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Published by Junior Management Science e.V.



Junior Management Science

journal homepage: www.jums.academy



The M&A Behavior of Family Firms

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Abstract

The present study aims to identify the driving acquisition goals of family firms' acquisitions and analyse the role of innovation in these acquisitions. Therefore, the study deploys a qualitative approach investigating 15 German family firms to derive patterns within the qualitative data. As a result, the study proposes 14 propositions, which mainly suggest a co-existence of multiple goals in acquisitions. Similarly, the propositions argue that the goals related to the categories of expansion, market competitiveness and innovation are decisively driving the acquisitions undertaken by family firms. The study further proposes that the acquisition of innovation is a critical key to the success of family firms and a means to an end for achieving other related goals such as the survival of family firms. Beyond getting a broader understanding of the acquisitions made by family firms, the study shows further avenues for research in the field of family firms' M&A activities.

Keywords: Family Firm; Innovation; Mergers & Acquisitions; Drivers of Mergers & Acquisitions; Acquisitions Motives; Acquisition Goals; Innovation in Mergers & Acquisitions.

1. Introduction

1.1. Problem Relevance

"Family Firms are crucially important for Europe. They make a significant contribution to Europe's GDP and employement, and tend to be great innovators, with a longer-term vision," highlighted José Manuel Barroso, President of the European Commision, at the II GEEF European Meeting in 2007 (Barroso, 2007).

Family firms characterized by dominant ownership, family ownership, and dynastic intention are well known to be the earliest type of commercial organizations, and they remain among the most prevalent types of businesses now (Anderson, Mansi, & Reeb, 2003; Aronoff & Ward, 1995; Chua, Chrisman, & Sharma, 1999). Family firms, mainly, embody the backbone of society as well as the driving force behind the global economy ever since. To be precise, family firms constitute two-thirds of all businesses worldwide and the share of family firms in total to all types of businesses is even higher depending on the different parts of the world (Family Firm Institute, n.d.). Furthermore, they contribute around 70–90% to the global annual GDP and provide between 50% and 80% of employment in the majority of countries (Family Firm Institute, n.d.).

Besides, family firms are often associated with a high level of innovativeness and a well-defined position in a specific niche (Gudmundson, Tower, & Hartman, 2003), where innovation describes the process of turning an idea or invention into a good or service that creates value for which customers are willing to pay (Sawhney, Wolcott, & Arroniz, 2006). In particular, in the business context, innovation aims to meet the customers' needs and expectations. Therefore, it can be regarded as a powerful and strategic way to create competitive advantage (Classen, Van Gils, Bammens, & Carree, 2012; Dess & Picken, 2000; Grundström, Sjöström, Uddenberg, & Rönnbäck, 2012; Hatak, Kautonen, Fink, & Kansikas, 2016; Kleinschmidt & Cooper, 1991; Porter, 1996; Santoro, Ferraris, Giacosa, & Giovando, 2018). Specifically for this type of business, innovation plays a significant role in the firm's economic development and growth (De Massis, Di Minin, & Frattini, 2015; Nieto, Santamaria, & Fernandez, 2015) as it leads to both long-term performance (Alberti & Pizzurno, 2013; Kellermanns, Eddleston, Sarathy, & Murphy, 2012; Partanen, Chetty, & Rajala, 2014) and survival of the family firm (Carnes & Ireland, 2013; De Massis et al., 2015) due to the possibility of creating competitive advantages (Classen et al., 2012; Dess & Picken, 2000; Grundström et al., 2012; Hatak et al., 2016).

As mergers and acquisitions (M&A) has turned into a standard strategic business option for all types of businesses, it is increasingly crucial for family firms as it allows an inorganic approach to extend the firm's capacity to create value (Bower, 2001; Cartwright & Schoenberg, 2006). Principally, it refers to the consolidation of companies or assets through various types of financial transactions and is a fashionable but risky way to expand and complement existing resources (Benou & Madura, 2005; Cartwright & Schoenberg, 2006; Hagedoorn & Duysters, 2002a, 2002b; Kohers & Kohers, 2000, 2001). Hence, it enables firms to acquire external resources (Lee, 2017; Michelino, Caputo, Cammarano, & Lamberti, 2014). In the context of innovation, M&A provides family firms with additional solutions, such as mergers, acquisitions, management takeovers, asset acquisitions, takeover bids, and consolidations, to follow a more openminded innovation process which enables them to acquire know-how and technology from external sources (André, Ben-Amar, & Saadi, 2014; Broekaert, Andries, & Debackere, 2016; Chesbrough & Crowther, 2006; Tsai & Wang, 2008; West & Bogers, 2017).

Previous research that contributes to the understanding of innovation and M&A in family firms separately agrees that family firms differ significantly from their non-family firm's counterparts, and identifies important insights into various fields such as family firm's performance (Alberti & Pizzurno, 2013), innovation process (Braga, Correia, Braga, & Lemos, 2017; Broekaert et al., 2016; Filser, Brem, Gast, Kraus, & Calabrò, 2016), collaborative innovation (Feranita, Kotlar, & De Massis, 2017), innovation behavior (Nieto et al., 2015), and M&A in family firms (Defrancq, Huyghebaert, & Luypaert, 2016; Worek, De Massis, Wright, & Veider, 2018). Nonetheless, there is still a lack of comprehensive understanding of family business research (Worek, 2017).

Despite the current advancement, not much is known about the underlying relation of innovation as a driving factor in M&A activities in family firms. Recent research shows significant differences between family firms and non-family firms (Worek et al., 2018) and highlights different aspects influencing the M&A decision-making process (Shim & Okamuro, 2011). However, it remains unclear which factors drive M&A activities in family firms and to what extent innovation is pushing these activities.

1.2. Objective

Due to the lacking understanding of innovation and M&A in family firms, this study follows the call from contemporary literature to analyze the acquisition goals of family firms by a qualitative approach to enrich the theory (Angwin, 2007; Bower, 2001; Walter & Barney, 1990). Therefore, this qualitative study aims to extend the current findings in the literature by complementary and profound insights into innovation-related M&A in family firms. By analyzing and examining M&A activities in family firms, it aims to understand the underlying goals and motives of family firms to engage in M&A and to identify the correlation between innovation and M&A. It is of particular interest to what extent innovation is pushing M&A activities in family firms. As the present literature shows that acquisitions rather than mergers are more likely in family firms, the focus of this study lies on the acquisition activity (Worek et al., 2018).

This study can benefit scholars, family firms and even non-family firms with remarkable insights into and knowledge of the unique setting of family firms as well as the innovation and M&A behavior of family firms. Moreover, it can contribute to the explanation of family firms being both highly innovative and successful in the global economy. For this reason, the following three questions will be answered:

- RQ1: What influence the family has on the firm? How important is growth?
- RQ2: Which goals are driving the acquisition activities in family firms?
- RQ3: What role does innovation have in the acquisitions?

By answering the research questions mentioned above, this qualitative study also fills a research gap put forward by a recently published academic paper about M&A in family firms – to extend the literature on acquisition goals in family firms (Worek et al., 2018).

In the following, I am going to present first a comprehensive literature overview of the current state of research and thereby illustrate how academia portrays family firms in setting their innovation and M&A. Subsequent, the emphasis is laid upon the main body of this study: starting with the presentation of the methodological approach of this qualitative study and ending with the evaluation and analysis of the obtained findings based on the 15 conducted interviews with family firms. Besides, a model focusing on the links between innovation and M&A in family firms is introduced in this part and afterwards used for connecting the findings. The last part of this study focuses on comparing the findings of the undertaken interviews and the findings of the current literature and identifying differences and similarities. Added to that, the last part examines limitations, practical and theoretical implications, and avenues for future research.

2. Theoretical Background¹

2.1. Ownership Structure

Previous academic work indicates that the ownership structure has a significant influence on M&A behavior in both non-family and family firms (Astrachan, 2010; Shim & Okamuro, 2011; Worek et al., 2018). To be precise, both the size of ownership and type of owner may have implications for both the growth preferences (Caprio, Croci, & Del Giudice, 2011; Feito-Ruiz & Menéndez-Requejo, 2010) and the probability of M&A, as ownership is actively shaping the decision-making process and thus the decision to engage

¹An overview of the identified literature can be found in Appendix 1.

in M&A Caprio et al. (2011). To this perspective, Haleblian, Devers, McNamara, Carpenter, and Davison (2009) add that the ownership further reveals different interests as wells as different acquisition goals in M&A. Therefore, the owners among firms indicate contrasting interests and motives displaying different M&A behavior. Hence, the prevailing acquisition theories based on non-family firms cannot fully be applied to family firms (Worek et al., 2018).

2.1.1. Non-Family Firms

Comparing both types of firms, non-family firms are mainly identifiable by three characteristics: dispersed ownership, atomistic shareholder, and separation between control and ownership (Boellis, Mariotti, Minichilli, & Piscitello, 2016; Demsetz & Lehn, 1985). Furthermore, Worek et al. (2018) highlight the significance of the distinct composition, a combination of non-family control, low wealth concentration, and the importance of economic utilities, of non-family firms as the main differentiator to family firms. Mainly due to these characteristics of non-family firms, there is a high probability of the principal-agent problem occurring, thus leading to difficulties in decision-making among both the shareholders and managers (Defrancq et al., 2016). Consequently, managers may pursue actions to extend their benefits at the firm's cost and shareholders. In particular, such irrational and unbeneficial decision for the firms is caused by the term "hubris" which is excessive self-confidence (Hayward & Hambrick, 1997; Kets de Vries, 1990; Roll, 1986). Moreover, Nguyen, Yung, and Sun (2012) reveal in their study, analyzing 3,530 domestic acquisitions in the United States from 1984 to 2004, that more than the majority are connected to agency motives and/or hubris, and various motives are involved when undertaking M&A activities.

2.1.2. Family Firms

Family firms are identifiable by three characteristics: dominant ownership, family ownership, and dynastic intention (May, 2018). Scholars have considered these three aspects to determine the unique family firms' ownership structure (Duran, Kammerlander, van Essen, & Zellweger, 2015):

First, the high level of control is related to the dominant ownership in family firms (Arregle, Hitt, Sirmon, & Very, 2007; Carney, 2005; Casson, 1999; Fiss & Zajac, 2004; Gedajlovic & Carney, 2010; Gómez-Mejía, Haynes, Núñez-Nickel, Jacobson, & Moyano-Fuentes, 2007; Kim & Gao, 2013; Kotlar, Signori, De Massis, & Vismara, 2018; Palmer, Friedland, R., Jennings, & Powers, 1987; Zellweger, Kellermanns, Chrisman, & Chua, 2012). Therefore, family firms are highly concerned about the ability to preserve control and even pass the control and business over to future generations (Alberti & Pizzurno, 2013; Arregle et al., 2007; Bourdieu, Wacquant, & Farage, 1994; Caprio et al., 2011; Casson, 1999; Fiss & Zajac, 2004; Gómez-Mejía et al., 2007; Kotlar et al., 2018; Miller & Le Breton-Miller, 2005; Zellweger et al., 2012).

