higher PV penetration rates can be implemented without the need of any curtailment measures.

b. Line loads

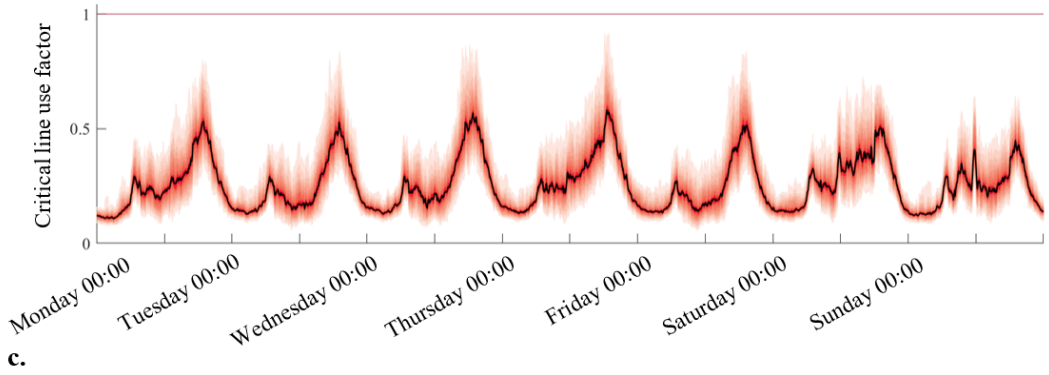
An investigation of transformer and line load limits indicates that transformers are not the most critical component in the grid. This is due to the smaller use factor of the transformer in the base-case without EV loads. An analysis of line use factors over the simulation period of one week in March is presented in Figure 24. Line limits are most likely to be exceeded at weekends in a scenario with 30% EV penetration. Compared to the former two investigated grids, more volatility in deployed loads is observable in the urban grid. This is due to the relatively high number of simulated households



(a)



(b)



(c)

Figure 24: Urban line use factor in March. **a.** Household and 30% EV penetration; **b.** Household and 30% EV + PV penetration; **c.** Household and 30% EV + PV + BESS penetration.

and individuals. This leads to a higher likelihood of extreme cases where multiple peak loads coincide. A small percentile of simulations exceeds line load limits with 30% EV penetration. The addition of a PV array with BESS significantly reduces the median line use factor for the whole week, while worst-case peaks remain relatively unchanged. This might be due to the constant size of the BESS which is independent of the house size. Multi-home houses are therefore more likely to deplete the stored energy before the evening peak load occurs.

c. Bus voltages

An analysis of the voltage behavior suggests that undervoltage issues do not occur in the urban grid. This is owed to the short feeder line lengths and thus voltage drops are not as significant. The worst-case scenario for line voltages are high and focused loads in branches. Figure 25 illustrates minimum line voltages in the urban grid during December with an EV penetration rate of 75% and no PVs.

d. Sensitivity of load mitigation

To understand how varying EV and PV penetration rates

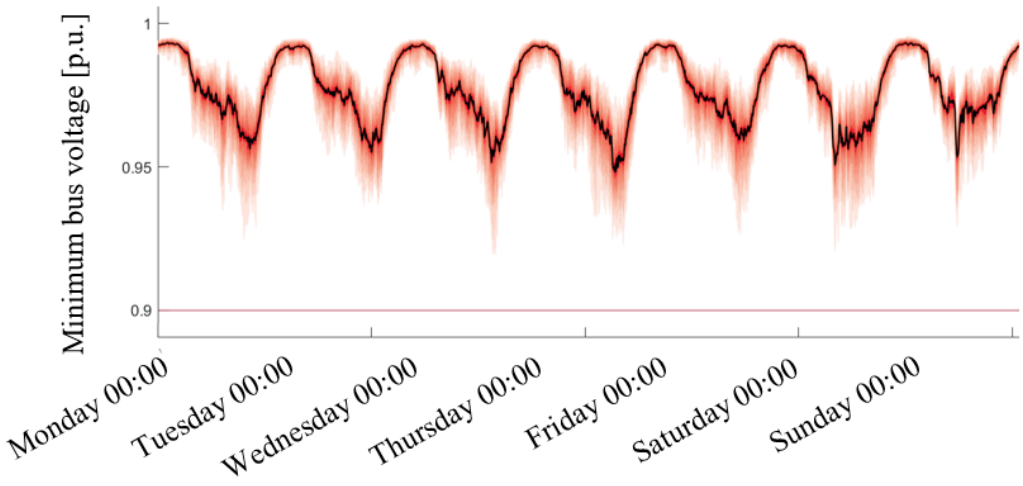


Figure 25: Minimum bus voltage in the urban grid in December with 75% EV penetration.

Table 18: Percentile of simulation iterations with urban line limit violations with PV and BESS. **a.** December; **b.** March; **c.** June; **d.** September.

PV and BESS penetration [%]

EV penetration [%]	0	30	60	90
0	0	0	0	0
10	1	0	0	0
20	4	1	0	0
30	10	3	0	0
40	19	10	7	1
50	29	18	12	4
60	40	29	14	11
70	51	39	17	15

a.

EV penetration [%]	0	30	60	90
0	0	0	0	0
10	0	0	0	0
20	1	0	0	0
30	3	0	0	0
40	9	3	1	0
50	14	6	3	1
60	17	9	6	4
70	32	12	9	7

b.

EV penetration [%]	0	30	60	90
0	0	0	0	0
10	0	0	0	0
20	0	0	0	0
30	1	0	0	0
40	8	0	0	0
50	13	0	0	0
60	16	0	0	0
70	19	5	5	1

c.

EV penetration [%]	0	30	60	90
0	0	0	0	0
10	0	0	0	0
20	1	0	0	0
30	3	0	0	0
40	9	3	1	0
50	13	6	2	1
60	16	8	5	3
70	31	12	8	6

d.

Table 19: Percentile of simulation iterations with urban transformer limit violations with PV and BESS. **a.** December; **b.** March; **c.** June; **d.** September.

PV and BESS penetration [%]

EV penetration [%]	0	30	60	90
0	0	0	0	0
10	1	0	0	0
20	5	0	0	0
30	12	0	0	0
40	27	5	0	0
50	40	16	4	3
60	51	31	12	10
70	65	48	35	34

a.

EV penetration [%]	0	30	60	90
0	0	0	0	0
10	0	0	0	0
20	0	0	0	0
30	1	0	0	0
40	7	0	0	0
50	12	2	1	1
60	17	5	4	3
70	40	16	11	7

b.

EV penetration [%]	0	30	60	90
0	0	0	0	0
10	0	0	0	0
20	0	0	0	0
30	0	0	0	0
40	2	0	0	0
50	7	0	0	0
60	16	0	0	0
70	23	2	0	0

c.

EV penetration [%]	0	30	60	90
0	0	0	0	0
10	0	0	0	0
20	0	0	0	0
30	1	0	0	0
40	6	0	0	0
50	12	1	1	1
60	17	4	4	3
70	38	15	10	6

d.

influence the results, a sensitivity analysis was conducted for urban grid loads as well. This is depicted in Figure 18 and Figure 19. Compared to the base-case without PV, the 30% PV and BESS penetration case increased maximum feasible EV penetration by approximately 10% in December and 50% in June. These results cast new light on the potential of EV charging load mitigation with PV arrays depending on the time of year.

The urban grid is more robust compared to the rural grid. Even though this grid has the lowest PV generation capacity per household, the addition of PV and BESS still mitigated grid overloading's induced by additional EV charging successfully. With increasingly higher EV penetration rates line limits are violated first, afterwards the urban transformer limits are

exceeded.

7. Discussion

This section summarizes the findings and contributions made and discusses potential implications as well as limitations.

7.1. Potential of PV and BESS to mitigate EV charging loads

The developed simulation models allowed to study the impact of high EV penetration, PV penetration as well as BESS interactions in varying grid topologies and time of year. Extensive results show that the presence of PV arrays have the potential to mitigate EV charging impact, especially during weekends. The intermittent nature of PV generation however limits the mitigation potential for peak loads which occur on weekdays in the evening. This result ties well with previous studies.[212] A promising finding was that BESS can leverage the potential of PVs to mitigate the charging impact. Further, they contribute to improved electrical quality as well as higher PV self-consumption by reducing the need for power curtailment measures. In general, maximum feasible EV penetration rates increased by 10% - 50% while the need for active power curtailment measures was reduced. With the addition of PV arrays in combination with BESS, grids can be sufficiently supported to handle EV charging loads of the targeted EV penetration of 30% for 2030. Especially, as some DSOs allow a temporarily loading of 130% of maximum steady-state loading for MV/LV transformers.[213] This however reduces the lifetime of the transformer.[214]

The results also demonstrated that for this thesis employed measures and assumptions regarding PV penetration and BESS are not enough to support the long-term goal of 100% electrification in the transport sector. One weakness is that the potential to mitigate charging impacts strongly depends on time of year dependent solar irradiance. While PV generation in summer months has the potential to generate enough electricity to mitigate evening charging loads, this is not the case in December. Here, higher PV penetration rates as well as bigger BESS are required to support grids sufficiently.

Critical grid components are transformers in the rural grid, and feeder lines in the semi-urban and urban grid. Limit violations mainly occur in feeder lines as well as MV/LV transformers. These findings are in accordance with findings reported by previous studies.[215] Contrasting to existing literature voltage deviations are not as likely to occur.[216] This is mainly due to two reasons. First, SimBench lines in rural grids (which are most prone to undervoltage issues) are generously sized compared to other LV rural grids.[217] Second, the investigated power flow assumes balanced loads and therefore single-phase overloading and thus resulting undervoltage is more unlikely. Further implications of this assumption and other limitations are discussed in the next section.

7.2. Limitations and uncertainties

One limitation of the implementation is that only home charging is assumed. Therefore, charging loads are probably overestimated as the whole EV energy demand is supplied by the residential distribution grid. Furthermore, this thesis modelled the grid loads symmetrically. Because a three phase 11 kW AC charger was set as the charging standard it was assumed that all additional loads in the grid are balanced. In practice, smaller chargers might be used as well. These draw power from one or two phases and might introduces significant imbalances requiring an investigation of grid imbalances as this can have an influence on results.[218]

Other limitations are given in the simulation of driving and household behaviors. Both these behaviors are not linked to each other therefore reducing load overlapping. It might be expected that an agent arrives at home, connects the EV, and begins to perform energy intensive household tasks. Therefore, charging loads and energy intensive household loads might coincide more frequently. This is supported by the fact that it was assumed that the number of charging ports equals the number of EVs in a household. It is likely that a household only invests in one EV charging station instead of owning a charger for each EV. These limitations are apparent in many existing simulations. Furthermore, this thesis assumes that all households regardless of role in the society follow the same mobility behavior. This was done because the mobility dataset was too sparse to categorize individuals in specific groups.

While reverse power flows have been investigated, uncertainties regarding the occurrence of overvoltage have not been addressed in this study. This is due to limitations of MATLAB MATPOWER to model renewable energy sources. Because of this potential limitation, this thesis treated excess PV energy, as energy which should be curtailed.

In conclusion, some limitations might increase the impact of EV charging on distribution while other limitations reduce the impact. The results in general, provide a better understanding of the exact interactions between EV charging loads, distributed PV energy generation and BESS. A differentiation between agglomeration scenarios and time of year enables a holistic view on the issue at hand.

8. Conclusion

New energy challenges and greenhouse gas emissions necessitate a shift towards mobility and energy solutions without fossil fuel dependency. The presence of EVs will introduce substantial challenges for distribution grids, on the one

[212] Cf. Luthander et al. (2019); Cf. ElNozahy and Salama (2014).
[213] Cf. Meinecke et al. (2019).
[214] Cf. Gray and Morsi (2017); Cf. Hong et al. (2020).
[215] Cf. Wang and Infield (2018); Cf. Habib et al. (2020); Cf. Clement-Nyns et al. (2010).
[216] Cf. Ul-Haq et al. (2015); Cf. Ma et al. (2017); Cf. Clement-Nyns et al. (2010).
[217] Cf. Prettico et al. (2016).
[218] Cf. Held et al. (2017, pp. 8–10).

hand. Distributed and emission free PV electricity generation on the other hand, provides a unique opportunity to support distribution grids. Understanding EV charging loads and fed in distributed electricity into electrical distribution grids is therefore essential. This thesis deployed representative grid models for varying agglomeration scenarios and seasons to model the synergy potential between high EV penetration rates, PV electricity generation and BESS.

Results show that the presence of PV arrays with BESS have the potential to mitigate EV charging impacts. In general, maximum feasible EV penetration rates can be increased by 10% - 50% depending on the grid topology and the time of year. At the same time active power curtailment measures which might be necessary due to excess PV energy can be reduced. With the addition of PV arrays in combination with BESS, grids can sufficiently support EV charging loads of the targeted EV penetration of 30% for 2030 in Germany. Whilst rural grids are most vulnerable to increased loads through higher EV penetration rates, the mitigation potential with PV electricity generation and BESS is also highest. This is due to the spatial conditions as well as population density. The simulation results suggest that the feasible PV yield per household in rural areas is significantly higher than the PV yield in urban areas. Semi-urban and urban grids on the other hand are more robustly dimensioned in Germany and transformer overloading is not as likely to occur.

Limitations in the mitigation potential are given due to the intermittent nature of PV generation and the strong dependence on seasonality patterns. EV penetration rates of 50% and above are not supportable with the current grid infrastructure and the assumed PV and BESS specifications. To cope with days of low PV yield, the BESS might also require charging energy from the grid. Therefore, it can be guaranteed that BESS have enough stored energy to shave critical peak loads. Governmental incentives might be required to increase PV adoption rates, to achieve necessary PV penetration rates and to support the widespread installation of BESS. Recent price reductions for battery capacity as well as affordable BESS by extending used EV batteries' lifetime increases the feasibility of widespread BESS installation.[219] Future research should investigate if the integration of widespread PV with BESS also proves economically feasible by comparing investment costs, energy cost savings, and practicability of alternative measures.

[219] Cf. Heymans et al. (2014).

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Virtual Reality Transforming the Digital Learning Environment: An Analysis of Students' Acceptance

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Abstract

Virtual reality (VR) is gaining prominence in post-secondary education. In fields such as medicine or engineering education, VR is widespread and enhances educational opportunities. The technologies' popularity is, however, swapping over to more theoretical fields of study. Institutions, therefore, need to understand what factors influence the decision of post-secondary students to accept immersive VR applications in non-practical lectures. The Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) provides a theoretical framework for technology acceptance research. While most previous studies have taken a quantitative approach, this study adopts a qualitative method to deliver profound insights into the students' perspectives on VR acceptance. Based on a thematic analysis of focus group interviews, the study extends UTAUT2 by adding two core constructs and additionally identifying upstream factors influencing all core constructs of UTAUT2. The results indicate that the original UTAUT2 is too superficial to capture the underlying influences on students' VR acceptance. Thereby, my study contributes to current VR acceptance research by providing a context-specific UTAUT2 model that may guide decision-makers in successfully implementing VR in post-secondary education.

Keywords: Virtual reality; Technology acceptance; UTAUT2; Post-secondary education.

1. Introduction

Virtual reality (VR) is not as futuristic as often portrayed. Especially in fields such as engineering or medicine, the technology is already widely used (Jayaram et al., 2007, p. 217; Burdea & Coiffet, 2003, p. 3). Technological advancements and cost reductions made VR applications more accessible than ever (Concannon, Esmail, & Roduta Roberts, 2019, p. 2). Specifically, immersive VR technologies using head-mounted displays (HMD) have gained popularity, and the amount of available content has increased (Statista, 2021, p. 4). New HMDs such as the Oculus Quest 2 offer an excellent price-performance ratio, making VR increasingly attractive for universities (Radianti, Majchrzak, Fromm, & Wohlgenannt, 2020, p. 2).

After almost three years of online education, the question if VR could be a game-changer for the educational sector has arisen. Due to the Covid-19 pandemic, face-to-face teaching has been shifted to online formats. This situation impacted students' educational experience and diminished the quality of education. Undergraduate students reported decreased motivation, isolation, and communication difficulties (Baltà-Salvador, Olmedo-Torre, Peña, & Renta-Davids, 2021, p. 18-19; Almossa, 2021, p. 7173-7177). A study carried out during the pandemic observed an increased interest in introducing immersive VR in education (Radianti et al., 2020, p. 22).

Amplified theoretical research on VRs' educational application additionally indicates its rising recognition (Radianti et al., 2020, p. 22; Abich, Parker, Murphy, & Eudy, 2021, p. 923). The global VR market is expected to be valued at USD 12.19 billion by 2024 growing significantly from USD 3.89 billion in 2020. Experts predicted technology disruptions in the educational sector and forecasted VR to be used for immersive classroom experiences and soft-skill training (Statista, 2021, p. 5-20). Due to the increasing potential of VR technology and the significant cost reductions, it is time to study immersive VR in education further.

Literature on immersive VR in education particularly debated its effectiveness in teaching. Parong and Mayer (2018) have noticed higher motivation of students, however, worse learning success (p. 794). Contrary, Li, Liang, Quigley, Zhao,

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and Yu (2017) have demonstrated immersive VR training to be effective (p. 1283). The content-based learning approach of VR especially improves creative and problem-solving skills (Velev & Zlateva, 2017, p. 35). Another research field relating to VR in education addresses the acceptance of VR, describing what influences users' decision to accept VR as a teaching tool. Available acceptance research, however, mainly focuses on VR acceptance in other domains than education or considers other educational technologies (Toyoda, Abegao, Gill, & Glassey, 2021, p. 1; Bernd, 2001, p. 1-2). The existing body of literature, nevertheless, suggests similar factors influencing students' technology acceptance. The scarce research on VR acceptance in education tended to focus on quantitative methods generating broadly applicable findings rather than concentrating on the underlying students' perspective (Noble, Saville, & Foster, 2022, p. 7; Fussell & Truong, 2022, p. 255; Chahal & Rani, 2022, p. 9-10).

Even though the acceptance of VR applications has been discussed rather extensively, only a few studies in the literature focus on students' VR acceptance in theory education. Using primarily quantitative methods, the inherent factors influencing students' decisions remain unclear. In an attempt to fill this research gap, my study addresses the question: What factors influence the decision of post-secondary students to accept the use of immersive VR applications in a non-practical lecture? Using an exploratory qualitative approach, I conducted focus group interviews with three different groups of post-secondary students.

The thesis aims to find influencing factors on a students' decision to use immersive VR applications in a theoretical educational setting. The goal is to categorise the gathered qualitative data into distinct influencing themes. The heterogeneity of the focus groups allows for collecting deep and diverse insights into post-secondary students' decision-making (Saunders, Lewis, & Thornhill, 2019, p. 321-322). I based the research on the extended Unified Theory of Acceptance and Use of Technology 2 (UTAUT2), which describes factors influencing consumers to accept and use technology (Venkatesh, Thong, & Xu, 2012, p. 158-159). The theory is appropriate as post-secondary students can be considered customers of universities (Guilbault, 2016, p. 137). Part of the aim is to develop an extension of the UTAUT2 model, specifically applicable to students' VR acceptance in post-secondary education.

The findings of the exploratory study contribute to the existing literature on VR acceptance and generate a deeper understanding of post-secondary students' intention to use VR. By providing a proposed extension of UTAUT2, I reveal underlying linkages of acceptance factors as a conceptual model. From a managerial perspective, the research primarily informs universities implementing VR and supports them in ensuring students' acceptance. In addition, companies can use the results to understand their customers' acceptance of VR client training and thus increase the likelihood of adoption.

The thesis is structured into four parts. The following section introduces the theoretical background examining the existing literature on VR aspects, primarily focusing on its application in education. The subsequent section illustrates the research design, data collection, and analysis approach. The results are then presented and immediately discussed along with the identified core themes, and the part ends with the extended model of UTAUT2. The final section discusses how these findings contribute to the existing literature and outlines managerial implications, limitations, and opportunities for future research.

2. Theoretical background

The first patent for VR was issued in 1962, and the initial idea significantly developed in 1965 (Burdea & Coiffet, 2003, p. 3-4; Sutherland, 1965, p. 506-507). Hence, VR is not a recent innovation. The big buzz around VR, however, resurfaced in 2021 when Meta launched and heavily marketed its metaverse, claiming it could be the new internet where people not only play games but also collaborate and enjoy their free time. (BBC, 2021, para. 1-3). The technology, in general, can be defined as "a way of transporting a person to a reality . . . , in which he or she is not physically present but feels like he or she is there" (Rebelo, Noriega, Duarte, & Soares, 2012, p. 969). Zhang (2014) further defines VR as "a kind of special environment generated by a computer . . . people can dominate or control . . . " (p. 2427).

There is a distinction between non-immersive and immersive VR applications (Ventura, Brivio, Riva, & Baños, 2019, p. 2). In my thesis, I focus on immersive VR, which has proven to be more effective in education and leads to better performance of mental activity (Bailey, Johnson, Schroeder, & Marraffino, 2017, p. 9; Ragan, Sowndararajan, Kopper, & Bowman, 2010, p. 541). In recent years, interest in adopting VR in education has increased, and the application of immersive VR has been intensively researched (Radianti et al., 2020, p. 22; Concannon et al., 2019, p. 1-2). One reason for this development could be the amplified availability and accessibility of consumer HMDs (Concannon et al., 2019, p. 2; Battussi & Chittaro, 2017, p. 1063). Additionally, recently developed HMDs offer an excellent price-performance ratio, making VR increasingly attractive for universities (Radianti et al., 2020, p. 2).

2.1. Virtual reality technology

VR delivers solutions in various fields, including engineering, medicine, and the military (Burdea & Coiffet, 2003, p. 3). Recent research on VR has ranged from survival training for kids to applications for mental health (Molan, Weber, & Kor, 2022, p. 1; Bell, Nicholas, Alvarez-Jimenez, & Thompson, 2020, p. 169). One of the main advantages of VR is its flexibility, which enables virtual content to illustrate a variety of cases (Bliss, Tidwell, & Guest, 1997, p. 84). Likewise, related technologies such as augmented reality (AR) have found increasing popularity in the same domains of application (Alkhamisi & Monowar, 2013, p. 28). AR, however,

belongs to the mixed realities and displays real and virtual objects at the same time (Milgram & Kishino, 1994, p. 1323-1326). Apart from the specific application or the technology in use, different features shape the virtual experience.

2.1.1. VR features

Terms describing features of VR do not have a homogeneously used meaning across literature and, therefore, need to be defined to ensure consistent terminology (Radianti et al., 2020, p. 22). According to Burdea and Coiffet (2003), VR consists of the three Is', including immersion, interaction, and imagination (p. 3). The term *immersion* describes the feeling of being inside a virtual environment (VE), and the sense of hearing and sight are most crucial for its creation (Rebelo et al., 2012, p. 969). *Interactivity* is created with multiple sensory channels and is increased by input hardware such as motion trackers or sensing gloves (Rebelo et al., 2012, p. 970). The term *imagination* implies the ability of the brain to perceive fictional things (Burdea & Coiffet, 2003, p. 3). These three features are the most vital for a satisfying VR experience. However, additional terms have been applied in the literature.