Second, scholars have identified high wealth concentrations as well as undiversified firm portfolios in family firms. This can be explained by the fact that the wealth of the business-owning family members is heavily tied up and concentrated on the core competency in the firm (Eisenmann, 2002; Hautz, Mayer, & Stadler, 2013). Since the family wealth is profoundly committed in the firm, family firms are focusing on long-term oriented investments to nurture the established wealth (Arregle et al., 2007; Gómez-Mejía et al., 2007; Miller, Le Breton-Miller, & Lester, 2009; Palmer & Barber, 2001) and pursuing investments, e.g., acquisitions, not causing risks, uncertainties, and threats for the family firm survival (Duran et al., 2015; Miller et al., 2009).

Third, scholars have highlighted the importance of noneconomic utilities and their effect on the behavior of family firms, which, therefore, have a significant influence on the decision-making (Astrachan & Jaskiewicz, 2008; Berrone, Cruz, & Gómez-Mejía, 2012; Chrisman, Chua, Pearson, & Barnett, 2012; Chrisman et al., 2012; Gómez-Mejía et al., 2007; Kotlar & De Massis, 2013; Worek et al., 2018; Zellweger & Astrachan, 2008). Mainly, this can be observed in social engagement and high investments in both employees and business roots of family firms in order to sustain the dynastic intention and thus shape the M&A behavior (Cruz, Gómez-Mejia, & Becerra, 2010; Fiss & Zajac, 2004; Gómez-Mejía et al., 2007; Kotlar et al., 2018; Zellweger, Nason, Nordqvist, & Brush, 2013).

The different properties of both firms, identified by past academic work, highlight the main differences between nonfamily firms and family firms. Furthermore, the observations mentioned above may potentially imply the indication of divergent aftermath regarding the M&A behavior. Figure 1 illustrates the insights mentioned above:

2.2. M&A Behavior

In terms of the M&A behavior of family firms, scholars have different points of view. On the one hand, they have revealed that family firms are in general hesitant to engage in M&A (Caprio et al., 2011; Miller et al., 2009; Shim & Okamuro, 2011). In support, Shim and Okamuro (2011) reach a similar conclusion in their study, investigating 488 M&Adeals, and highlight that family firms are less prone to merge than their non-family counterparts due to the threat of diminishing ownership and thus losing control. By the same token, the study of Requeio, Reves-Reina, Sanchez-Bueno, and Suárez-González (2018), investigating 4,387 European publicly traded firms, points similar results referring that family firms with high family involvement in the firm have a more considerable reluctance towards acquisitions due to the risk of uncertain outcomes. Also, Miller et al. (2009), analyzing 898 of the Fortune 1,000 firms, conclude a greater aversion of family firms to undertake M&A due to business risks such as financial dependence or loss of control.

Given the unwilling behavior of family firms to engage in M&A, many scholars have tried to explain why these firms do not participate in M&A. In general, recent studies have confirmed that family firms are more willing to develop their business organically and therefore do not employ M&A as a mean (Astrachan, 2010; Caprio et al., 2011). However, the main reason for not participating in M&A appears to be the



Source: own illustration based on Boellis et al. (2016), Demsetz and Lehn (1985), Duran et al. (2015), May (2018) and Worek et al. (2018)

Figure 1: Principle Differences between Family Firms and Non-Family Firms.

risk aversion of family firms (Wiseman & Bromiley, 1996). As Caprio et al. (2011) report, the risk aversion of family firms has a strong influence on the decision for M&A and can lead to the denial of positive value-adding acquisitions. In this context, Requejo et al. (2018) emphasize a remarkably increasing reluctance to undertake acquisitions in situations where the family has a higher share in the family business, especially if an insufficient shareholder protection mechanism and socioemotional wealth are present. The rejection of such acquisitions seems plausible since family firms are generally reluctant to make acquisitions that could dilute family control and ownership as well as socioemotional wealth (Amihud, Lev, & Travlos, 1990; Caprio et al., 2011; Dreux, 1990; Gómez-Mejía, Patel, & Zellweger, 2015; Miller et al., 2009).

On the other hand, scholars have revealed that family firms undertake M&A. Even if family firms are more susceptible to vague investments and strategic decisions (Worek et al., 2018), they are involved in M&A activities to promote and maintain their growth since acquisitions can be regarded as a common tactic for the firm's development (De Massis et al., 2015; Nieto et al., 2015) and growth (Astrachan, 2010). Nevertheless, contemporary studies do not sufficiently explain the relatively low propensity of family firms undertaking acquisitions compared to non-family firms. Scholars state problems associated with diverse family priorities (Requejo et al., 2018), i.e., the dilution of non-economic utilities (Gómez-Mejía et al., 2015), the absence of financial resources (Requejo et al., 2018), and the decline of control due to the demand for external resources (Gómez-Mejía, Makri, & Kintana, 2010; Requejo et al., 2018; Worek et al., 2018) as an explanation for the low willingness.

Additionally, there appears to be a notable difference in the decision-making on related or non-related acquisition targets, primarily concerning the interest of family firms in reducing risks given the undiversified nature of family firms (Gómez-Mejía et al., 2010). In particular, Gómez-Mejía et al. (2015) highlight that family firms, undertaking acquisitions, prefer related targets and emphasize that the acquisition of non-related targets, which could be advantageous for the diversification of the business, is confronted with unwilling behaviors of by family firms due to the unpredictable financial outcome and the potential dilution of family interests. In contrast, Miller et al. (2009), examining the industrydiversifying nature of M&A transactions by firms, show that even if family firms are usually less prone to engage in M&A, family ownership has a positive impact on a firm's willingness to engage in non-related M&A and thus non-related targets in order to diversify the firm portfolio. Besides, in exceptional circumstances which pose a threat to family firms, they may also make acquisitions of non-related targets to diversify and reduce risks (Worek, 2017).

To conclude, the previously identified characteristics of family firms do actually imply significant aftermath regarding the M&A behavior in family firms. There are several discussions about the probability of family firms engaging in M&A. On both sides, scholars have arguments supporting their standpoints. Some scholars indicate that the great risk-aversion towards control loss and uncertainty causes the reluctance of family firms engaging in M&A. Other scholars state that family firms undertake M&A regardless of the relative low propensity but diverge on the decision to execute related or non-related M&A. Figure 2 shows the primary influences on the decision-making to make acquisitions in family firms.

2.3. Acquisition Goals

The current literature states that several aspects shape the acquisition goals of firms (Arnold & Parker, 2009; Hodgkinson & Partington, 2008; Nguyen et al., 2012; Walter & Barney, 1990). Scholars declare that the distinct ownership structures among firms forge and have a significant influence on (Haleblian et al., 2009; Worek et al., 2018). Mainly due to the varying interests of family and non-family firms, the acquisition goals are not regularly interchangeable among firms (Angwin, 2007; Feito-Ruiz & Menéndez-Requejo, 2010; Haleblian et al., 2009; Miller et al., 2009).

2.3.1. Non-Family Firms

Regarding the acquisition goals in non-family firms, contemporary literature shows several points of view in determining these goals. It appears that scholars have difficulty in conventionally assessing and specifying precise goals among these firms (Hodgkinson & Partington, 2008; Nguyen et al., 2012; Walter & Barney, 1990). Due to this fact, many scholars attempt to integrate different viewpoints of varying theories to get a good understanding of the acquisition goals.

With the analysis of 335 M&A deals of state-owned enterprises, Florio, Ferraris, and Vandone (2018) determine two main objectives: (1) shareholder value and (2) utility maximization in M&A. The former is linked to increases in efficiency (Houston, James, & Ryngaert, 2001), risk reduction by product and geographic diversification (Amihud & Lev, 1981; Denis, Denis, & Yost, 2002), and an increase in market power by entering a new market or reducing competition (Gugler, Mueller, Yurtoglu, & Zulehner, 2003; Lanine & Vennet, 2007; Martin & McConnell, 1991). The latter is linked to maximizing the benefit of managers and not the firm value (Florio et al., 2018; Jensen, 1986; Matsusaka, 1993; Seth, Song, & Pettit, 2002).

Further, Angwin (2007) points to the classical approach to M&A motivation and divides the motives and goals, which are all intended at maximizing shareholder value, into the respective literature categories of finance, economics, and classical strategy. First, M&A is seen in the financial literature as a one-off gain aimed at increasing shareholders' wealth. Therefore, it is related to decreasing capital costs, decreasing tax liabilities, or increasing control over the target's liquid assets (Angwin, 2007). Second, when looking at the economic literature, the M&A goals positively correlate to maximizing the firm's long-term profitability, which can be achieved by building sustainable competitive advantages over competitors Angwin (2007). Therefore, activities connected with realizing economies of scale and scope are assumed to reach these benefits. Finally, the classical strategy literature regards M&A as an opportunity to position the firm in its industry in a particular way. Thus, M&A implies opportunities such as reducing overcapacity, exploiting synergies, or creating barriers to entry in order to obtain an appropriate positioning (Angwin, 2007).

In addition to the perspectives on M&A objectives previously mentioned, the literature exhibits more approaches to explaining motivations for M&A (Angwin, 2007) and shows that objects interact with each other and often happen in a combination in M&A activities (Nguyen et al., 2012). To conclude, it appears that the different literature perspectives, referring to different motivations and goals in M&A activities, imply mainly shareholder maximization as the underlying motivation for undertaking M&A.

2.3.2. Family Firms

Concerning acquisitions in family firms, the current literature stresses that not much is known about these acquisition goals (Astrachan, 2010). In particular, the literature notes that the ownership structure and goal preference, a combination of economic and non-economic objectives, represent an essential part in M&A among family firms (Worek et al., 2018). For instance, these aspects reflect the preference of tangible rather than intangible synergies or the choice of current rather than unknown and risky technologies or markets in the decision-making to undertake acquisitions (Angwin, 2007; Hodgkinson & Partington, 2008). Recently, examining 588 M&A deals of European manufacturing companies, Worek et al. (2018) have identified seven acquisition goal categories: finance, innovation, resources, market competitiveness, strategy, and expansion. A detailed overview of these acquisition categories and the respective acquisition goals can be found in Appendix 2.

In general, the finance goal category describes a one-off gain (Angwin, 2007) which is not known as a common strategy pursued by family firms since they focus on long-term oriented investments securing the firm survival (Arregle et al., 2007; Duran et al., 2015; Gómez-Mejía et al., 2007; Miller et al., 2009). In this regard, Worek et al. (2018) show that family firms are less inclined to engage in acquisitions based on financial aspects, as wealth concentration contradicts with risky and uncertain investments in family firms (Anderson et al., 2003; Bianco, Bontempi, Golinelli, & Parigi, 2013; Miller et al., 2009). Moreover, the family firms' preference for noneconomic utilities such as social engagement and preserving the business (Fiss & Zajac, 2004; Gómez-Mejía et al., 2007; Kotlar et al., 2018) outweigh financial returns diluting the family interests (Gómez-Mejía et al., 2007). Therefore, any activity diminishing stability and profitability is viewed as a threat to the family firm (Chrisman et al., 2012; Gómez-Mejía et al., 2010).

In terms of innovation, scholars have shown a high significance for growth purposes (Morck & Yeung, 1991). Notably, instead of developing innovations internally through tradition (De Massis, Audretsch, Uhlaner, & Kammerlander, 2018; De Massis et al., 2015), the external acquisition of innovation provides a strategic option for growth (Kotlar, De Massis, Frattini, Bianchi, & Fang, 2013). However, this challenges the specific characteristics of family firms, since if acquisitions are undertaken solely based on innovation, control may be diluted through the involvement of external parties (Duran et al., 2015), and the family firm survival is endangered



Source: own illustration based on Caprio et al. (2011), De Massis et al. (2015), Gómez-Mejía et al. (2015), Miller et al. (2009), Requejo et al. (2018), Shim and Okamuro (2011), Wiseman and Bromiley (1996), Worek et al. (2018) and Worek et al. (2018)

Figure 2: Influences on the Family Firm's Decision-Making on Acquisition.

by the uncertain outcomes of innovation (Duran et al., 2015; Gómez-Mejía et al., 2015). Consistent with the insights mentioned above, Worek et al. (2018) obtained similar results and note that the acquisition of innovation is less likely in family firms compared to non-family firms.

Moreover, Worek et al. (2018) unveil that the distinct ownership structure of family firms valuing non-economic utilities, as mentioned earlier, has significant implications on the firm behavior and decision making in family firms. In particular, it leads to the derivation of the stakeholder goal category for acquisitions (Worek et al., 2018). The non-economic utility indicates the incorporation of activities to increase social engagement and reputation (Arregle et al., 2007; Gómez-Mejía et al., 2007) as well as building trusting relationships and loyalty of stakeholders (Miller & Le Breton-Miller, 2005; Ward, 1988). Thus, family firms are more likely to engage in acquisitions driven by stakeholder goals than their counterparts in order to enhance non-economic utilities (Fiss & Zajac, 2004; Gómez-Mejía et al., 2015; Kotlar et al., 2018; Worek et al., 2018).

Concerning the resource goal category, Worek et al. (2018) show that family firms are as likely as non-family firms to disclose resource goals in acquisitions, but note that family firms are reluctant to undertake acquisitions based on resources such as distribution and marketing/sales network.

Other scholars agree with this observation and highlight the family firm's ability to develop vital resources internally and the aversion to losing control as explanations (Duran et al., 2015; Sirmon, Hitt, Ireland, & Gilbert, 2011). Furthermore, it seems that resource-based acquisitions are more likely to happen in cases of physical resources because family firms hesitate to engage in uncertain investments and thus favor activities with clear outcomes (Caprio et al., 2011; Miller et al., 2009; Requejo et al., 2018; Shim & Okamuro, 2011). Moreover, the second observation focusing on clear outcomes and thus certain investments is in the consensus of the innovation goal category, in which innovation, reflecting an uncertain investment, is less likely to drive acquisitions in family firms (Duran et al., 2015; Gómez-Mejía et al., 2015).

The market competitiveness goal category focuses on the positioning of firms in the current market and thus refers to strengthening long-term profitability (Ghosh, 2004). As long-term oriented profitability is crucial for the survival of family firms (Gómez-Mejía et al., 2007), the pursuit of market competitiveness goals in acquisitions enables family firms to achieve long-term continuity through fostering their positioning. In accordance, Worek et al. (2018) conclude that family firms are more prone to engage in acquisitions based on goals associated with this goal category since positioning in current markets are less risky (Gómez-Mejía et al., 2010;

Sirmon & Hitt, 2003) and ensure the survival of family firms (Gómez-Mejía et al., 2007). This observation is also consistent with the family firms' preference for domestic rather than foreign M&A deals (Chen, Huang, & Chen, 2009). However, Miller et al. (2009) counter this observation by highlighting the importance of diversification for family firms. Therefore, family firms with significant ownership are not reluctant to undertake acquisitions aiming to position in new, unknown markets for diversification (Miller et al., 2009).

In contrast to the goal categories mentioned above, the strategy goal category seems to be broader in its composition. In particular, Worek et al. (2018) reveal this category as universal and specify it as *"important in any acquisition transaction"* (Worek et al., 2018, p. 259). In the manner that it is interlinked with other goals and is equally important in all type of firms. Therefore, the strategy goal category occurs in a combination of different purposes.

Similar to the previous category, the expansion goal category constitutes a broader perspective of acquisitions, primarily focusing on growth (Worek et al., 2018). Despite the limited literature on this (Caprio et al., 2011), scholars have confirmed its importance in acquisitions (Bower, 2001; Calipha, Tarba, & Brock, 2010). Based on the study carried out by (Worek et al., 2018), it seems that the expansion goal category is equally likely to occur within family and nonfamily firms. Hence, it is anticipated that expansion goals are universally applicable. Morever, Worek et al. (2018) indicate that family firms are more prone to undertake growth acquisitions related to diversification purposes. In support of this, Worek et al. (2018) refer to findings that indicate the advantages of reducing risks as well as securing non-economic utilities (Miller et al., 2009; Patel & King, 2015). Added to that, scholars note that the diversification by acquisitions takes place outside of the core business, aiming to minimize further the risks of concentrated wealth (Colli, 2002; Khanna & Yafeh, 2007). Nevertheless, it contradicts with the market competitiveness goal category, which notes that family firms are reluctant to engage in acquisitions associated with risky and unknown outcomes due to the family firms' interest to preserve the survival of the business in the long run (Gómez-Mejía et al., 2010; Sirmon & Hitt, 2003).

All seven acquisition goal categories, identified by Worek et al. (2018), highlight the significant influence of the family firms' characteristics (Duran et al., 2015) which are a high level of control, wealth concentration, and non-economic utilities on the decision-making to undertake acquisitions and thus shape acquisition goals, considerably. In particular, they indicate that family firms are more likely to engage in acquisitions based on goals which are both averting uncertainty (Caprio et al., 2011; Miller et al., 2009; Requejo et al., 2018; Shim & Okamuro, 2011) and ensuring the longterm survival of the business (Arregle et al., 2007; Duran et al., 2015; Gómez-Mejía et al., 2007; Miller & Le Breton-Miller, 2005). Furthermore, the acquisition goal categories mentioned above also show that these goals may occur in combination as well as in contradiction with other goals.

2.4. Relation of Innovation and M&A

The study of Worek et al. (2018) is consistent with the findings of other scholars highlighting that family firms, even having a more exceptional ability of obtaining innovation by M&A (Casprini, De Massis, Di Minin, Frattini, & Piccaluga, 2017; Chrisman, Chua, De Massis, Frattini, & Wright, 2015), are less inclined to make innovation acquisitions due to risks and uncertainties endangering the firm's survival (Garcia & Calantone, 2002; Gómez-Mejía et al., 2007; McDermott & O'Connor, 2002). However, in recent years, innovation has become a topic of great interest in the research of family firms (De Massis et al., 2015) as innovation is one of the essential factors for success and leads to growth, competitive advantages, and durability of the firm (Alberti & Pizzurno, 2013; Braga et al., 2017; Chrisman et al., 2015; Classen et al., 2012; Dess & Picken, 2000; Filser et al., 2016; Grundström et al., 2012; Hatak et al., 2016; Kleinschmidt & Cooper, 1991; Nieto et al., 2015; Porter, 1996). Even considering the limited resources in family firms, Nieto et al. (2015) underline the innovativeness of this type of firms, which, specifically, is mainly driven by technological innovation (Alberti & Pizzurno, 2013). In contrast to that, Cassia et al. (2011) diminish the relevance of technology and note that customers and markets rather than technology mostly drive family firms.

2.4.1. Product and Process Innovation

In general, innovation emerges in two value-creating ways: product/service innovation and process innovations (Rogers & Rogers, 1998). Regarding the former type of innovation, contemporary literature indicates that it is dependent on internal factors such as R&D (Broekaert et al., 2016) because family firms are less inclined to share control with non-family members and thus less inclined to rely on external sources of technological knowledge (Kotlar et al., 2013; Nieto et al., 2015). Furthermore, scholars highlight that the development of products is mainly driven by market knowledge rather than technology knowledge because it contributes to the possibility of securing social relationships (Alberti & Pizzurno, 2013). Regarding the latter one, Broekaert et al. (2016) note that other activities besides internal R&D can achieve process innovation. Notably, they highlight that process innovation is mainly dependent on external rather than internal factors.

Comparing both innovations, it seems that family firms are more likely to create process innovation rather than product innovation (Classen et al., 2012). Furthermore, scholars also affirm that family firms are less effective in product innovation (Classen et al., 2012) and less willing to innovate in terms of product innovation as succeeding generations are highly concerned about the firm's survival (Werner, Schröder, & Chlosta, 2018).

2.4.2. Incremental and Radical Innovation

Additionally, the current literature shows that family firms are more likely to engage in conservative innovations, namely, exploitation (*incremental*) rather than exploration (*radical*) (Nieto et al., 2015; Werner et al., 2018; Fuetsch & Suess-Reyes, 2017) since family firms are highly interested in securing the socioemotional wealth as well as maintaining the survival of the family firm (Filser et al., 2016).

2.4.3. Acquisition of Innovation

Commonly, innovation describes a term that combines various activities (Calipha et al., 2010), which can be driven by internal or external factors, leading to an increase in firm performance (Rogers & Rogers, 1998). In terms of internal activities such as R&D, scholars have identified that family firms are investing less in R&D, a foreseeable investment, compared to non-family firms (Broekaert et al., 2016). The primary explanation for this seems to be the overall risk aversion and limited resources of family firms (Nieto et al., 2015). Nevertheless, neglecting these low investments, family firms are more likely to develop innovation internally through tradition rather than acquiring from external resources, according to De Massis et al. (2015) and Rondi, De Massis, and Kotlar (2019), since the acquisition of external innovation is associated with uncertainty and dilution of control (Kotlar & De Massis, 2013; Duran et al., 2015). In terms of external activities, the acquisition of innovation is likely to increase the propensity for product and process innovation (Adner & Levinthal, 2001; Xiaojie & Tingting, 2017) as it causes the absorption of the acquired firm's knowledge base (Ahuja & Katila, 2001) and thus it can complement the internal knowledge base by external knowledge (Chesbrough & Crowther, 2006).

Furthermore, innovation in M&A is associated with the acquisition of technology (Rogers & Rogers, 1998), and therefore it is essential to separate the acquisition of technological innovation or non-technological innovation because only the former can enhance innovation performance and output (Ahuja & Katila, 2001). Additionally, according to Dezi, Battisti, Ferraris, and Papa (2018), M&A and innovation can also enhance innovative capacity and sustain competitive advantage, which is vital for the firm's survival (De Massis et al., 2015). However, it is still unclear why family firms engage in the acquisition of technological innovation in the first place. Concerning this question, Ranft and Lord (2000) highlight two explanations: First, the firm is in a position hindering the development of a valuable knowledge base internally. Second, developing a valuable knowledge base takes too long or is too costly to do by itself. These two explanations are consistent with other scholars who declare the acquisition of innovation as a possible response to innovativeness and growth of firms (Ahuja & Katila, 2001). Moreover, there seems to be a trade-off based on the cost perspective. Hence, firms have to weigh between the relative costs to develop technology internally or acquire it externally (Kotlar et al., 2013).