Closely related to *immersion* and *interactivity* is *fidelity*. This term implies the perceived degree of realism of the experienced VE (Ragan et al., 2015, p. 794). Witmer and Singer (1998) define the feature of *involvement* as "a psychological state experienced as a consequence of focusing one's ... attention on a coherent set of stimuli ..." (p. 227). Lastly, *presence* refers to shifting the attention from a physical to a virtual setting. *Presence* is the combination of *involvement* and *immersion and* increasing both features leads to a superior level of *presence* (Witmer & Singer, 1998, p. 226-227). Understanding the different terms will help when interpreting the results later.

2.1.2. Immersive VR

As I will focus on immersive VR applications, it is necessary to clarify the concept of immersion further. Research has found that immersive VR compared to non-immersive applications, can lead to improved skill and knowledge acquisition, higher engagement and enjoyment (Concannon et al., 2019, p. 14-15). People experiencing immersion describe themselves to be "in" the VE. However, despite this unique engagement, immersion can cause a lack of awareness in time (Jennett et al., 2008, p. 643-657).

Different levels of immersion are caused by various factors such as VE construction or real-world distractions (Jennett et al., 2008, p. 642). The level of immersion increases with more realistic VEs, bundled user concentration and the representation through a virtual body, known as an avatar (Liang et al., 2017, p. 11; Rebelo et al., 2012, p. 971; Slater & Wilbur, 1997, p. 606). To support the creation of immersion, immersive VR utilises devices such as HMDs or cave automatic virtual environments (Cochrane, 2016, p. 46; Liang et al., 2017, p. 11). HMDs convey visual, audio, or tactile cues creating a more realistic environment and enabling more intuitive virtual interaction (Bailey et al., 2017, p. 2; Liang et al., 2017, p. 1). Since immersive VR causes improved concentration and performance, its usage in education could be beneficial.

2.2. VR in education

VR was already studied in several educational fields, such as medical training, safety education, engineering, or assembly task training (Huang, Liaw, & Lai, 2016, p. 3; Li et al., 2017, p. 1275; Wang, Wu, Wang, Chi, & Wang, 2018, p. 1; Jayaram et al., 2007, p. 217). Hence, its use in education is not new Cochrane, 2016, p. 46. Recent research primarily focused on medical-related topics and VR usage in higher education. However, there is a rising popularity of VR education across industries (Abich et al., 2021, p. 932; Kavanagh, Luxton-Reilly, Wuensche, & Plimmer, 2017, p. 89). This increase in attractiveness could be explained by more content availability, cost reduction of equipment and government interest (Abich et al., 2021, p. 923).

Universities mainly implement VR because of skills training, increased engagement, convenience, and team building (Concannon et al., 2019, p. 14-15). VR enables the direct practice of new tasks by avoiding the gap between theory and practice (Li et al., 2017, p. 1283). For example, the technology allows users to flexibly enter any location at any condition without being at risk (Rebelo et al., 2012, p. 970). Alternatively, users can simulate complex tasks or situations to study critical skills (Freina & Ott, 2015, p. 4; Bailey et al., 2017, p. 2). VR saves time and money and enables accessible and early-stage data collection during the design or training phase (Rebelo et al., 2012, p. 970; Carlson, Peters, Gilbert, Vance, & Luse, 2015, p. 780). The technology, likewise, is an opportunity for disabled people who are less satisfied with the current learning environment (Freina & Ott, 2015, p. 6; Gierdowski, 2019, p. 20). By introducing VR, the existing teacher-centred approach might shift to more student-centred learning and promote the education of 21st-century skills, such as communication or creativity (Wang et al., 2018, p. 12; Kong et al., 2014, p. 76). Despite the advantages of VR in education, its effectiveness also needs to be demonstrated.

2.2.1. Effectiveness of VR in education

Studies on VR training have found varying results on its effectiveness in education (Abich et al., 2021, p. 928). Li et al. (2017) have demonstrated VR training to be more effective than conventional teaching (p. 1283). The immersive VEs create a complex and content-based learning approach, which improves technical, creative, and problem-solving skills (Velev & Zlateva, 2017, p. 35). Active interaction with learning materials and direct modification of objects support learning and the building of associations. This, however, suggests that viewing non-interactive material through VR has no additional benefit (Abich et al., 2021, p. 929; Jang, Vitale, Jyung, & Black, 2017, p. 160). The technology enhances motivation, engagement and interest through the playful approach offered and the variety of possible learning styles (Parong & Mayer, 2018, p. 795; Freina

& Ott, 2015, p. 6). In particular, VR learning improves procedural knowledge, fine motor skills and enhances students' confidence in performing procedures (Abich et al., 2021, p. 925-930; Pulijala, Ma, Pears, Peebles, & Ayoub, 2018, p. 1070-1071). Studies have shown that desktop learning is more efficient than VR. Nonetheless, immersive VR training enables higher task performance and better knowledge acquisition and is overall more effective (Bailey et al., 2017, p. 9; Abich et al., 2021, p. 929).

In contrast, other studies have revealed mixed results, providing only weak to no evidence of VR effectiveness (Abich et al., 2021, p. 928). Bailey et al. (2017) have found no difference between desktop and VR training. Additionally, they could not prove a relationship between immersion and better learning outcomes (p. 8). Battussi and Chittaro (2017), likewise, were unable to prove better memorisation through higher fidelity (p. 1073). Other studies reported higher motivation of students through VR but worse post-test results (Parong & Mayer, 2018, p. 794). Researchers, however, argue that the negative results could be due to a lack of routine in learning with VR and that increased VR familiarity would improve performance (Bliss et al., 1997, p. 83-84; Abich et al., 2021, p. 930). Murcia-Lopez and Steed (2018) similarly have not found a significant difference between physical and virtual training. The researchers nonetheless, appeal for VR training as time should not be the only measure of effectiveness (p. 1583).

To overcome possible struggles of VR effectiveness, Parong and Mayer (2018) suggest using VR in combination with conventional teaching methods to arouse students' interest and motivation (p. 795). Theoretical content should, furthermore, be conveyed by utilising the interactivity VR provides. (Abich et al., 2021, p. 930). Jang et al. (2017) recommend using VR training for students with prior knowledge (p. 160). In contrast, other researchers have indicated that VR training might be more effective for students with less experience (Abich et al., 2021, p. 929; Parong & Mayer, 2018, p. 795). Hence, this implies the importance of adapting VR training to its target group (Abich et al., 2021, p. 929). Despite the partly demonstrated VR effectiveness, there is still criticism for its application in education.

2.2.2. Criticism of VR in education

According to Concannon et al. (2019), the technology should not replace traditional and established teaching methods (p. 14). One reason is the missing face-to-face interaction and hands-on experience (Velev & Zlateva, 2017, p. 36). Cochrane (2016) argued that VR offers excellent potential, but this cannot be exploited with current teaching methods. Therefore, a more student-centred approach needs to be implemented before using VR (p. 48). Secondly, immersive VR potentially causes cybersickness. Cybersickness is triggered by visual delays in VE adjustment due to refresh rates and lack of tactile feedback, creating an unrealistic and difficult-to-control environment (Rebelo et al., 2012, p. 972; Li et al., 2017, p. 9). Heavy HMDs can, additionally, exert pressure on the head causing discomfort during use (Yan, Chen, Xie, Song, & Liu, 2019, p. 248). Unnecessary movements in the VE, further, can distract and weaken students' attention (Parong & Mayer, 2018, p. 794). Kavanagh et al. (2017) have outlined that we should not forget that VR could potentially exclude some students from education (p. 108). Understanding influencing factors on VR acceptance, particularly student acceptance conditions, is vital to avoid potential exclusion.

2.3. Theoretical Framework

The success of VR in education depends considerably on the students' acceptance of the technology. Acceptance is "an antagonism to the term refusal and means the positive decision to use an innovation" (Bernd, 2001, p. 87). Various theories and frameworks explain the acceptance and adoption of new technologies (Taherdoost, 2018, p. 961). A prominent acceptance theory is the Technology Acceptance Model (TAM), which investigates *perceived ease of use* and *perceived usefulness*. One main finding is the strong correlation between the usefulness of technology and its actual usage (Davis, 1989, p. 333). TAM was widely used in technology acceptance research (Venkatesh, Morris, Davis, & Davis, 2003, p. 428). Venkatesh and Davis (2000) have, however, extended the model to TAM2 and included, among others, influences such as voluntariness, experience and output quality (p. 197). Another key theory is the Theory of Planned Behavior (TPB), which tries to explain human behaviour with *attitudes, subjective norms* and *perceived behavioral control.* The three aspects were found to correlate with human behaviour. Yet, other influences remained unresolved (Ajzen, 1991, p. 182-206).

Venkatesh et al. (2003) consolidated conceptual and empirical similarities of eight theories, including the three theories mentioned above and created the Unified Theory of Acceptance and Use of Technology (UTAUT). The models' application focuses on the organisational context (Venkatesh et al., 2003, p. 467). As students can be regarded as customers of post-secondary institutions, I applied the UTAUT2 model for my research (Guilbault, 2016, p. 137). Venkatesh et al. (2012) designed UTAUT2 to explain the technology acceptance of consumers (p. 158). The model was already used in several studies. However, its application for qualitative and VR acceptance research is rare (Tamilmani, Rana, & Dwivedi, 2017, p. 45). I only found a few studies using UTAUT or UTAUT2 in a qualitative context (Bixter, Blocker, Mitzner, Prakash, & Rogers, 2019, p. 75; Gharaibeh, Arshad, & Gharaibeh, 2018, p. 125). Janzik (2022), nevertheless, describes UTAUT2 as a reasonable basis for technology acceptance research (p. 107).

To create UTAUT2, Venkatesh et al. (2012) incurred four constructs from the original UTAUT model. These include *performance expectancy (PE),* indicating the perceived benefits gathered by technology usage, *effort expectancy (EE),* capturing the ease of use, *social influence (SoIn)* and *facilitating conditions (FC),* describing the perceived resources and support accessible (p. 159). According to Venkatesh et al. (2012), SoIn indicates whether students feel that important

people, such as family or peers, think they should use VR (p. 159). This question is inapplicable at this point as VR is not yet widely employed (Janzik, 2022, p. 107-108). The focus group discussion, therefore, debated whether students perceive that important others could influence their VR adoption.

For UTAUT2, the researchers have added three constructs (Venkatesh et al., 2012, p. 158-160). The first construct is hedonic motivation (HM), describing the enjoyment of using technology. Secondly, they have added price value (PV), representing the accord between consumer benefit and monetary costs. Lastly, the construct habit (HA), refers to automated use behaviour created through technology familiarity (Venkatesh et al., 2012, p.161). However, as the diffusion of VR is limited, only a minority was able to create HA in terms of automated behaviour (Janzik, 2022, p. 107-108). Therefore, the focus group interviews aimed to find requirements VR has to meet for regular use. All constructs influence the behavioral intention (BI) of people to use a particular technology (Venkatesh et al., 2012, p. 160).