Besides, there is a crucial differentiation between product/service and process innovation in M&A. Regarding product and service innovation, acquisitions promote new organizational models and provide access to research and innovation capacities of other firms. In particular, it allows extending the company's knowledge base by new technologies for faster time to market (Ferraris, Santoro, & Dezi, 2017). Regarding process innovation, acquisitions contribute to achieving economies of scale and scope by decreasing production costs and offering synergies between available resources (Singh & Montgomery, 1987).

Nevertheless, the acquisition of technological innovation portrays a risky type of M&A, as it is linked to both high growth potentials and high risks (Benou & Madura, 2005; Hagedoorn & Duysters, 2002b; Kohers & Kohers, 2000, 2001), and therefore it indicates that family firms are less inclined to acquire external technology due to the risk aversion (Kotlar et al., 2013) and threat towards the family firm's survival (De Massis et al., 2015).

To sum up, innovation presents an essential component for the success of family firms because it creates competitive advantages and ensures the survival of family firms. One approach to sustain the innovativeness of family firms is the acquisition of innovation, particularly, technological innovation in order to increase the propensity of product/service and process innovation. Mainly, it complements the internal knowledge base by external knowledge of other firms quickly and effectively (Ahuja & Katila, 2001).

3. Methodological Approach

As the present bachelor thesis reflects a qualitative study, it follows a case-based approach in order to extend the given literature on innovation and M&A in family firms by findings of something *new* and *interesting* and aims to answer the question of "*how*" and "*why*," but stays open to alternative observations of particular significance.

Therefore, the conducted interviews shed lights on the topics of innovation and M&A in family firms, which appears of highly practical significance. The underlying qualitative data set incorporates 15 interviews in 15 different German family firms.

3.1. Research Design and Setting

By comparing different types of case studies, my study builds on the variance-based case study approach as suggested by Eisenhardt (1989) and Miles and Huberman (1994) with the goals of explaining heterogeneity among family firms and consequently deriving propositions as an output of the case studies.

Notably, the information used for this qualitative study was generated through the conducting of interviews and enriched by additional information retrieved by secondary sources, to be precise, information made available on the firm's websites and company reports. I identified a list of 60 German family firms which seemed of excellent suitability and could potentially be integrated into the study through reaching out to the Senat der Wirtschaft e.V. as well as accessing German databases (e.g., InPraxi). With this, I contacted each family firm through a personal call or email with an exposé emphasizing the explanation of the research interest, the connected professorship, and details on the method and timing (Appendix 4–5). As a result, I was able to schedule 15 interviews with 15 family firms out of these 60 family firms. The remaining family firms declined due to missing interests or time constraints.

The interviews were conducted with only one family or non-family employee of the respective firm each. Except for Firm D, which provided information through an email, all interviews were scheduled as an in-person interview at the respective headquarter (Firm E; Firm G; Firm H; Firm I; Firm J; Firm K; Firm N) or an interview organized by a phone call (Firm A; Firm B; Firm C; Firm F; Firm L; Firm M; Firm O). In four out of 15 family firms, the interviews were conducted with non-family members due to time constraints of the business-owning family members or expert knowledge, especially, positions of the non-family members within the respective firm. In the other eleven family firms, I interviewed the business-owning family members for two reasons: First, the interviewed family members were highly interested in the research topic and were more than willing to attend the interviews. Secondly, I indicated a high interest to conduct an interview with business-owning family members highly involved in the business of the family firm in prior contact with the firms.

In terms of the family firms' characteristics, the 15 family firms included in the final sample range in their size between 70 and 7,500 employees with an average of 1,856 employees and between \notin 4 million and \notin 900 million in revenue with an average of \notin 301 million. Furthermore, the firm ages differ between 13 and 164 years since foundation with an average of 92 years. Moreover, the interviewed family firms are engaged in different industries. Further information about the family firms and interviewees can be retrieved in Table 1 and Table 2.

Added to that, choosing to include family firms that differ considerably in their characteristics allows setting an essential prerequisite for obtaining an extensive understanding of innovation and M&A among family firms differing in their age, industry, revenue, and size. Mainly, it allows for observing potential similarities and differences between different types of family firms.

3.2. Data Collection

In order to conduct the interviews successfully, an interview guideline, consisting of 33 questions divided into eight segments, was developed for listing fundamental questions that could potentially be used to fall back on and offers interviewees a basic understanding of the nature of the scheduled interviews as preparation. However, despite this interview guideline which can be found in the appendix (Appendix 2), the conducted interviews were semi-structured and thus allowed for adaption depending on the interviewee's responses (Eisenhardt, 1989). Hence, it was possible to have conversations in a natural flow, engaging both interview participants in a dialogue without interruptions.

Furthermore, the semi-structured interviews allowed to emphasize specific and interesting points and aspects mentioned by the interviewees. Hence, it allowed generating insights that would be unavailable otherwise (Eisenhardt, 1989). As a result of this particular interview approach increased both the flexibility during the interview and the overall authenticity of all conducted interviews due to more beneficial, especially, more familiar and trustworthy interview setting.

The interview guideline, as mentioned above, was established upon three steps that helped me outline the major sections and the associated questions within each section. First of all, I focused on the findings derived from the literature review and used these insights to create an essential structure for the guideline. By this first step, I blueprinted and designed the eight general question sections. Secondly, after having an even closer look at the literature findings, I came up with a long list of questions related to these findings for each section of the interview guideline. Based on this long list, I decided to focus on questions that allowed me to accept, reject, or expand previously made assertions of the literature related to innovation and M&A in family firms. Shortly after, I was able to specify and narrow the long list down to a shortlist of questions to gather practical insights into these specific fields in family firms by the interviewees. By this second step, I added relevant questions to the respective sections and aimed to collect valuable as well as new insights that have not been subject to past research. Thirdly, I arranged an expert interview with a senator (member) of the Senat der Wirtschaft e.V. in order to challenge the previously defined interview guideline. The senator identified critical gaps and provided valuable insights to finalize them. By this third and last step, I applied the gained insights to wrap up the interview guideline by adding and modifying questions based on the exchange.

The first two question sections aim to create a beneficial interview environment that potentially enables the possibility to retrieve more sensitive information from the interview partner in the following conversation. Therefore, these two sections serve as a warm-up phase by gathering basic information about the family firms and interviewees. Moreover, the basic information obtained during these two sections provides fundamental insights into comparing the family firms objectively.

The following three-question sections serve as a bridge between the introduction and main body of the interview and aim to gather more specific and meaningful information about family firms in terms of the influences on the firm as well as their overall goals. The information obtained in this section provides a general understanding of the behavior of family firms and indicates potential perceptions of the family firms' engagement in innovation and M&A.

The sixth and seventh question sections function as the main body and intend to discover more about the family firms' approach to being innovative and undertaking M&A. The sixth section focuses strongly on the topic of innovation and thus highlights different aspects of innovation. The seventh section directs the subject of M&A in family firms. Hence, it aims to gather valuable insights into the importance

Family Firm	Industry	Location	Foundation	Generation	Employees	Revenue (in \in)	Number of M
Firm A	Building Materials		·	3rd	3,000	ı	11
Firm B	Passenger Transport	I	I	4th	850		σ
Firm C	Automotive	I	I	5th	7,500		6
Firm D	Automotive	I	I	2nd	1,100		2
Firm E	Consumer Goods	I	I	3rd	150	I	0
Firm F	Media	I	I	3rd	1,000	I	υ
Firm G	Building Materials	I	I	3rd	1,250	1	10
Firm H	Trade	I		4th	90		4
Firm I	Passenger Transport	I		1st	70		2
Firm J	Energy Supply	ı		4th	200		6
Firm K	Engineering	ı		3rd	1,500		6
Firm L	Consumer Goods	ı		5th	5,000		7
Firm M	Consumer Goods	ı		3rd	3,000		21
Firm N	Food & Beverage	ı		5th	130		ω
Firm O	Measurement	ı	I	2nd	3,000	ı	2
	Instrumentation						

Table 1: Overview of the interviewed Family Firms

Source: own illustration based on conducted interviews

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Family Firm	Interviewee	Family Member	Position	Date of Interview
Firm A	-	No	Head of M&A and	26/04/2019
			Integration Management	
Firm B	-	Yes	CEO	19/04/2019
Firm C	-	Yes	CEO	19/04/2019
Firm D	-	Yes	CEO	00/04/2019
Firm E	-	Yes	CEO	16/04/2019
Firm F	-	Yes	CEO	27/04/2019
Firm G	-	No	CEO	16/04/2019
Firm H	-	Yes	CEO	18/04/2019
Firm I	-	Yes	CEO	08/04/2019
Firm J	-	Yes	CEO	24/04/2019
Firm K	-	No	Director Tax & Finance	10/04/2019
			International	
Firm L	-	No	VP Strategy &	15/04/2019
			Corporate Development	
Firm M	-	Yes	Co-CEO	24/04/2019
Firm N	-	Yes	Former-CEO	09/04/2019
Firm O	-	Yes	CEO	25/04/2019

Table 2: Overview of the Interviewees

Source: own illustration based on conducted interviews

and drivers of M&A.

The interview guideline finishes with the eighth and last section and serves as rounding the interview through further questions linked to the research and development (R&D) of the firms. Moreover, this section informally serves as a possibility to clarify unclarity and to answer questions asked by the interview partners.

This interview guideline was shared with nine interviewees in advance. However, the six other interviewees did not receive the guideline beforehand. Thus it increased the authenticity of the conducted interviews as some interviewees had to answer the questions without any preparation (Appendix 3). Added to that, all interviewees agreed with the recording of the conversations for assessment purposes. Besides, all interviews were carried out in German, and significant insights and statements were translated into English later on.

Principally, all interviews were conducted during three weeks between April 8, 2019, and April 27, 2019 (Appendix 3; Table 2). As mentioned earlier, seven interviews were carried out in-person with the interviewees at the respective company's headquarter, seven were conducted through telephone calls, and one was done by electronic communication. The length of the interviews ranges between 14 and 43 minutes, with an average of 30 minutes (Appendix 3). Also, the circumstance that the family firms which participated in the interviews differ significantly in their characteristics provided broad but detailed insights into the research topic.

3.3. Data Analysis

Since theory-building aims to reveal new "descriptions, insights, and explanations of events" (Gioia & Pitre, 1990, p. 588), the role of data analysis is undoubtedly increasing in the field of both qualitative and quantitative studies. Particularly, Eisenhardt (1989, p. 539) highlights that "[a]nalyzing data is at the heart of building theory from case studies". Therefore, it is critical to apply a well-defined process of collecting and analyzing data in order to observe innovation and M&A in family firms adequately (Figure 3).

In order to do so, the available data generated by the interviews pass through two critical stages. Firstly, after carrying out the interviews, I collected qualitative information for each family firm. Explicitly, I assembled my notes of significant statements taken during each interview, as well as the transcribed citations in the interest of consolidating all available information in a compromised form with the computer program Excel for straightforwardness (Miles & Huberman, 1994; Sutton & Callahan, 1987). Additionally, due to the semi-structured interview guideline, which does not require answering questions in a strict order, the conducted interviews followed open structures and developments. Hence, the consolidation of all available information enabled the restructuring of insights and statements based on the predefined question sections and their underlying questions.