UTAUT2 further includes *use behavior*. Janzik (2022), however, argues that *use behavior* should be excluded in the VR context as only few people currently use VR (p. 107-108). The model also involves three moderating variables of *age, gender* and *experience*, which differently influence the constructs (Venkatesh et al., 2012, p. 160). As my research only studied young students with a median age of 24.5, the moderator *age* is inapplicable. Additionally, according to Janzik (2022), the moderating variable *gender* is based on merely stereotypic arguments and, therefore, should be dismissed (p. 112). Venkatesh et al. (2012) encourage the adaption of UTAUT2 to different contexts (p. 173). Therefore, I will apply a modified UTAUT2 model as seen in Figure 1, including all constructs but excluding *use behavior, gender* and *age*.

2.4. Technology Acceptance

Although UTAUT2 has not been directly applied to understand factors influencing post-secondary students' acceptance and intention to use VR in education, prior research used other technology acceptance frameworks. Disztinger, Schlögl, and Groth (2017), for example, applied TAM to research VR acceptance (p. 259). Whereas other researchers used UTAUT, UTAUT2 or combinations of theories to study general VR acceptance or specifically VR acceptance in education (Algahtani, Altameem, & Baig, 2021, p. 221-224; Shen, Ho, Kuo, & Luon, 2017, p. 130; Noble et al., 2022, p. 3-4).

Technology is primarily adopted because of its functions and users only evaluate the required effort in a second step. Therefore, perceived usefulness is more decisive than ease of use. In general, users weigh the benefits against the costs, implying that they are willing to accept difficulties if a system offers enough valuable functions (Davis, 1989, p. 333-334). Perceived usefulness from TAM can be equated with PE in UTAUT2 and perceived ease of use with EE (Venkatesh et al., 2003, p. 448-451). According to Venkatesh et al. (2012), especially PE, FC, HM and PV influence the intention to use a technology (p. 170-171).

In addition, the level of experience influences technology acceptance. Taylor and Todd (1995) have determined that, especially for inexperienced users, provided information can positively alter the intention to use a technology (p. 565). Inexperienced people further pose more importance on *perceived usefulness* (Taylor & Todd, 1995, p. 566). Contrary, Toyoda et al. (2021) have found PE to be more important for experienced users, whereas EE is crucial for inexperienced users (p. 8). People with low experience are, additionally, motivated by technology novelty, whereas experienced users search for efficiency through technology (Venkatesh et al., 2012, p. 161-163). Despite the contradictions, which construct is most influential, researchers agree that higher experience positively affects the intention to use and accept VR (Janzik, 2022, p. 243; Taylor & Todd, 1995, p. 565).

2.4.1. Acceptance of VR

Research on VR acceptance in various domains revealed several influencing factors. Janzik (2022) has found that users consider the four original UTAUT constructs as significant influences. Technology usefulness, ease of use, social acceptance, and the received support are, therefore, crucial. (p. 103). Algahtani et al. (2021) describe *HM* and *PE* as particularly influential on the intention to use VR. In contrast, *EE*, *HA*, and *SoIn* have a minor influence (p. 226). Toyoda et al. (2021), additionally, have discovered HM to be more influential compared to SoIn and EE when it comes to VR adoption (p. 10). As described, SoIn only has a minor influence, especially family is less influential compared to friends in the VR context (Janzik, 2022, p. 245). However, digital natives can barely be influenced, as they are able to evaluate technologies themselves (Toyoda et al., 2021, p. 10).

Additionally to the UTAUT2 constructs, Algahtani et al. (2021) have described satisfaction and personal innovativeness as influences on the intention to use VR (p. 222-226). Other researchers have found personal characteristics, such as innovativeness, technology readiness or sensation seeking (Sagnier, Loup-Escande, Lourdeaux, Thouvenin, & Valléry, 2020, p. 1002; Janzik (2022), p. 231). Disztinger et al. (2017) further indicated that enjoyment is decisive as VR is a hedonistic system (p. 265). Toyoda et al. (2021) also described this finding (p. 10). Sagnier et al. (2020) explained that a positive opinion about VR makes its use seem easier (p. 1001). According to Disztinger et al. (2017), nevertheless, the most substantial influence on VR acceptance is general interest (p. 265). In contrast, Janzik (2022) declared previous gaming experiences as the strongest predictor (p. 233). The feature of immersion, additionally, influences acceptance, meaning the higher the level of immersion, the more people accept VR (Disztinger et al., 2017, p. 265). Contrary, cybersickness harms the enthusiasm for usage (Sagnier et al., 2020, p. 1001). Having discussed the general VR acceptance, I now focus on the literature on the acceptance of learning technologies and VR within the educational context.

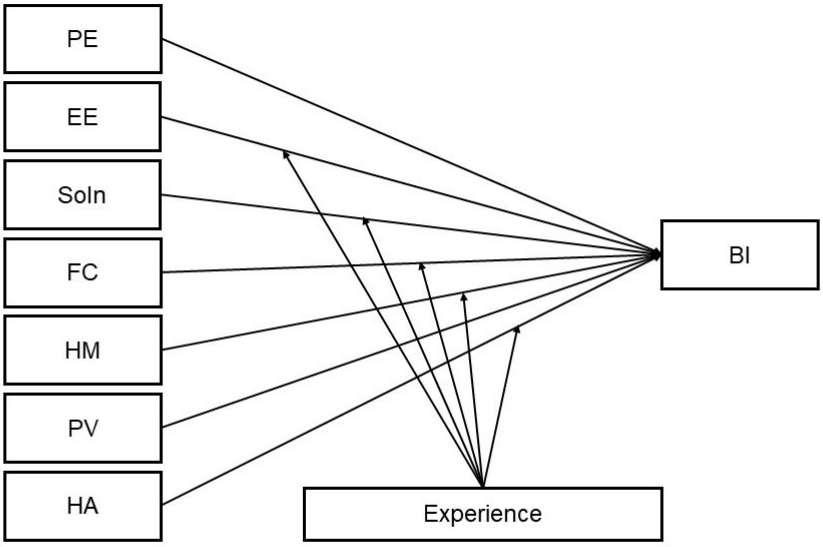

Figure 1: Modified UTAUT2 Model

Note. The modified UTAUT2 model showing the relationships of the constructs. Adapted from "Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology", by V. Venkatesh, J. Y. Thong, and X. Xu, 2012, *MIS Quarterly, 36*(1), p. 160.

2.4.2. Acceptance of technology in education

Literature on learning technologies and VR acceptance in education reveals several similarities and additions to the findings outlined above. Researchers have found *PE* most significant for students' VR acceptance (Noble et al., 2022, p. 13; Fussell & Truong, 2022, p. 260; Chahal & Rani, 2022, p. 19). Bernd (2001) especially outlined the quality of technology to be influential (p. 145). These results align with Davis (1989, p. 333) and Venkatesh et al. (2012, p. 171). Immersion, interaction and imagination positively impact PE (Huang et al., 2016, p. 15-16). Pettey (2018), nevertheless, outlined VRs' current weakness in terms of user experience, impeding its mass adoption in education (para. 3). Students evaluate the user interface according to its user-friendliness, facileness, and gratification (Zakaria, Abuhassna, & Ravindaran, 2020, p. 1291; Shen et al., 2017, p. 134). Currently, students, however, perceive VR as inconvenient in usage (Pettey, 2018, para. 4). Straightforward systems increase performance and productivity, enhancing students' use motivation, operating confidence and, in turn, technology acceptance (Chahal & Rani, 2022, p. 19; Shen et al., 2017, p. 134; Zakaria et al., 2020, p. 1291). According to Noble et al. (2022), students are willing to spend more money when they experience higher performance (p. 13).

Additionally, user competence positively affects students' technology acceptance (Bernd, 2001, p. 144). Competence can be achieved by providing training sessions and ensuring the support of the school, teachers and fellow students (Shen et al., 2017, p. 134). Even though students thought learning to operate with VR would be effortless, demonstrations on how to use and benefit from VR could improve the acceptance process (Zakaria et al., 2020, p. 1289; Fussell & Truong, 2022, p. 260). Other facilitating measures, such as providing technical or financial support or supplying equipment, encourage the active application of VR in education (Majid & Shamsudin, 2019, p. 58; Shen et al., 2017, p. 134; Bernd, 2001, p. 139). Nevertheless, not only internal facilities and resources but also external infrastructure influences the intention to use (Shen et al., 2017, p.134). Overall, the introduction and integration into the learning environment greatly influence the acceptance of VR in education (Fussell & Truong, 2022, p. 260).

Majid and Shamsudin (2019) again found attitude as an influencing factor. The researchers, however, outlined that PE can alter the attitude of users (p. 58). Likewise, Noble et al. (2022, p. 14) see attitude as a predictor of acceptance, in line with Chahal and Rani (2022, p. 19), who have found attitude and additionally personal innovativeness as influencing factors. Students perceive VR as innovative and a better application than videos (Noble et al., 2022, p. 14). Other influences on intention are perceived enjoyment and habit, so if a system is fun and fits the habits already in place, it is easier to integrate (Fussell & Truong, 2022, p. 258; Bernd, 2001, p. 144). Health risks or regulatory uncertainties were not crucial for students, which is explained by low experience and unawareness. However, these factors

will gain importance in the future (Fussell & Truong, 2022, p. 261). According to Pettey (2018), educational mass adoption is avoided by experiencing eye strain and sound disorientations (para. 3). SoIn and self-efficacy can be influential, whereas SoIn only has an indirect effect. Personal innovativeness and skills training increase self-efficacy and following intention to use e-learning (Chahal & Rani, 2022, p. 18-19). In general, students see technology as means of communication and engagement. However, face-to-face provides the opportunity to network more effectively. Therefore, students prefer a blended learning environment (Gierdowski, 2019, p. 3-8).

The reviewed literature illustrates the effectiveness and usability of VR in education. The mainly quantitative studies, nevertheless, provide a superficial understanding of the factors influencing students' acceptance of VR in education. Especially, qualitative research is missing and outlines a gap in the students' perspective on the application of immersive VR in non-practical lectures.

3. Methodology

I undertook a qualitative empirical study to investigate the technology acceptance of post-secondary students. According to Yin (2011), qualitative studies are beneficial for conducting in-depth research on peoples' opinions and attitudes (p. 3-4).

3.1. Research design

The intended research design was a qualitative methodology utilising focus group interviews to collect data over a cross-sectional time horizon. The subject of this research revolved around the acceptance of VR applications in post-secondary education. The exploratory study aimed to discover factors influencing students' decision to accept the use of immersive VR applications in theory lectures. I conducted the study within the research philosophy of critical realism, which claims that cultural background and experiences influence research. Therefore, minimising biases and irregularities is crucial (Saunders et al., 2019, p. 147-148).

A profound sampling strategy can strengthen validity through a defined research context that avoids overgeneralisation (Robinson, 2014, p. 39-40). Further, bias often is a problem during interviews. Therefore, I avoided positive or negative reactions to participants' answers to minimise influence (Saunders et al., 2019, p. 460). Saunders et al. (2019) recommend examining data from different angles, making results more valid and credible (p. 451). To ensure ethical considerations, participants were informed about the purpose and the use of the collected data. At least two days before the interview, each participant received an information sheet and had to sign a consent form, which can be found in the Appendix. Before the interview started, I repeated the information and outlined that participants were free to join, leave and refuse participation (Hennink, 2014, p. 46). To ensure confidentiality and data protection, all names got coded (ALLEA, 2017, p. 6; Saunders et al., 2019, p. 272).

Focus groups are especially suitable for exploring participants' opinions, perceptions, and revealing pre-held views from the populations' point of view (Hennink, 2014, p. 2; Saunders et al., 2019, p. 470). They, additionally, encourage discussion and interaction between participants and make data occur naturally (Vaughn, Schumm, & Sinagub, 1996, p. 15). The choice of method got further substantiated by its wide use in social science research (Hennink, 2014, p. 15).