Secondly, I carried out a cross-case (cross-interview) analysis aiming to gather insights based on all conducted interviews, as the content of these interviews were in the same context, namely, innovation and M&A in family firms, and thus represented an appropriate setting for this type of analysis (Yin, 1981). I mainly focused on finding similarities and differences as well as iterative patterns between the 15 family firms. For simplicity, I decided to establish a coding scheme (Gioia & Pitre, 1990) in order to classify, evaluate, and visualize the obtained information in such a way that leads to the derivation of propositions (Eisenhardt, 1989). The coding schemes can be found in Appendix 6–10.

4. Findings

4.1. Single Case Summary

With my qualitative study of the acquisition goals and the role of innovation in acquisitions in family firms, I intend to gain advanced insights into the M&A behavior of family firms. The following chapter summarizes all 15 investigated family firms and displays their perspective of acquisition drivers and the role of innovation in acquisitions briefly.

Firm A, as a premium manufacturer of building materials, focuses primarily on its product portfolio. Therefore, the firm follows two approaches, i.e., the internal development and improvement as well as the acquisition of external products, in order to quicken growth and expansion. Hence, M&A play a significant and strategic role in the firm's development and success (e.g., *"In principle, we can say that of the revenue we have today, about half comes from acquisitions."* Firm A). Corresponding to this, Firm A also has an extensive M&A track record dating back 20 years, highlighting the importance of acquisitions. Since the firm aims to become a one-stop-shop solution for craftsmen, Firm A engages in acquisitions whose objectives result in expanding the firm's product portfolio and global presence.

Firm B is active in the passenger transport industry, highly influenced by the local authorities due to the flow of subsidies and public funds. Thus, the firm's motivation to engage in acquisitions depends mainly on the following question: "*If we don't buy it, but a competitor buys it, how will the market change for us?*" (Firm B). Therefore, the firm is highly valuing acquisitions increasing market competitiveness in order to maintain and enhance the firm's position in both the market and country. In terms of innovation and acquisitions, Firm B notes that innovation is driving none of their acquisitions but remarks that any acquisition which appears to be new-to-the-firm results in innovations for the firm.

Firm C is active in two industries which are automotive supply and engineering. As customers greatly influence the firm's automotive supply industry, acquisitions are less likely to occur. Consequently, Firm C focuses on the optimization of internal processes in order to attain cost leadership. However, in the engineering industry, Firm C follows a different approach to grow and strengthen its market position. In particular, the firm utilizes acquisitions for complementing internal with external technology (e.g., "*M&A plays a role in expanding technology. In particular, to extend knowledge and thereby generate additional revenue.*" Firm C). For that reason, innovation is driving the acquisitions undertaken by Firm C. However, the acquisition of innovation remains a means to an end for achieving overall goals such as expansion and market competitiveness.

Firm D is a manufacturer of cable confection and system technology. Generally, the firm is aiming to increase profitability, precisely, to grow in revenue and earnings. In order to do so, Firm D' approach is to develop customer-oriented products in close collaboration with its customers. The result of these collaborations is product and process innovation which benefits both parties. However, in terms of acquisitions, innovation has no relevance as a driving factor. Notably, Firm D names goals related to accessing markets and customers as crucial drivers of acquisitions of the firm (e.g., *"We acquired companies in order to open new markets and support our growth."* Firm D). Thereby, the firm aims to shorten the time to market and to accelerate growth.

Firm E operates in the skincare industry and is the only family firm in this sample without any acquisitions yet. Firm E highlights the importance of growth for the firm's development but reveals that growth should stay in a healthy frame. Mainly, innovation, more specifically product innovation, contributes to the firm's success. For this purpose, the firm is continuously improving and developing its product portfolio internally. Due to this conservative approach to do business, Firm E is not reliant on external resources, e.g., acquisitions of other firms. However, the firm is open to complementary acquisition opportunities to increase independence ("We really don't have much experience with that. Well, you go through life with open eyes. You don't know whether it will be interesting to acquire a firm at some point. Well, it depends. [...] Is there perhaps a bottler or producer who would be complementing or who has the whole infrastructure, machines and further afield? Something like that would certainly be conceivable." Firm E).

Firm F is a digital-driven media company focusing on combining traditional media business and business that emerged by the digital trend in the industry. Notably, Firm F utilizes two strategies to leverage digitalization and to increase the firm's level of innovativeness: on the one side, by adapting the existing products to the digital change, and on the other side, by explicitly acquiring companies (e.g., "We have done it ourselves in many years, but in recent years we have tended to acquire more." Firm F). Here, the acquisitions display a strategy to reposition the company and incorporate (local) business opportunities as well as goals related to market competitiveness such as to strengthen the market position (e.g., "A strong idea of how can I take precautions by strengthening the digital sector and let the company as a whole participate in this huge media change, in the gigantic digitalization, and in the new businesses that result from it? That has been the decisive driver, and it is still today." Firm F).

Firm G is doing business in the building material industry and is heavily investing in growing the business and extending the product portfolio. Unusually, this family firm differs considerably from the other interviewed family firms. In contrast to the past, Firm G is now carrying out a greenfield approach rather than undertaking acquisitions for the last few years in order to increase its market competitiveness (e.g.,



Source: own illustration

Figure 3: Overview of the Methodological Approach.

"We now have a strategy change that we completed 5–10 years ago and are now focusing on greenfield investments. We are trying to go with the customers. We are going to the regions where we already deliver only from further away, build a production facility there and then also a sales office." Firm G). The goal of increasing market competitiveness remains the same, yet how such goals are achieved has changed because of the hidden cost of acquiring existing firms with plants at favorable prices. Innovation is essential for the firm as it secures meeting customer expectations (e.g., "Innovation is like Oliver Kahn, according to the saying: Always further! [...] The expectations of our customers are much higher, and they will be even higher in 10 years." Firm G), but does not influence the decision-making to make acquisitions.

Firm H is a trading company offering various goods to its customers. As this specific type of business operates between industry and retail, the family firm faces several challenges, one of which is the high dependence on industry suppliers. In order to decrease dependence, its previous acquisitions refer to market competitiveness, expansion, and finance. However, more recently, the firm is highly interested in becoming more independent in terms of vertical integration — notably, the firm is fascinated by the acquisition and integration of an existing supplier of the firm in order to reduce risks (e.g., *"For example, I am currently considering acquiring an upstream business. It is a small company that has its own collection of wool."* Firm H).

Firm I is a provider of passengers transport, particularly

limousine service for its customers in Germany. In order to increase market competitiveness and accelerate growth, the firm is highly interested in inorganic approaches to reach its goals. In accordance with this, Firm I reveals market competitiveness and growth as the drivers of previous M&A activities. Further, the firm shows interest to expand its business into other German-speaking countries. It appears that innovation does not drive acquisitions.

Firm J is a family firm with a unique ownership structure of which the family owns half of all shares. In general, the firm operates in the energy supply industry and is highly customer-oriented. Therefore, customer feedbacks are significantly shaping the business of Firm J. In principle, the firm is not reluctant to undertake acquisitions but favors organic growth or growth by collaborations and partnerships. Also, the firm shows that there are two approaches to make acquisitions: on the one hand, by opportunity, and on the other hand, by strategy. Besides the acquisitions that emerged by opportunity, Firm J unveils drivers such as product portfolio expansion, strengthening market position, and growth as the determining factors for acquisitions. In addition to these factors, the firm shows that Innovation is essential for the firm's survival since it allows Firm J to please the customer's demands (e.g., "Innovation is not an end in itself. I can only survive in the market if I do something where the customer says: Yes! I think this service is excellent. This is what I want. In this respect, my drive for Innovation is always one that has to please the customer. I can't innovate otherwise." Firm J).

Firm K is a family firm active in the engineering industry. It aims to become a one-stop solution provider combing different levels along the value chain, thereby adding value for its customers and the family firm itself. As inorganic growth is profoundly significant for the firm's development, Firm K is not hesitant to engage in acquisitions. Quite the opposite, the M&A strategy is in line with the firm's overall strategy to grow disproportionally to the market. In connection with it, the firm shows that the firm's acquisitions refer to two drivers: product portfolio expansion and technology expertise — the latter points towards innovation and thus highlights its importance in the acquisition of firms. Furthermore, the acquisition of innovation offers the firm an alternative approach to develop product innovation as it surpasses financial and time constraints to do it internally.

Firm L is a family firm active in the following three industries: cosmetics, office supplies, and outdoor equipment. The interview reveals that the firm is long-term oriented and risk-averse in its behavior to do business. Further, Firm L acknowledges the importance of growth but highlights its preference for stable and profitable growth rather than fast growth. In terms of M&A, the firm notes that the acquisition of other firms represents an approach to hedge risks, as it extends the business base and thus secures the stability and independence of the family firm. Notably, acquisition goals such as growth, product portfolio expansion, and geographic expansion, related to the goal category expansion drive primarily the acquisitions undertaken by Firm L (e.g., "It is the portfolio reach to be able to introduce, in particular, a new category or a new product line, notably, in terms of geographic reach. If I am planning a market entry and there is a potential partner in the target country who is already successful and could help us or has a complementary portfolio, then an acquisition makes it much easier to enter the market." Firm L).

Firm M operates in the consumer goods industry, to be precise, in the toys industry and represents a family firm profoundly shaped by acquisitions. Since inorganic growth contributes more than organic growth to the group's overall growth, it is increasingly crucial for Firm M's firm development (e.g., "It is part of our growth strategy to grow through existing structures and sales units worldwide." Firm M). The interview reveals that there are three triggers for acquisitions: opportunity, insolvency, and strategy. Mainly, the firm is strategically acquiring financially distressed firms or have enormous potentials to restructure them. However, in all cases, the firm's driver is to exploit synergies in order to increase the group's revenue and profitability (e.g., "We can simply leverage synergies by acquiring companies that are not yet positioned worldwide." Firm M). Despite the general importance of innovation in the firm's products and processes, it has a limited influence on the acquisition of other firms (e.g., "Without innovations, we have little or no chance to develop and grow in the market. It is undoubtedly an important topic, but innovation can be developed in very different ways." Firm M).

Firm N is active in the food and beverage industry and shows that inorganic growth is vital for the firm's develop-

ment as economies of scale emerged by concentrating the production of bakers and increasing profitability and market share. Furthermore, Firm N highlights that previous acquisitions point to established relationships with the acquired firms and notes that these firms are on sale due to insolvency or missing succeeding generations. However, it seems that the primary driver is to increase market competitiveness. Innovation does not represent a driver in Firm N's acquisitions.

Firm O is a manufacturer of measurement instruments. The family firm reveals that it is favoring organic rather than inorganic growth and notes its several collaborations and partnerships with external companies and institutes. In terms of the firm's acquisitions, Firm O highlights two approaches: an opportunity-driven approach (e.g., "The company Matter was a typical case of opportunity. The company offered itself as part of a collaboration that we already have with the company. [...] It was financially-distressed, and that is why they asked us if we wanted to join or acquire." Firm O) and a systematic approach. Furthermore, the firm displays product portfolio expansion as an essential driver for acquisitions but mentions that the acquisition is not a systematic instrument of innovation. It seems that innovation has a minor role in the decision-making to undertake acquisitions (e.g., "We innovate, but we don't innovate by acquisitions, at least not systematically. [...] When I say that acquisition is not a systematic instrument of innovation, it only means that we don't rule out something like this in our business model [...]. That means we systematically also innovate by acquiring innovative firms, but we usually don't. It can happen, but it's rare." Firm O).