3.2. Data collection

I conducted three differing semi-structured focus group interviews. Saunders et al. (2019) suggested that four to twelve participants per focus group are desirable (p. 467). The detailed group compositions can be seen in Table 1. The first focus group consisted of five graduate students, of which three had never had contact with immersive VR applications, and two had already had first experiences. The second group consisted of five undergraduate students without prior VR knowledge. Lastly, the third group involved six undergraduate or graduate students, who had already had contact with immersive VR and were familiar with the topic. The nine male and seven female participants ranged from 19 to 31 years and had a median age of 24.5. The variety of focus groups led to information saturation, and an additional focus group was unnecessary (Hennink, 2014, p. 43). The participants were mainly contacted via LinkedIn and recruited over direct contact. The transcribed and anonymised interviews of the three focus groups can be found in the Appendix.

3.2.1. Sampling method

The participants for the three groups were selected through a multi-stage process of non-probability sampling techniques (Saunders et al., 2019, p. 325). At the focus group level, I applied heterogeneous sampling. Saunders et al. (2019) stated that heterogeneous sampling ensures diverse characteristics of the focus groups and helps to identify key themes of the research question (p. 321). The level of study and experience captured the group diversity.

On the participants' level, I firstly applied homogeneous sampling, which according to Saunders et al. (2019), supports getting in-depth results and making minor differences in opinions prominent (p. 321-322). Homogeneity and a low acquaintance support participants to contribute actively in the discussion (Hennink, 2014, p. 38-40). Secondly, I applied self-selection sampling to guarantee total voluntariness. The self-selection stage ensured the will of individuals to share their thoughts and made sure participants had an opinion on the research topic (Saunders et al., 2019, p. 323-324). The multi-stage process led to a solid research sample in ensuring a variety of information gathered through heterogeneity and depth of information through homogeneity. At the same time, self-selection ensured participants' motivation (Robinson, 2014, p. 36).

Table 1: Overview of Participants

Interviewee	Group	Age	Gender	Experience	Field of Study
A	1	25	m	low	Business Informatics
B	1	27	m	low	Medicine
C	1	25	f	low	Politics
D	1	24	m	medium	Mechatronics
E	1	25	m	medium	Business & Law
F	2	19	f	low	Business
G	2	21	f	low	Business
H	2	24	f	low	Business
I	2	24	f	low	Business
J	2	23	f	low	Law
K	3	27	m	high	Architecture
L	3	25	m	high	Software-engineering
M	3	31	f	high	Software-engineering
N	3	27	m	high	Architecture
O	3	23	m	medium	Communication & IT
P	3	24	m	high	Communication & IT

Note. Demographic data of the focus group participants divided into the three groups.

3.2.2. Procedure of data collection

Semi-structured interviews are a non-standardised method, utilising key questions as guidance (Saunders et al., 2019, p. 437). Therefore, I created a discussion guide, which can be seen in the Appendix (Hennink, 2014, p. 48). The guideline structure was deducted from the UTAUT2 constructs, and each construct included one to four key questions (Venkatesh et al., 2012, p. 160). Moderation is an essential task in group interviews and requires the critical skill of active listening (Saunders et al., 2019, p. 460-471; Hennink, 2014, p. 69-71). As a support, the discussion guide included the introductory part, prompts promoting discussion and reminders. I pretested the discussion guide with a pilot group to check the timing and comprehensibility of questions (Hennink, 2014, p. 68-69).

All three interviews took place on the same day in Innsbruck in a meeting room, which was convenient to reach for all participants (Saunders et al., 2019, p. 454). The chairs were arranged in a semi-circle so I could have direct eye contact with each interviewee. Due to the Covid-19 situation, however, facial masks were required, which reduced the ability to observe facial expressions. A research assistant was present and supported me with the recording equipment and in observing noticeable group dynamics and body language (Hennink, 2014, p. 69).

The procedure of the discussion was two-fold. I started with an introductory part showing a short explanatory video from "Horizon Workrooms" (Meta Quest, 2021). The video explained what collaboration and office work could look like with VR. Additionally, participants tried on the HMD "Oculus Quest 2" and experienced the metaverse "Spatial" as seen in Figure 2. Lastly, my introductory part included some general information. The combination of activities established common sense of the topic and lightened the group situation (Hennink, 2014, p. 56). Secondly, I conducted the discussion. All three focus group interviews lasted around 45 minutes, and every key question was posed to each group, which allowed to systematically compare the answers to each topic (Saunders et al., 2019, p. 437).

3.3. Data analysis

After fully transcribing the focus group discussions and familiarising myself with the data, I started the thematic analysis following an abductive approach. To ease the process, I used the software MAXQDA. First, I broadly and deductively coded the data with the UTAUT2 constructs (Braun & Clarke, 2006, p. 88; Venkatesh et al., 2012, p. 160). Data segments which did not fit into one of the themes were provisionally coded separately. Some segments also fitted into several themes and were coded multiple times (Braun & Clarke, 2006, p. 89). Especially, memo writing helped to collect, elaborate, and refine my ideas (Charmaz, 1996, p. 42-43). In the second step, I inductively identified subcodes to the UTAUT2 themes and tried to review and fit loose segments in. In the end, two additional themes emerged (Braun & Clarke, 2006, p. 89-91). After obtaining the structure, I analysed each theme by reviewing the interviewees' contributions and analysing potential interrelations between themes and their subcodes. The analysis resulted in an extension of the UTAUT2 model, shown and explained in the next chapter.

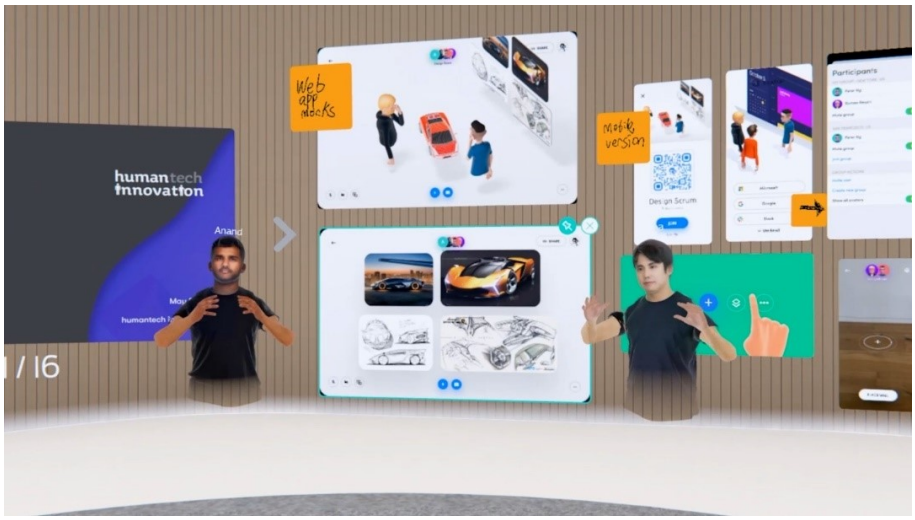

Figure 2: "Spatial" Virtual Environment

Note. VE shown to the participants before the focus group discussion started. From *Telepresence with Spatial vs. Video Conferencing,* by Spatial (2021). https://spatial.io/blog/telepresence-vs-videoconferencing. Copyright 2022 by Spatial Systems, Inc.

4. Results and discussion

This study addresses the factors influencing students' acceptance of VR in theory lectures, thus contributing to the existing research concerning technology acceptance in education. To this end, the focus group discussions revealed two additional themes to the UTAUT2 constructs, namely *student innovativeness (StIn)* and *attitude (AT)*. *Attitude can be defined as* "the degree to which a person has a favorable or unfavorable evaluation ... of the [usage] behavior in question" (Ajzen, 1991, p. 188). I additionally discovered underlying influencing factors of the UTAUT2 constructs. Beyond this, the analysis revealed a thematic framework including nine core themes and 18 subthemes, as presented in Figure 3.

Following this, I analysed and subsequently discussed each theme and its underlying subthemes by summarising the interviewees' statements, underpinning them with cited examples and relating them to existing literature. I continue by evaluating the themes and subthemes in terms of their applicability to VR in post-secondary education. The following section is structured according to the core themes and ends with a proposed extension of the UTAUT2 model.

4.1. Core themes

4.1.1. Performance expectancy

Across all three focus groups, PE was the most widely discussed topic. Concerns regarding VR in non-practical lectures were widespread. Participants mostly declared VR as not applicable for theory education, such as person E, who misses "the added value, especially in theory lectures" (I1, para. 39). Other participants agreed, "because what is the advantage? As it is only listening and no practical tasks" (I3, para. 27). One interviewee with no technical background, however, suggested how universities could effectively apply VR in a theoretical context:

> I can imagine that a professor ... wants to explain a certain topic, such as "organisation". So, all the information ... can also be visualised. How can you imagine that [an organisation]? Perhaps that could create a greater practical relevance .... Or also in human resources, ... one could be the boss and learn how to deal with a dismissal. That you can do some kind of role play. (I2, para. 51)

Other participants mentioned theoretical applications such as history, economic lectures or anxiety therapy. Most participants, however, envisioned using VR for practical lectures, such as in medicine or technical fields. Students with technical backgrounds especially mentioned joint prototyping and reviewing architectural or mechanical work. As for the reason, one interviewee outlined that, "It definitely helps if you first have it on the computer and afterwards in VR before you buy anything. This is where you can also save time and money" (I1, para. 62).

Interestingly, participants also discussed VRs' influence over access to education. Interviewees, specifically, raised concerns that the required HMDs may be prohibitively expensive for some students or that the technology may not work as required. In contrast, other respondents noted that VR could improve the situation for some people by enabling a better and easier connection worldwide:

> I see a lot of potential, maybe not for everyone, but maybe for people who are limited, who cannot move and cannot come to the university. So, targeting some groups would make sense. Even if someone wants to study at Harvard and cannot find an apartment ... he can still participate. (I3, para. 142)

A common view amongst interviewees was that VR pro-

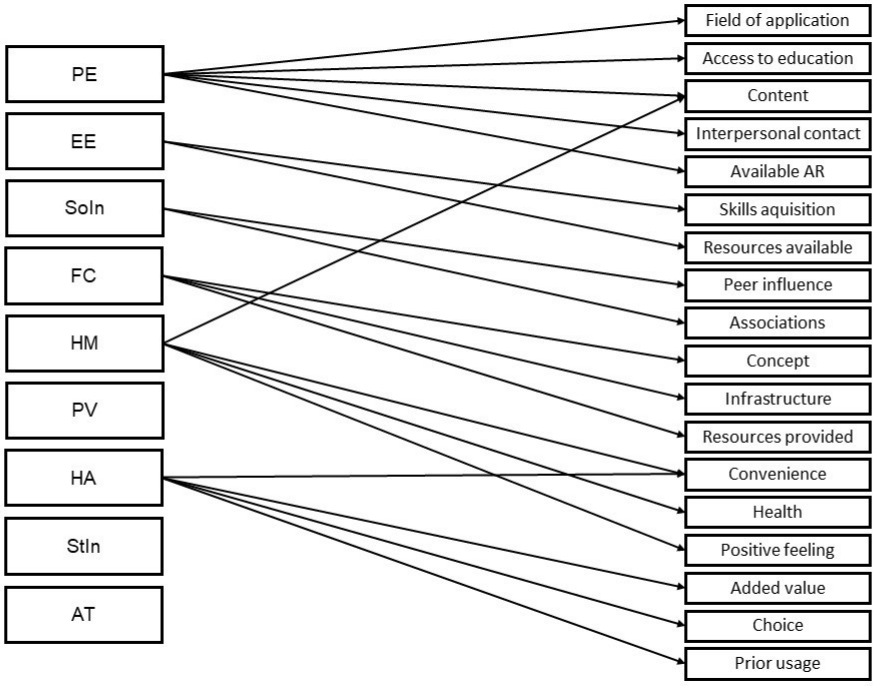

Figure 3: Thematic Framework

Note. The thematic framework after the analysis, revealing two additional constructs and 18 subthemes.

vides a different teaching environment from face-to-face lectures. Person P argued that it is necessary "to adapt the entire teaching content. Because the way you teach now ... would be nothing for VR goggles" (I3, para. 48). Additionally, as person F indicated, "I would find it strange to see only avatars all the time and no real people at all" (I2, para. 58). Student L, moreover, claimed, "It depends on how the content is made and that probably takes many years to produce a cool teaching content" (I3, para. 100). Others referred to new opportunities, such as visualisations, individualised and realistic avatars, or easy guest visits from international professors. The following quote represents a shared opinion from groups two and three regarding the VE experienced:

> I think the question is how this space will look like. Because if we now see the metaverse, for example ... that seems childish. I don't know whether the lecture should be like that, and I don't know how seriously I could take it. The question is if we have our bodies somehow scanned through other technologies and then being projected in a more realistic way. (I3, para. 39)

All interviewees remarked on VRs' influence over interpersonal contact. Some interviewees agreed on VRs' benefits for group work, presentations and interactivity in the classroom. As person M outlined, "Online [desktop collaboration] it is difficult ... that two people are talking at the same time. You can't stand away a bit to talk ... and you can't say anything because otherwise you don't understand the others" (I3, para. 131). Meanwhile, other students indicated that they prefer real over virtual contact and that the Covid-19 pandemic could have influenced this preference. As student E argued, "There is still something lost I don't think an avatar can and will replace" (I1, para. 130). Missing body language, facial expressions and eye contact make it significantly more difficult to communicate through VR, as outlined by student K:

> The whole facial expression, the face is not yet scanned, the whole body language, and so on. You probably have your avatar that tells you something, but still something is missing. If everything is scanned ... and in real-time, then it might work. (I3, para. 103)

Interestingly, a few interviewees brought up related technologies such as AR, which student P perceived as "certainly more interesting, especially because I think that studying should remain face-to-face" (I3, para. 96). Out of the results, five subthemes emerged regarding PE. These include field of application, access to education, content, interpersonal contact, and available AR. Further analysis revealed relationships between the subcodes content and access to education and content and field of application.

The number of interviewee contributions to the theme PE suggest its powerful influence over VR acceptance. This finding is consistent with those of Venkatesh et al. (2012, p. 171)

and Noble et al. (2022, p. 13). The results imply five subthemes influencing PE. The first possible influence concerns the field of application. However, this result has not previously been described. Nevertheless, the participants' suggestion for a possible theoretical application remains in line with findings from Freina and Ott (2015), who stated that VR can aid in learning to cope with difficult emotions (p. 4). Most participants, however, focused on VRs' practical applications. In particular, students with a technical background could hardly imagine that VR could be used in theoretical education. Therefore, it seems that the field of study influences the identified field of application and subsequently, perhaps VRs' acceptance in theory education. Another possible explanation for the preferred practical application comes from the already widespread educational usage of VR in medicine or engineering (Huang et al., 2016, p. 3; Wang et al., 2018, p. 1). However, the literature does not provide sufficient evidence to assume the field of application influences PE.

Furthermore, the findings imply that PE is influenced by access to education. This result is not fully confirmed by other researchers, yet the discovered opportunity for disabled students remains consistent with findings from Freina and Ott (2015, p. 6). These results, additionally, match those from Rebelo et al. (2012), who demonstrated the improved access to other locations through VR (p. 970). Comparing the findings against those from Kavanagh et al. (2017) further confirms that VR applications can lead to potential exclusion of students (p. 108). In general, it seems that access to education can be improved, but also worsened, by the use of VR. However, these results should be interpreted with caution, as the comparable literature does not assess the influence on VR acceptance. As such, there remains no evidence that access to education influences PE, and so this subtheme is not considered further.

The third possible influence involves content. In accordance with this finding, Zakaria et al. (2020, p. 1291) and Shen et al. (2017, p. 134) found the user interface to be an important influence over acceptance. My results further support the idea of Bernd (2001), who found that VR quality influences students' use intention (p. 145). Abich et al. (2021), meanwhile, reinforced the importance of content adaption for leveraging VRs' potential, which is in accordance with participant contributions (p. 928). According to strong overlap with literature, I include content as an influence of PE. Additionally, content revealed a relationship with field of application and access to education. In turn, this indicates an indirect influence by both excluded subthemes.

Continuing, the results further suggest an influence of interpersonal contact. These results match those obtained by Gierdowski (2019), who determined that students see technology as a means of communication and engagement (p. 3). My results concerning face-to-face interaction seem to be consistent with Gierdowski (2019, p. 3) and Velev and Zlateva (2017, p. 36), who found face-to-face interaction to be missing in a VE. Nevertheless, this demonstrates little evidence concerning how interpersonal contact influences acceptance. One possible explanation for the lack of literature on this topic could be the Covid-19 pandemic, as students remained unaware of the importance of face-to-face contact and the impact of its absence beforehand. As the majority of participants strengthened the importance of interpersonal contact, I suggest it as an influence over PE.

One unanticipated finding concerned the indicated influence of available AR, which has not previously been described. One possible explanation for this finding could be the wish for a blended learning environment and the fear of losing face-to-face interactions (Gierdowski, 2019, p. 8), as VR can produce an exclusionary effect over the social environment. Contrary, AR belongs to mixed realities, and thus does not fully shield users from the outside world (Janzik, 2022, p. 110; Milgram & Kishino, 1994, p. 1327). Nevertheless, there remains no evidence provided that available AR influences VR acceptance. Therefore, it is excluded.

4.1.2. Effort expectancy

Regarding EE, participants indicated whether they consider adaption to VR lectures as difficult. The majority of interviewees indicated that they do not believe adjusting to the new environment would require much effort. As student F argued, "I've been switching back and forth between online, hybrid, and face-to-face regularly in my last two years of school and even now in my first year of college. I'm actually pretty good at adapting to the situation quickly" (I2, para. 32). In all cases, participants stated that for young, tech-savvy students, it might take a short time to become familiar with the equipment, but older generations might struggle:

> I think it also depends on how the professors deal with it, because during the online conversion, you saw that with some, it worked super well and with others after two years, it still doesn't work to set up Big Blue Button in a way we are allowed to speak. (I2, para. 35)

The majority of interviewees agreed that only a few adaptions to the learning space are required, and resources such as laptop and Wi-Fi are available, with exception of VR equipment. Nevertheless, student P "could imagine that there are courses of study where perhaps not everyone has a laptop" (I3, para. 43), implying that not all study programmes are digitalised enough to begin using VR. In contrast, student L invalidates this claim, as, "Theoretically, you could make it optional that those who don't have one [an HMD] just look at it on the screen" (I3, para. 114). Out of this discussion, two subthemes for *EE* emerged: *skills acquisition* and *resources available*. Further analysis revealed that *resources available* related to a subtheme discussed later, namely, *resources provided*.

Consistent with the literature from Davis (1989, p. 333-334) and Algahtani et al. (2021, p. 226), the interviewee contributions suggest that EE bears a relatively weak influence over students' VR acceptance as they perceive non to low effort. Therefore, students might narrowly consider EE in their decision for adoption. The data further indicate that

EE is influenced by *skills acquisition*. The finding that students do not perceive effort for adapting and acquire skills is consistent with Zakaria et al. (2020, p. 1289). This self-efficacy also positively influences the adoption of VR (Chahal & Rani, 2022, p. 18). The Covid-19 pandemic may help explain the low perceived effort, as students became accustomed to switching back and forth between teaching concepts and technologies. Interviewees, nevertheless, still perceived that the older generation could struggle with adaption. However, as students do not necessarily need to adapt their skill set, and thus do not consider it a factor of acceptance, I will exclude skills acquisition.

Additionally, my findings imply the influence of *resources available*. This result has not previously been described, but studies such as those by Majid and Shamsudin (2019, p. 58) and Shen et al. (2017, p. 134) have confirmed the importance of resources *provided*. One possible explanation for this literature gap on already available resources might be that, in education, equipment is often provided by the institution and self-procurement has not been addressed so far. As my analysis suggests a relationship between both subthemes, I merge them into the "resources" subtheme and suggest it as an influence over EE. I assume this influence as failing to provide equipment would tremendously increase the required effort by students, subsequently diminishing VRs' acceptance as a result.

4.1.3. Social influence

The questions in the focus group discussion regarding SoIn aimed at emphasising whether students perceived that, important others could influence them. Student C argued that they feel "the five people with whom you do the most influence you. So, I think that's true because people influence what you do" (I1, para. 74). Another interviewee indicated family members as an influence:

> If my father buys a pair of [VR] goggles and says they are so good for different things, I can imagine being persuaded, even if I don't know anything about them beforehand or wouldn't have needed them before. (I2, para. 77)

By contrast, student I considered, "I think it also depends on the interest because men are perhaps more interested than women in such things" (I2, para. 76). Most interviewees additionally made clear associations with games or companies when thinking about VR, but they remained unable to indicate whether this influences their usage decision. Out of the discussion, two subthemes regarding *SoIn* emerged: *peer influence* and *associations*.

The number of interviewee contributions indicates that SoIn plays a minor role in VR acceptance, which is supported by Algahtani et al. (2021, p. 226). The influence of family members, meanwhile, is contrary to previous studies from Janzik (2022), which indicated that family plays a minor role, especially in VR acceptance (p. 245). This inconsistency may be due to an intense personal bond between the respondent and their family members, although this may not apply to the majority. The result concerning the influence of general interest is in line with Disztinger et al. (2017), though it bears little applicability to SoIn (p. 265). Toyoda et al. (2021) found that digital natives barely are influence by others in their technology usage decisions, indicating that peer influence is not applicable in this context, as students are primarily digital natives (p. 10). The findings remain in addition unable to demonstrate an influence of associations, and there is no supporting literature. Therefore, the subthemes are dropped, and SoIn remains a minor influence over VR acceptance.

4.1.4. Facilitating conditions

A common view amongst interviewees, regarding FC, concerned the importance of a study concept and a plan for introducing the new study format. As student L argued, "It is not only the glasses, but you also need a concept. Therefore, I imagine that to be difficult" (I3, para. 51). Contributions strongly overlapped with the subtheme *content*, as demonstrated in the following quote:

> The question is, how is this enforced? If there are 30 people, do I sit in my chair because it's supposed to be a lecture? Or ... do I look through the VR goggles? Or am I so limited that I can only see a part [of the VE]. (I3, para. 29)

One interviewee recommended clear communication regarding the amount of usage and required equipment to avoid confusion. Participants on the whole, demonstrated the importance of training sessions. Interviewee J argued, "I also think that introductory courses are important. I think that the university would be obliged to offer them for a week at the beginning of the semester" (I2, para. 39).