4.2. Cross-Case Analysis and Propositions

By the use of cross-case analysis, I have identified various patterns in the interviewed family firms and thus have suggested the following set of 14 propositions which emerged from our explorative study. My findings are illustrated in Figure 4 and Appendix 6–11.

4.2.1. Influence of the Family on the Family Firm

My first observation is that the business-owning family has a critical role for all family firms that I interviewed. All these firms highlight that the family, being directly or indirectly involved in the business, are highly interested in the situation of the firm, as the following quote illustrates:

> Much information goes to the family members because they are very interested in the business. They want to be informed and stay informed. This is a strict requirement, and if the management does not follow this, it will quickly become noticeable. (Firm G)

Additionally, I have noticed that family firms with no family members in management have an advisory board with family members and neutral persons. This level of supervision enables the family to assert its interests and goals in the decision-making of the family firm: The family is represented by the advisory council. This council consists of five people, two of whom are delegated by the respective owner families. (Firm A)

The family has a decisive influence. What part of the supervisory board is in non-family firms is the advisory council in family firms. There, the shareholders are informed about business development. (Firm G)

In particular, the business-owning family is significantly shaping the firm's goals and strategy since the family is passing essential values over to the firm. The following quote emphasizes it:

There is a significant relationship between family values and business strategy. In particular, all family values are an essential part of the business strategy. (Firm L)

To sum up, the qualitative data set shows that the business-owning family, regardless of the level of involvement, significantly influences the family firm. Notably, the family transfers specific goals and values to the firm, thereby shaping the overall business.

4.2.2. Importance of Inorganic Growth

The cross-case analysis and search for patterns reveal that family firms primarily focus on three fundamental goals: stability, profitability, and growth. Remarkably, the majority of interviewed firms emphasize the importance of stability and profitability, which can be seen in the following:

We are risk averse and prefer stability and profitable growth rather than fast growth which can lead to managerial problems. We do not follow all trends, but we analyze all business options carefully and decide on the possibility of leading to sustainable development. (Firm L)

According to Firm L, it seems that growth refers to two types, namely, profitable growth and fast growth. Strikingly, fast growth does not represent a primary goal than the others because it reflects risks that can endanger family firms' survival. However, most firms stress the importance of growth for the firm's development:

The goal, of course, is to grow. It is our philosophy to grow health or to grow within a healthy frame. (Firm E)

All investigated family firms acknowledge growth as significant because it provides a way to be stable, independent, and profitable to develop the business (Firm L). Moreover, family firms note that growth is a term that combines organic and inorganic growth (e.g., *"Firm K is also aiming to grow both organically and inorganically."* Firm K). Primarily, inorganic growth, in terms of acquisitions, offers a strategic option to create sustainable advantages and to maintain the long-term durability of family firms, as the following quotes illustrate:

In this respect, the acquisition of companies has made a significant contribution to our growth in recent years. It has accounted for a more substantial proportion of our overall growth than organic growth. (Firm M)

Inorganic growth has a significant role in family firms. Thus, family firms are engaging in acquisitions. (Firm K)

Notably, in the last five to six years, we have gained more through acquisitions. In some companies [of our firm portfolio], following organic growth, we have even occurred losses because of the challenging market conditions in the toy industry. (Firm M)

To summarize, it seems that business-owning family members have a significant influence on family firms. Notably, family values are decisively shaping the firm's development. As the family is severely concerned about the long-term survival of the family firm, growth has a vital role alongside stability and profitability in securing and enhancing the family firm. In particular, growth in terms of inorganic growth, namely, growth by acquisitions, is a strategic option. Based on the observed pattern, I propose the following:

Proposition 1: Growth, mainly, inorganic growth provides the foundation on which family firms can obtain stability and profitability. The mean of acquiring other firms leads to sustainable development and the survival of family firms.

4.2.3. M&A Behavior

The importance of inorganic growth, to be precise, growth by acquisitions can be seen above, but it still does not explain the M&A behavior of family firms and the likelihood of acquisitions. In an effort to identify possible reasons why family firms are acquiring other firms as an option to grow, I searched for further common patterns in my qualitative study.

Mainly, I noticed that the investigated family firms, even highlighting the relevance of organic growth (Firm J, Firm O), are generally not reluctant to engage in acquisitions (e.g., "[*T*]*he focus is on organic growth. However, that is not so easy in a niche market. When opportunities have arisen in the past, we have always said that we would try our luck, [...]. When we were able to acquire something, then we also did it." Firm J). Quite the contrary, the majority of the interviewed family firms regard acquisitions as a valuable complement to organic growth because it can positively impact the business (e.g., "M&A is intended to positively influence the business by which we can acquire new competencies or competitive edge through speed or the like." Firm L). Moreover, in some family*



Source: own illustration based on conducted interviews and coding schemes

Figure 4: Model to illustrate the Findings of the conducted Interviews and the created Coding Schemes.

firms, M&A is even a fixed component in the overall group strategy as it profoundly contributes to the firm's growth and stability (e.g., Firm A; Firm L; Firm K).

Furthermore, I recognized that there is one fundamental question for family firms in order to undertake acquisitions. Family firms have to answer the question of whether making or buying (e.g., acquiring) something, as the following quote illustrates:

In the M&A process, there is always a weighing. Do I now buy [acquire] something? [...] Or do I do it myself? (Firm F)

Therefore, family firms have to decide between the two options of make or buy and thereby consider a weighing of three factors, which are ability, costs, and time:

For example acquisition target X: Before the acquisition, we had to decide between developing a high-quality adult filler from scratch, a greenfield approach, at home or acquiring a target company and having the product in the firm's portfolio right away. We decided to buy the target, and thereby we have made a leap in time and can now develop the product further from there. It was not an option to develop the adult filler organically, because it simply would have taken too long and consumed too many resources. So, making an acquisition was the right decision. (Firm L) That [a complement to the firm's portfolio] has been missing so far. It would have cost us three to five years and many millions of euros with an unknown outcome in R&D. Now, we have simply bought ourselves into it. So, we can act overnight. (Firm K)

Hence, the probability of undertaking acquisitions highly depends on the firm's current resources and constraints. Additionally, the influence of the business-owning family on the family firm is also determining the decision-making between buying or making. For example, a family firm that was highly focused on growth by M&A in the past can favor the option of making by itself today (e.g., "Now, we have a strategy change which we completed five to ten years ago. Now, we are focusing on greenfield investments." Firm G)

Lastly, I identified another aspect affecting the M&A behavior of the family firms in my data set. This aspect is associated with the underlying nature of family firms, namely, the risk-aversion. The interviewed family firms mentioned their concerns regarding financial independence and the preference to self-finance acquisitions (Firm B; Firm J; Firm K; Firm L).

To conclude, the M&A behavior of family firms depends on several aspects, but the key is to decide strategically between organic growth (e.g., making something) or inorganic growth (e.g., acquiring something). This weighing incorporates three components: ability, cost, time, and general preferences of family firms such as financial independence or risk aversion. Based on the findings mentioned above, I propose the following:

Proposition 2a: The likelihood of acquisitions undertaken by family firms increases (decreases) with unbeneficial (beneficial) circumstances, in the context of ability, costs, and time, for making something.

Proposition 2b: The likelihood of acquisitions undertaken by family firms increases (decreases) with both higher (lower) willingness of the business-owning family to make acquisitions and increasing (decreasing) independence of the family firm.

4.2.4. Acquisition Goals

Regarding the acquisitions undertaken by the interviewed family firms, I have observed several acquisition goals which surface both in combination with other goals and individually. In order to simplify the emerged observations, this study adopts the goal categories (finance, innovation, stakeholder, resources, market competitiveness, strategy, and expansion) and acquisition goals named by Worek et al. (2018) for classifying and categorizing the drivers of the acquisitions in my data set. As a result of this approach, the cross-case analysis results in the observation that the goal category expansion, followed by market competitiveness and innovation, is the most significant driver of acquisitions in family firms.

4.2.5. Acquisition Goal - Goal Category Expansion

In general, the goal category expansion incorporates many related acquisition goals. In particular, the investigated family firms highlight growth, product portfolio expansion, geographic expansion, diversification, and brand addition as the driving goals for their acquisitions. Some of these firms note the importance of brand addition (e.g., Firm A) and diversification (e.g., "[...] today, we are very dependent on our suppliers and [...] many of them are in an awful economic situation. I am, now, trying to build something up for myself and become more independent by acquiring a smaller company [supplier]." Firm H) as highly relevant. However, most firms indicate the following three acquisition goals, namely, growth (e.g., "We bought companies in order to open new markets and support our growth." Firm D), product portfolio expansion (e.g., "And for office supply, it was the product portfolio because there were no such items as fountain pens in our product range, but a desire to extend the existing product portfolio." Firm L), and geographic expansion (e.g., "Let's say, there is a situation in which we are not sufficient or not present in a particular region. We would simply acquire a company that also produces tile adhesives there. That would in principle be a market entry or geographic expansion. You buy a market share to be in this market. We are currently looking very active in South America. We are also in an acquisition process there because we have no business there yet." Firm A) as the central drivers in this goal category and in comparison to all recognized acquisition goals.

As mentioned earlier, the identified acquisition goals occur individually and in combination, regardless of the intention, with other goals in the acquisition of firms. Notably, the qualitative data shows that the combination of goals also appears within one goal category, as the following quote illustrates three acquisition goals which are growth, product portfolio expansion, and geographic expansion:

If I am planning a market entry and there is a potential partner in the target country who is already successful, who could help us, or who has a complementary portfolio to mine, then this makes it much easier to enter the market. That's exactly what happened in the case of cosmetics: it also enriched our product portfolio, but primarily the geographic reach was relevant. (Firm L)

To summarize, it seems that the goal category expansion with the acquisition goals growth, product portfolio expansion, and geographic expansion is the primary driver of acquisitions undertaken by family firms. Thus, I propose the following proposition:

Proposition 3a: Family firms are primarily undertaking acquisitions of other firms because of expansion. Thereby, growth, product portfolio expansion, and geographic expansion are decisively influencing in the likelihood of acquisitions.

Proposition 3b: The likelihood of acquisitions undertaken by family firms increases (decreases) significantly with the importance (unimportance) of expansion goals, namely, growth, product portfolio expansion, and geographic expansion as acquisition goals.

4.2.6. Acquisitions Goal – Goal Category Market Competitiveness

Based on the investigated firms, the goal category market competitiveness represents the second most common goal category. The interviews reveal that family firms are primarily pursuing the following three acquisition goals in this category: customers (e.g., *"Then in recent years, we have tried to expand our liquid gas product portfolio by addressing a specific clientele – the one who has been dealing with the topic of proprietary tanks. We also made an acquisition there [...]. We aimed to address this clientele under a different brand name." Firm J), exploit synergies (e.g., Firm M), and strengthening the position in terms of market and country position (e.g., <i>"That's why our acquisitions tend to be motivated by the following question: If we don't acquire it [potential target], but a competitor does. How will the market change for us?"* Firm B).