The theme of *infrastructure also* recurred throughout the data set. Student E claimed that "reliability of the platform in use, ... and the internet connection must be given" (I1, para. 103) because otherwise, VR lectures could be frustrating. One interviewee added that "data protection may also have to be reliable depending on which applications are used" (I1, para. 109). As for another topic, the majority of interviewees concurred that "everyone has the right to study and should also have the same opportunities" (I3, para. 50). Therefore, the institution should at least offer education prices for VR equipment, but "it would make sense if the university provided at least a certain number of VR goggles and all the necessary equipment" (I2, para. 37), student G stated. Contrasting slightly, two students argued the following:

> I mean, nowadays the university is not obliged to provide laptops because everybody has them now. It's just a question of when [we are at that point with VR]. But now I think help should be offered because I don't think every student can afford it. (I1, para. 46)

Additionally, the institution should introduce a support system, as student N was concerned about issues where "someone has technical problems, for example. Who solves that? Is that the professor, or the student alone or is there support?" (I3, para. 45). Out of the discussion, three subthemes for *FC* emerged, namely, *concept, infrastructure* and *resources* provided.

Consistent with Venkatesh et al. (2012, p. 169-171), the number of interviewee contributions suggest FC as a highly influential factor over students' acceptance. The collected data indicate that *concept, which includes planned introduction and clear communication,* influences *FC*. This result matches those observed by Fussell and Truong (2022), who found that the way of introducing and integrating VR influences technology acceptance (p. 260). The subthemes of concept and content overlap, but I treat them as separate influences as concept relates more to the way of introduction. As most interviewees questioned the concept, I include this as an influencing factor over FC.

The finding that *infrastructure* influences *FC* remains consistent with the findings of Shen et al. (2017, p. 134). Surprisingly, interviewees outlined the importance of data protection. In contrast, Fussell and Truong (2022) found that regulatory uncertainties were insignificant for students (p. 261). This inconsistency may be due to the technical background of the contributing participant. Nevertheless, a participant with non-technical background contributed the same. Therefore, it seems that the awareness of data security overall has increased. According to the data, I include *infrastructure* as an influence over *FC*.

Beyond this, my research indicates that the *resources provided* are influential. To this end, researchers such as Shen et al. (2017, p. 134) and Majid and Shamsudin (2019, p. 58) outlined the importance of training sessions, providing technical or financial support and supplying equipment to students. As stated earlier, resources provided relates to resources available and thus are merged to the resources subtheme. According to the strong overlap with the literature, I suggest resources as an influence over FC.

4.1.5. Hedonic motivation

As influences on HM, interviewees, for instance, reported that VR *content* would reduce their pleasure, as it is barely available currently. As outlined by student N, who already had VR experience:

> The question arose, what can I actually do in it [the VE]? What possibilities are there in the next few years? But somehow, it hasn't expanded so blatantly ..., it's somehow nothing new and you can then also just stop using it. (I3, para. 87)

Additionally, the unrealistic presentation caused negative emotions, as student F argued, "I can't imagine looking at a comic all day long" (I2, para. 93). Interviewees would, however, derive pleasure if VR offered practical applications. As student K claimed, "The digital world has to offer me added value" (I3, para. 121).

The subtheme of *convenience* came up while discussing the VR equipment. The majority indicated that using VR seems to be more exhausting compared to online or face-to-face lectures. Student O argued, "I imagine it to be rather exhausting. I don't think it makes things any easier. So, it's exhausting for the eyes and it's also quite hard to have the thing on your head all day" (3, para. 32). This theme goes hand in hand with health concerns. Some interviewees reported having experienced cybersickness or were afraid of eye damage. Student C considered, "I don't know how it is for your health or in how far it is not just too exhausting for me, also for the body and for the psyche" (I1, para. 113).

Regarding feelings, some interviewees felt neutral about their VR experience and described it as confusing or needing to get used to it, meanwhile others perceived positive feelings such as fascination, curiosity, or a feeling of being "completely thrilled". One interviewee described, "You have the feeling you're in a new place now, you can actually do whatever you want" (I3, para. 82). Out of this extensive discussion, four subthemes for *HM* emerged: *content*, *convenience*, *health* and *positive feelings*.

Consistent with Venkatesh et al. (2012, p. 169-171) and Algahtani et al. (2021, p. 226), the interviewee contributions suggest *HM* as a highly influential factor over students' acceptance. My results indicate that *HM* is influenced by *content*. This finding accords with Bernd (2001), who outlined the influence of content quality on VR acceptance (p. 145). Content quality seems to offer a possible explanation for the participants' rejection of the unrealistic presentation. Realism of VEs, further, influence the level of immersion (Rebelo et al., 2012, p. 971) and according to Disztinger et al. (2017), a higher immersion level positively influences acceptance (p. 265). In contrast to Abich et al. (2021, p. 923), interviewees criticised the barely available VR content. Furthermore, researchers such as Rebelo et al. (2012, p. 971) or Freina and Ott (2015, p. 4-6) outlined added value through VR, but according to the contributions, students still need to be convinced. Corresponding to the data, I include *content* as an influence over *HM*.

The results, additionally, indicate convenience as an influence, which is broadly supported by Pettey (2018, para. 4). The literature suggests convenience in terms of user-friendliness to influence acceptance (Zakaria et al., 2020, p. 1291). Even though there is no evidence for the influence of wearing comfort, Yan et al. (2019) still prove the experienced discomfort through heavy HMDs (p. 248). The reason why the participants posed such importance on wearing comfort was probably caused by the assumption VR lectures would last the entire day. As the influence of convenience in terms of wearing comfort is not supported by literature, I exclude it.

Furthermore, the finding that *health* influences *HM* is consistent with the findings of Sagnier et al. (2020), who determined that cybersickness reduces acceptance (p. 1001). Additionally, findings from Pettey (2018) supported this, discovering that caused eye strain prevents mass adoption of VR (para. 3). Slightly contradictory are findings from Fussell

and Truong (2022), who did not identify such an influence. Nevertheless, they argued that this topic would be important in the future (p. 261). According to this overlap with literature, health is suggested to influence HM.

Lastly, the results suggest that positive feelings influence HM. These results match those obtained in earlier studies from Disztinger et al. (2017), who determined that enjoyment is crucial for VR acceptance (p. 265). Additionally, Toyoda et al. (2021) discovered perceived fun as an influence on VR acceptance (p. 9). Both findings and literature imply an influence of enjoyment on HM.

4.1.6. Price value

The opinion regarding PV was similar among the interviewees. The following quote represents the interviewees' common view:

> The costs also have a significant impact because I don't think it will work if someone doesn't get them [VR glasses] from the university, for example, or if they're not cheaper. Not everyone has money or can afford it financially. (I3, para. 128)

The majority argued that the institution had to provide financial support or offer education prices. Interviewee H pointed out, "I'm more of a fan of face-to-face lectures and wouldn't be happy at all even if I only had to spend € 100" (I2, para. 89). Consequently, the respondents argued that any necessary payment could lead to resistance to the introduction of VR lectures. Further analysis revealed a relation between *PV* and *resources*. The results on PV did not indicate any subthemes but they confirmed the influence of PV on acceptance.

Considering the interviewee contributions, PV possesses only medium importance. This outcome is contrary to Venkatesh et al. (2012), who found PV to exert a strong influence on technology acceptance (p. 171). A possible explanation for this inconsistency might be that students can be regarded as customers of universities (Guilbault, 2016, p. 137). However, universities often provide equipment or financial support to their students, just as companies do for their employees. In turn, this would also explain why PV strongly overlaps with the subtheme resources as students either ask for provided equipment or financial support. According to Noble et al. (2022), students are typically willing to spend more money if technology increases their performance (p. 13). Due to limited diffusion, however, most students could not experience higher performance through VR, and according to the answers, respondents are not willing to spend more money. Corresponding to this discussion, PV influences acceptance. It is, however, less influential in the educational context than in the consumer context.

4.1.7. Habit

For the topic of HA, the respondents named requirements that VR must fulfil in order for them to use it regularly. A common theme amongst interviewees included the *convenience* of wearing comfort and a simple user interface. Student H explained, "In terms of wearing comfort, VR goggles should perhaps be more like normal glasses" (I2, para. 94). In another group, student D added that it should have "an operating system that is also used on mobile phones ... so you don't have to learn anything new. It should be simple and not complicated" (I1, para. 104).

The topic of *added value* recurred throughout the dataset. Interviewees defined added value as better interaction in lectures, valuable use cases, a well-designed teaching environment and high-quality applications. Additionally, the utilisation should be meaningful "Because if it works just as well or better with the laptop, then why the VR goggles" (I3, para. 127). Student O outlined a common group understanding:

> For me, it depends on what you can do with it. I wouldn't just wear it and see what the day brings, but if you say there's a great game or other use cases that I imagine would be cool, then I would use it. (I3, para. 93)

Interestingly, students still preferred face-to-face lectures and mentioned *choice* as a prerequisite for regular usage. Participant I argued, "I would welcome it in addition to the lessons because probably it will be an important aspect in the future" (I2, para. 101). Student C further outlined the following:

> I find it difficult to say that all courses are now virtual because I still think it's nice to be present at the university. It would be pleasant to say, ok, we have a situation, like Corona, we all can't go to the university. Or in practical courses, it [VR] is used as an addition .... But I wouldn't say that it should completely replace the normal way of having lectures. (I1, para. 20)

Approximately half of the students already used VR in advance in gaming or within a technical study programme. Out of the discussion, four subthemes emerged for HA: *convenience, added value, choice, and prior usage.*

According to the focus group discussions, no interviewees were able to create HA for VR. However, they outlined different prerequisites for them to create it. Therefore, it seems that, especially at this point, HA has only a minor influence on students' acceptance. These findings are in agreement with Algahtani et al. (2021), who identified HA as a minor influence over VR acceptance (p. 226). The first possible influence on HA is convenience. As mentioned earlier, the influence of wearing comfort is barely supported by the literature. However, convenience in terms of user interface reflects the results of Zakaria et al. (2020, p. 1291) and Shen et al. (2017, p. 134), both of whom confirmed the influence of user-friendliness and facileness of interface for VR acceptance. Chahal and Rani (2022) also discovered that easy-to-use systems increase motivation to use and thus support the emergence of HA (p. 19). Out of this discussion, I suggest that convenience influences HA.

Additionally, the finding of added value influencing HA is consistent with Davis (1989), who noticed that users are willing to accept difficulties when a system offers benefits (p. 333-334). The results also support Fussell and Truong (2022), who determined the integration into the current learning environment to be crucial (p. 260). However, it seems that the discussed subjects within added value overlap with the subtheme content. For example, the findings again support Zakaria et al. (2020, p. 1291) and Shen et al. (2017, p. 134), who observed that the user-interface influences acceptance. Therefore, I merge added value with content and assume an influence on HA.

One unanticipated finding concerned the influence of choice. This result, however, has not previously been described. It seems possible that, especially after the Covid-19 pandemic, students have become increasingly aware of the importance of face-to-face communication, and thus are afraid of losing it again. Meanwhile, the interviewees know the convenience of working from home and want a choice. Nevertheless, no evidence has been provided that choice influences HA. Therefore, it is excluded.

Interviewees indicated that they had already used VR previously, especially in gaming. However, the participants did not indicate if they were more willing to use VR due to their prior usage. Regardless, Janzik (2022) identified previous gaming experience is one of the strongest influences for acceptance (p. 233). According to this finding, I suggest prior usage as influencing factor for HA.

4.1.8. Student innovativeness

Yet another theme to emerge from the data concerns StIn. Interviewees indicated that students are responsible for being innovative and remaining updated with technological advancements. One interviewee argued:

> Yes, it would be an effort [to introduce VR], but on the other hand ... I am asking myself: We are students, and we should go with the progress and be innovative. How far is it perhaps our duty, ... because I think it's questionable that youth or a student cannot master that [VR] at the end of the study. (I1, para. 34)

This view was echoed by other focus group participants, such as by student I, who stated, "I think it [VR] is part of it like all the other opportunities I think it's important for our education" (I2, para. 101).