Noticeably, the qualitative data set shows that two of these three goals, namely, exploiting synergies (e.g., Firm A; Firm I; Firm K; Firm M) and strengthening market and country position (e.g., Firm A; Firm B; Firm F) are peculiarly shaping the goal category since they lead to market competitiveness. As the interviews indicate, the goal of exploiting synergies can appear in two forms, which is more beneficial for the acquiring or acquired company. For example, Firm M shows that both types of synergies are also possible within one firm. The acquisition of target A displays the synergies of the acquiring firm, and the acquisition of target A displays the synergies for the acquired firm: The last acquisition was target A, an American company that we bought last autumn. [...] They have a very experienced R&D organization in Hong Kong and China. They have an excellent costing team. That means, they can analyze precisely how much the products can cost in production. When a product goes into development, they always look over the 3D structures and improve them from the production point of view. [...] So through the acquisition, we could apply this outstanding expertise to the product segments of our company. (Firm M)

Yes, as I have already said. The most significant effect with us is the international synergy that we can leverage in something like this [e.g., acquisitions]. That means we take over a small company like target B, for example. [...] We bought this company and now have the opportunity through our international sales structure [...] to take up the products of this smaller company and market them in the respective local markets, globally. (Firm M)

Moreover, the goal of strengthening the market and country position is especially shaping this goal category since the majority of firms refer to the importance of a stable positioning within both the market and country (e.g., *"Then we bought a company at lake Tegernsee. The aim was to position ourselves around Munich."* Firm B; e.g., *"A strong idea of how can I take precautions by strengthening the digital sector and let the company as a whole participate in this huge media change [...] That has been the decision driver, and it still is today."* Firm F).

To sum up, market competitiveness represents the second most common goal category for family firms' acquisitions. The interviewed family firms refer to three acquisition goals which are customers, exploit synergies, and strengthen market and country position in this goal category. Greatly, the latter two acquisition goals lead to an increase in market competitiveness.

Proposition 4a: Besides the goal category expansion, family firms are also undertaking acquisitions of other firms because of market competitiveness. The acquisition goals, namely, to exploit synergies and strengthen the market/country position are significantly influencing the likelihood of acquisitions.

Proposition 4b: The likelihood of acquisitions undertaken by family firms increases (decreases) significantly with the importance (unimportance) of goals leading to market competitiveness, namely, to exploit synergies and strengthen the market/country position as acquisition goals.

Proposition 4c: For family firms, the significance of exploiting synergies drives the probability of acquisitions positively due to the occurring synergies, for the acquiring or acquired company, to increases the market competitiveness.

4.2.7. Acquisition Goals - Goal Category Innovation

Furthermore, the conducted interviews show that innovation is the third most common goal category in family firms' acquisitions. As noted by Firm B, innovation is a broad term that describes anything new to and creates value for the firm:

The reasons for buying were not in the sense that we buy innovation. If we buy something else that we don't already do ourselves today, then it's also a kind of innovation because we're going into an area where we aren't today and believe that we're better off with it at the end of the day. (Firm B)

In particular, the quote of Firm B mentioned above exemplifies this broad meaning of innovation, and it seems that there is a difficulty in specifying explicit acquisition goals in terms of this goal category. Based on the investigated firms, the goal category innovation designates technology, particularly technology expertise, as the driving acquisition goal in this category. The following quote illustrates the significance of technology and its relation to technology knowledge:

> If you look at our acquisitions, you can easily see that they were linked to the components area. There, we try to acquire core components and core knowledge in order to integrate our knowledge. So, one plus one is not two, but becomes three. (Firm K)

This observation is consistent with other family firms, such as Firm C, Firm J, and Firm M, and highlight the importance of complementing internal with external technology. However, these two companies also note the influence of the market in the decision-making, as the following quote illustrates:

The markets we had served were not a) growing and b) market leading to the extent that growth in speed was only possible with a broadening of the technology portfolio. That is why we made acquisitions. (Firm C)

By connecting technology and market, the interview with Firm C highlights that time in terms of growth in speed is an additional determining aspect in the decision-making to undertake innovation-driven acquisitions in family firms.

Additionally, the interview with Firm M reveals that innovation also points to R&D, which reflects technology knowledge. Significantly, the example of the experienced R&D and its excellent costing team represents technology expertise which is a beneficial complement for the whole group (see "Acquisition Goals – Goal Category Market Competitiveness").

In summary, innovation reflects the third most common goal category for the acquisitions undertaken by the investigated family firms. Even considering innovation as a broad term, it seems that technology expertise is mainly driving the acquisitions in this goal category. Notably, the acquisition of firms associated with technology expertise leads to higher innovativeness of family firms. Added to that, it seems that unfavorable market conditions enhance the speed of acquiring technology expertise and thus innovation.

Proposition 5a: Besides the goal categories expansion and market competitiveness, family firms are further undertaking acquisitions of firms because of innovation. The acquisition goal, namely, obtaining technology expertise is significantly driving the likelihood of acquisitions.

Proposition 5b: The likelihood of acquisitions undertaken by family firms increases (decreases) significantly with the importance (unimportance) of goals increasing innovativeness, precisely, to obtain technology expertise as acquisition goal.

4.2.8. Acquisition Goals - Goal Category Strategy

Besides, the collected qualitative data indicate the goal category strategy as the last more common category. In particular, the interviewed family firms highlight strategic reorganization/repositioning (e.g., Firm J), local business opportunities (e.g., Firm B; Firm J), niche player/specialization (e.g., Firm H), strategic fit (e.g., Firm B), and market access (e.g., Firm B) as the underlying acquisition goals. Also, the data reveal that the acquisition goals surface not only in combination with other acquisition goals in this category but also of other goal categories, as the following quote illustrates:

Our business is politically influenced by the fact that we provide 70% of the classic liner traffic for cities and municipalities. The cities determine a lot of what has to be done. So, the own initiative is conditionally desired because there are many subsidies and public funds flowing. That's why our acquisitions tend to be motivated by the following question: If we don't buy it, but a competitor does. How will the market change for us? Also, it is partly influenced by the fact that you stand better on several legs next to the classic liner traffic. Thus, in addition to classic liner traffic, we also bought scheduled services in the region. Then, we bought a company at lake Tegernsee. The aim was to position ourselves around Munich. (Firm B)

The quote shows that a combination of several acquisition goals of this category (such as local business opportunities, strategic fit, and market access) and acquisition goals of other categories (such as strengthen market/country position, growth, and geographic expansion) which are associated with market competitiveness and expansion drive acquisitions in family firms.

To conclude, the data note that the goal category strategy is the last significant pool of drivers of acquisitions undertaken by family firms. Distinctly, this goal category additionally reveals that acquisition is driven by a combination of multiple acquisition goals based on at least one goal category. **Proposition 6:** The incorporation (non-incorporation) of multiple acquisition goals from different goal categories increases (decreases) the likelihood of a family firm to engage in the acquisition of companies.

4.2.9. Acquisitions Goals – Goal Categories Finance, Stakeholder, and Resources

In addition to the goal categories previously mentioned, there are others such as finance (e.g., Firm F), stakeholder, and resources (e.g., Firm H), as named by Worek et al. (2018). However, the conducted interviews in this study give little to no insights into these categories. Due to the lacking observations in the qualitative data set, it seems that these three-goal categories, as well as the respective acquisition goals, are less momentous as a driver for acquisitions undertaken by the family firms.

What stands out is the fact that none of the interviewed family firms considers the goal category stakeholder as a fundamental driver for making acquisitions. This observation is particularly interesting since family firms regard noneconomic goals such as the relationship with both employees (Firm C; Firm E; Firm G; Firm I; Firm L) and customers (Firm J; Firm K) as highly relevant. For example, the following three quotes illustrate this insight identified in the data set:

It's essential for me to be honest with the people. [...] Personally, I have the underlying attitude that the secret of why companies are successful is the employees. Therefore, it is crucial to pick up the right employees, and I have respect for every single employee, no matter if she/he is in our management or works in our warehouse. Everyone is important. Only the employees are decisive. (Firm H)

Trust and working together with our employees are the be-all and end-all of the company. There is nothing more important than this. We are always trying to do the maximum, especially in an unbeneficial situation, for them. For example, when our employees, i.e., our family, face financial problems, we are more than happy to support with private loans in order to bridge constraints. Furthermore, we also do our best to create an attractive work environment. In particular, if someone needs time off for a specific time for any reason, we are more than willing to find a solution in order to help our employees. (Firm I)

We try to develop solutions for our customers so that they say: yes, it was a good decision to go to Firm J. We are massively dependent on this. What we are doing here can only be in the interests of our customers. Then we will all be successful. The customers have their success, and we have our success. (Firm J) To sum up, the remaining goal categories such as finance, stakeholder, resources, identified by Worek et al. (2018), appear to be less relevant in the acquisitions of the interviewed family firms. Particularly, considering the relevance of good relationships with employees and customers, the investigated firms have not precisely stated acquisition goals related to the category stakeholder.

Proposition 7: In comparison to the goal categories mentioned above, finance, stakeholder, and resources have a minor relevance as a driver of acquisitions. Hence, family firms are less likely to engage in acquisitions solely based on these threegoal categories as drivers.

4.2.10. Relation between Innovation and Acquisitions

The conducted interviews with family firms present innovation not as the determining driver but as one of the three most significant drivers for family firms to engage in acquisitions. In particular, the investigated firms regard innovation as the key to success (e.g., "In this respect, innovation serves the success of the group." Firm J) and thus part of the overall strategy (e.g., "Innovation is part of our strategic position. [...] And you can only be or remain a differentiator by innovation." Firm L). The following quote by Firm M illustrates this observation:

Without innovation, we have little or no chance to develop and grow in the market. It is undoubtedly an important topic, but innovation can be developed in very different ways. (Firm M)

In addition to this, the investigated family firms note that "[*i*]*nnovation is not an end in itself*" (Firm J) but a continuous process (e.g., "Innovation is like Oliver Kahn according to the saying: Always further!" Firm G) of creating value for the customer (e.g., "I can only survive in the market if I do something where the customer says: Yes! I think this service is good. This is what I want. – In this respect, my drive for innovation is always one that has to please the customer! I can't innovate otherwise." Firm J) by technology or non-technology innovation (e.g., "The innovation should not be limited to technology but should be placed in the context of a company's business and strategy." Firm K) in order to succeed.