The contributions imply that *StIn* influences students' *BI*. This result is consistent with findings from Algahtani et al. (2021, p. 222-226), and Chahal and Rani (2022, p. 19), who found that personal innovativeness strongly influences the intention to use VR. Conversely, however, Sagnier et al. (2020, p. 1002) found personal innovativeness to be more of an indirect influence. One possible explanation for its only indirect influence could be that innovative users perceive less effort or have more available FC, following their innovativeness influences other constructs. However, according to the still substantial overlap with literature, I suggest StIn as a direct influence over BI.

4.1.9. Attitude

Continuing, AT emerged as an additional theme for UTAUT2 constructs. During the interviews, participants frequently expressed their *AT* towards VR in education. One interviewee indicated, "I think there are a lot of options. I already see it as the future" (I3, para. 142). Another participant added, "I believe that it will be a support at some point" (I1, para. 79). By contrast, other interviewees argued, "On the education aspect, it doesn't make sense to me currently" (I3, para. 135). Some participants also made clear that VR is only entertainment for them and not applicable for education.

Nonetheless, other interviewees explained how their AT could be altered. For example, as student G argued, "I think it has a lot to do with habit, that if you have more hands-on experience, eventually you will get used to it and accept it more" (I2, para. 118). A more diverse offer of applications, improved quality of lectures, or regular confrontation in use cases could further change AT.

The interview contributions suggest that AT influences BI, which supports the findings from Majid and Shamsudin (2019, p. 58) and Chahal and Rani (2022, p. 19). Noble et al. (2022) also determined that students perceive VR to be a better solution than videos, implying the influence of AT (p. 14). Outlined factors, such as content or teaching environment, which could alter students' attitude, overlap with themes from PE, which is supported by Majid and Shamsudin (2019, p. 58). According to this substantial overlap with literature, I suggest AT as an influence over BI.

4.2. Experience

Experience as a moderating variable in the UTAUT2 model influences the constructs outlined above. Through the focus groups' different experience levels, it was possible to compare its influence in the VR acceptance context. Surprisingly, experienced interviewees mentioned more negative comments compared to inexperienced participants. Student K claimed, "For me the fascination is always brief and then I want to put it off again, because I would rather be in the real world" (I3, para. 84). The interviewee further added, "I think that perhaps too many impressions could arise, that it becomes too exhausting in the digital world, that one simply needs a break" (I3, para. 46). Several participants also expressed their hope for education to remain face-to-face.

By contrast, some VR experienced students with a technical background also expressed strong positive feelings, such as student L, "I'm totally optimistic, if the whole financial issue gets sorted out for everyone and good content is made" (I3, para. 143). Inexperienced participants with no technical background, meanwhile, were more neutral about their feelings but believed future familiarity and increasing offerings could change their opinion. For instance, student F argued, "The experience that it just functions well could also change our mind" (I2, para. 117).

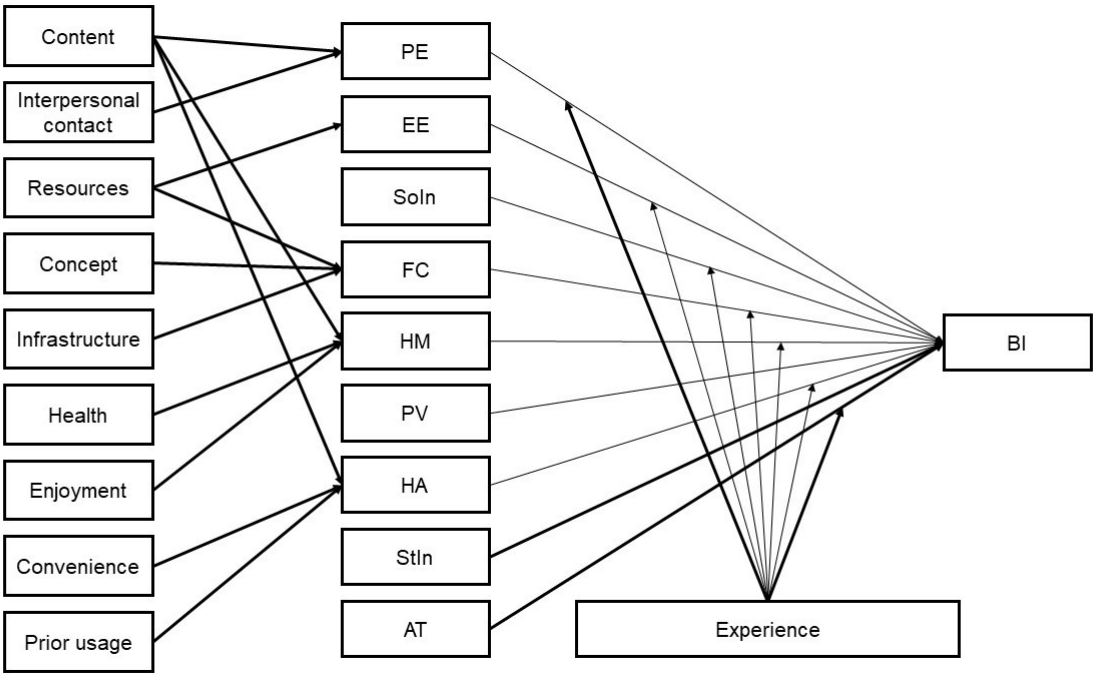

Figure 4: Extended UTAUT2 Model

Note. Proposed extension to the UTAUT2 model. Adapted from "Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology", by V. Venkatesh, J. Y. Thong, and X. Xu, 2012, *MIS Quarterly, 36*(1), p. 160.

According to the participant contributions, experience influences the core constructs influencing BI. This result is consistent with Janzik (2022), who found experience to be a strong predictor of VR acceptance (p. 243). Nevertheless, my findings reveal predominantly negative comments by experienced interviewees, contrary to Janzik (2022) findings, who found experience to be a positive influence over acceptance (p. 243). This inconsistency could be explained by cybersickness experienced by interviewees, missing usability of the system or missing content availability. For instance, Toyoda et al. (2021) suggested that PE is more important for users with higher levels of experience (p. 8). Whereas inexperienced need more information to be provided which is also suggested by my results (Taylor & Todd, 1995, p. 565). According to this discussion, I suggest that experience influences EE, SoIn, FC, HM and HA as in the original UTAUT2 model (Venkatesh et al., 2012, p. 160). I further assume that experience influences PE and AT.

4.3. Extended UTAUT2 model

According to the themes discussed, I created a proposition for an extension of UTAUT2, as presented in Figure 4. After analysing and discussing the nine themes, the before identified subthemes were reduced to nine influencing factors. The combination of results leads to the conceptual assumption that the upstream factors influence the nine constructs as indicated by the lines.

In turn, the constructs are influenced by the upstream factors of content, interpersonal contact, resources, concept, infrastructure, health, enjoyment, convenience, and prior usage. One significant finding is that content, especially, is suggested to be an important influencing factor for the constructs PE, HM, and HA. The factor content includes unrestricted guest lectures and generally content adaption to VEs to make lessons more engaging, effective, and collaborative. Another significant finding concerns the two new constructs, StIn and AT, directly influencing BI. Both constructs strongly correlate with BI in other research (Algahtani et al., 2021, p. 226; Majid & Shamsudin, 2019, p. 58). The strongest influences on the students' intention to use VR, however, comprise PE, FC and HM, which correlates with findings from Venkatesh et al. (2012, p. 169-171)

The new influence of experience on PE is based on Toyoda et al. (2021), who found that experience level positively influences PE. In turn, this suggests that users with higher experience ask for better performance (p. 8). This phenomenon was also reflected in the participants' contributions. As PE can alter AT, I further assume AT to be moderated by experience (Majid & Shamsudin, 2019, p. 58). According to the results of my study, it seems that attitude toward VR is reinforced positively or negatively depending on the experiences students have had, whereas inexperienced users' attitude remains neutral. The findings of this study reveal that post-secondary students' VR acceptance can be influenced in various ways and remains dependent on their experience with

the technology. However, as I conducted a qualitative study, caution must be applied, as the findings are not generalisable and remain somewhat specific to the data's context.

5. Conclusion

This study aimed to identify factors influencing post-secondary students' decision to accept the use of immersive VR applications in non-practical lectures. To this end, this study applied a qualitative approach utilising focus group interviews. I subsequently analysed and discussed the gathered data within the scope of a modified UTAUT2 model and encompassed new factors relevant to students' VR acceptance.

The outcomes of this research possess several theoretical implications. First, this study contributes to the body of knowledge concerning VR acceptance and adoption (Fussell & Truong, 2022, p. 249; Noble et al., 2022, p. 1). The research confirms the relevance and applicability of UTAUT2 in identifying technology acceptance (Venkatesh et al., 2012, p. 160). VR acceptance is, however, not solely influenced by the UTAUT2 constructs, but additional influences have to be considered. These supplementary influences are upstream factors, including content, interpersonal contact, resources, concept, infrastructure, health, enjoyment, convenience and prior usage. The context-specific factors subsequently influence the core constructs. This research, furthermore, proposes two additional core constructs, StIn and AT, to be integrated, as they may be relevant for understanding students' intention to use VR. Additionally, I incurred the moderating variable experience, which influences all constructs except PV and StIn. The resulting context-specific extension of the UTAUT2 model, supports the adaption and implementation of VR for educational purposes while ensuring students' acceptance.

In terms of practical implications, this study primarily offers insights for post-secondary institutions considering whether to implement VR as a means of education. Teaching can benefit from VR applications, though students' acceptance remains crucial for successful implementation (Fussell & Truong, 2022, p. 260). According to the results, universities should consider underlying influencing factors and core constructs. This comprehension is vital to ensure students' VR acceptance and avoid a drop in academic performance. Additionally, companies can use the results to understand their customers' acceptance of VR training. Therefore, the suggested model extension informs decision-makers about possible influencing factors and supports them in identifying measures to increase VR acceptance in theory education.

Nonetheless, this research possesses certain limitations that should be pointed out. First, it should be emphasised that the findings demonstrate subjective appraisal by a small number of students, which is caused by the sample size of 16 participants. Additionally, due to time restrictions, the time to conduct the focus group interviews was limited. As such, all interviews took place on the same day, which might have influenced my concentration while moderating. With more available time, additional focus groups could have been conducted. In turn, the added data might have changed the UTAUT2 model extension. Another limitation is the interviewer bias, which means how I posed questions or behaved could have influenced the participants' answers (Saunders et al., 2019, p. 447). Even though the participants of the focus groups came from different study fields and had various VR experience levels, the qualitative study is still not generalisable.

These limitations leave ample room for further research. I suggest that future research additionally assesses the moderating variable of age as it possibly influences the acceptance of VR. Furthermore, VRs' potential diffusion into post-secondary education will offer richer and more accurate insights into students' acceptance of the technology. In particular, I recommend researching the influence of HA and SoIn as these two constructs could gain influence (Janzik, 2022, p. 107-108). Finally, my research identifies several factors influencing post-secondary students' VR acceptance, summarised in the proposed extension of the UTAUT2 model. I recommend future quantitative and qualitative research to confirm and adjust the identified factors in their applicability to the context of VR in university education. In particular, to provide educational institutions with a solid decision-making basis for successfully introducing VR while ensuring students' acceptance.

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