Regarding the acquisition of innovation, the family firms display different perspectives of the likelihood of acquisitions for obtaining innovation in family firms. Mainly, Firm O is the only family firm in the data set, highlighting that the firm does not usually search actively to acquire innovation. Instead, it happens by opportunity, as the following quote illustrates:

For us, the acquisition is not a systematic instrument of innovation. We innovate, but we don't innovate by acquisitions, at least not systematically. When I say that acquisition is not a systematic instrument of innovation, it only means that we don't rule out something like this in our business model. It is more likely to be driven by opportunity. (Firm O) In contrast, the other family firms reveal a more consistent attitude towards innovation as a driver and note, especially, that the acquisition of innovation is an efficient and effective alternative for developing innovation internally (e.g., Firm K) in order to realize goals such as *growth* (Firm C) or *reach different market segments* (Firm J). Besides, the following quote illustrates that innovation as a driver of acquisitions is potentially not the *ultimate goal* (Firm E) for family firms:

> We try to reach different market segments, and it's easier to achieve this by purchasing a specialist [i.e., technology expertise] than to develop something from your brand. (Firm J)

Similarly, the interviewed family firms, even Firm O, indicate that the acquisition of innovation refers to other goals, as the next quotes demonstrate:

> I don't believe that innovation is the ultimate goal but rather a means to an end. However, it is a significant one since it helps you to achieve your company goals. I don't think that innovation should be seen in isolation, because it's part of the whole. It would help if you had it, and you can't do without it. (Firm E)

> The motivation to do M&A is based on the strategy to grow and expand a specific market position, and as a result of this, especially, innovation was a means to end. (Firm C)

To conclude, family firms regard innovation as a relevant component in the decision-making to undertake acquisitions. Remarkably, the acquisition of innovation appears to be a strategic and continuous process for creating value for customers and thus leads to the success of family firms. In particular, it allows an alternative approach to internal development and increases the level of innovativeness within the firms. However, innovation does not represent the ultimate goal as it leads to other goals such as expansion.

Proposition 8a: The more important innovation is for family firms, the more likely they will engage in acquisitions driven by innovation.

Proposition 8b: The importance of innovation for family firms drives acquisitions positively. As high levels of innovativeness in family firms aim to achieve other goals, the acquisition of innovation serves as a means to an end.

5. Discussion

In the present study about the M&A behavior and acquisition goals of family firms, the aim is to exhibit in detail what goals are driving family firm's acquisitions and what role innovation in acquisitions has. Based on the observed patterns in the qualitative data set, the study proposes that the basic idea of acquisitions is the family firm's interest to grow, to be precise, by inorganic growth to secure stability and profitability of the firm. Additionally, the identified

patterns suggest that the likelihood of acquisitions in family firms is positively associated with unbeneficial circumstances, in the context of ability, costs, and time, to make something, increase willingness to make acquisitions, and increase the firm's independence. Moreover, the process of detecting similarities and differences among the investigated family firms leads to the proposition that acquisitions goals associated with expansion, market competitiveness, and innovation are mainly driving the acquisitions. Subsequently, the qualitative data set portrays those acquisition goals related to finance, stakeholder, and resources as less determining for acquisitions. Lastly, the observed patterns propose that the acquisition goals, which family firms refer to, appear commonly in combination with other goals and that innovation is crucial for the firm's success, but serves as a means to an end in order to achieve fundamental goals of the firm.

5.1. Comparison of the Results with the Literature

Concordant with the literature, the interviewed family firms reveal insights into their M&A behavior and acquisitions goals and thereby display similarities and differences between the findings of the qualitative study and the literature, as illustrated in Table 3.

In general, both the qualitative study and the literature highlight that the business-owning family is highly influential on the firm's development and decision-making. Mainly, the qualitative data add that the family transfers its values and goals to the family firm and thereby significantly shapes the firm.

Regarding the M&A behavior of family firms, the interviewed family firms contradict the literature finding that family firms are generally hesitant to undertake M&A (Caprio et al., 2011; Miller et al., 2009; Requejo et al., 2018; Shim & Okamuro, 2011).

Contrarily, the qualitative data notes that family firms are generally not reluctant to engage in acquisitions (e.g., Firm J) and highlights its importance to complement organic growth. Moreover, the interviews remark that M&A is a fundamental part of the overall strategy of family firms as it contributes to the firm's stability and profitability. In correspondence with this, the literature adds that M&A promotes and maintains the growth of family firms since it represents a strategic tactic contributing to the firm's development (De Massis et al., 2015; Nieto et al., 2015).

As family firms are not generally reluctant to engage in acquisitions, the literature points out several aspects explaining the low propensity of acquisitions undertaken by family firms. Primarily, the literature refers to the firm's riskaversion and threats against the firm's survival to explain the low propensity (Amihud et al., 1990; Caprio et al., 2011; Gómez-Mejía et al., 2015; Miller et al., 2009). Consistently, the investigated family firms acknowledge the explanations mentioned above as influencing factors in the likelihood of undertaking acquisitions but note further that family firms have to answer one fundamental question of whether to make or buy something (e.g., Firm F). In this context, family firms have to incorporate the firm's current situation in terms of ability, costs, and time in addition to the firm's risk preference in the weighing between making or buying (acquiring) something (Firm K; Firm L).

In terms of the specific acquisition goals, the literature, particularly the study of Worek et al. (2018), reveals that three-goal categories are primarily driving family firms' acquisitions. As noticed in my study, expansion followed by market competitiveness and stakeholder is the decisive goal category. The findings of the conducted interviews affirm the goal category expansion (with the following acquisition goals: growth, product portfolio, and geographic expansion), followed by market competitiveness (with the following acquisition goals: exploit synergy and strengthen market/country position) as the most crucial driver of acquisitions in family firms. The third goal category stakeholder emerged in the study of Worek et al. (2018) is not regarded as critical in driving acquisitions based on the qualitative data set. Quite the contrary, the findings of the interviews show that none of the investigated family firms considers stakeholder as a crucial driver of acquisitions. Instead, the qualitative data set reveals that the third most common goal category for driving acquisitions is innovation. Despite the risks and uncertainties noted in the literature (Duran et al., 2015; Gómez-Mejía et al., 2015), even the literature recognizes innovation-driven acquisitions as a strategic option to grow (e.g., Kotlar et al., 2013, Morck & Yeung, 2003), which is consistent with the observation derived by the interviews.

Both the qualitative study and literature show that innovation is essential for the family firm' success as it enhances firm development and leads to the durability of the family firm. In contrast to the literature, which shows that the market shapes the firm's innovativeness, the qualitative study contradicts and supports Alberti and Pizzurno (2013) by highlighting technological innovation (technology expertise) as the enhancer of innovation. Moreover, both agree that the acquisition of innovation, e.g., technology expertise, contributes to the success of family firms as it provides an alternative approach to obtain innovation efficiently and effectively by complementing internal with external knowledge. In addition to this, the findings of the conducted interviews reveal that the acquisition of innovation, e.g., the goal of being innovative, is not the ultimate goal but a means to an end for achieving other goals.

5.2. Implications

5.2.1. Theoretical Implication

The current qualitative study extends the contemporary literature by complementary insights into the M&A behavior and acquisition goals of family firms as well as the role of innovation in family firms' acquisitions. Previous research in the family business field refers to insights into innovation and M&A in family firms separately and note that there is a significant difference between family firms and non-family firms. Mainly, it focuses on fields such as family firm performance (Alberti & Pizzurno, 2013), innovation process (Braga et al., 2017; Broekaert et al., 2016; Filser et al., 2016), collaborative innovation (Feranita et al., 2017), innovation behavior

Tabl	le :	3:	Com	parison	of	the	Result	ts with	ı the	Literatu	re
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Category	Literature	Comparison	Interview (New Insights)
Family Influence on the Family Firm	The business-owning family members have a significant influence on the family firm.	Agree	N.A.
Likelihood of Acquisitions	Family firms are generally hesitant to undertake M&A (Caprio et al., 2011; Miller et al., 2009; Requejo et al., 2018; Shim & Okamuro, 2011).	Disagree	Family firms are generally not reluctant to engage in acquisitions.
Likelihood of Acquisitions	M&A promotes and maintains the family firm's development (De Massis et al., 2015; Nieto et al., 2015).	Agree	N.A.
Likelihood of Acquisitions	The low propensity of acqui- sitions undertaken by family firms is mainly caused by the risk-aversion and threats to- wards the survival of family firms (Amihud et al., 1990; Caprio et al., 2011; Gómez- Mejía et al., 2015; Miller et al., 2009).	Extend	Family firms have to an- swer one basic question of whether making or buying something.
Driver of Acquisitions	The three-goal categories mainly driving acquisitions undertaken by family firms are expansion, market com- petitiveness, and stakeholder (Worek et al., 2018).	Disagree	The goal categories expan- sion, market competitive- ness, and innovation are primarily driven acquisi- tions.
Driver of Acquisitions	Regardless of the risks and uncertainties associated with the acquisition of innovation, it remains a strategic option for family firms to grow (Kot- lar et al., 2013; Morck & Ye- ung, 2003).	Agree	N.A.
Innovation	Innovation is essential for family firms' success, as it leads to firm development and durability.	Agree	N.A.
Innovation	The market shapes the firm's innovativeness (Alberti & Piz- zurno, 2013).	Disagree	Technological innovation shapes the firm's innova-tiveness.

Source: own illustration based on conducted interviews and literature review

(Nieto et al., 2015) and M&A in family firms (Defrancq et al., 2016; Worek et al., 2018).

However, the current study focuses on the acquisition goals driving acquisitions undertaken by family firms and the role of innovation in these acquisitions. Therefore, it addresses recent calls to analyze the acquisition goals of family firms by a qualitative approach to enrich the theory (Angwin, 2007; Bower, 2001; Walter & Barney, 1990; Cartwright et al., 2012). In particular, the qualitative study reveals that the insights into the acquisition goals of family firms in the literature are insufficiently researched, to be precise, not well-enough researched in order to reflect the acquisition goals of the investigated family firms. Notably, the study displays that acquisition goal associated with the goal categories ex-



Source: own illustration

Figure 5: Limitations and Future Research.

pansion, market competitiveness, and innovation are the decisive drivers of family firms' acquisitions. Furthermore, the cross-case analysis allows an explanation of similarities and differences across the interviewed family firms instead of focusing on unconnected insights derived by each firm separately.

5.2.2. Practical Implication

In addition to the theoretical implications, the present study also generates important implications for practitioners. Given the increasing importance of M&A and innovation for family firms, these and, in particular, the business-owning family members should be aware of the meaning of acquiring other firms for growth purposes. Based on the present study, it appears that the acquisition, namely, the acquisition of innovation, is a means to end for achieving other primary goals and involves several acquisition goals. In order to undertake value-creating acquisitions, family firms have to reflect on the family firm's preferences and constraints. Additionally, as the conducted interviews indicate, the likelihood of acquisitions undertaken by family firms vary considerably, and arguably, it seems that the willingness to make acquisitions can change over time. Thus, the current study advises family firms to answer whether to buy (acquire) or make in the context of the firm's ability, costs, time constraints, and the firm's interests and risk aversion.

5.3. Limitations

As in any empirical research, the current cross-case study has some restrictions but offers new areas for future research. First and most critically, a limitation is found in the research design of this study, which refers to a small sample of 15 family firms. Due to this small sample size, the findings obtained by the cross-case analysis are not representative and cannot be generalized to all family firms. Second, as the investigated family firms are German firms spread all over Germany, the study cannot conclude results for specific geographic locations since differences among family firms can emerge by opposing cultures of areas and countries. Hence, the observed patterns are not significant nor representative for German family firms or any other family firm in general. Third, the interviewed family firms differ considerably in terms of revenue, industry, and employees. These differences further contribute to the limitation of generalizing the observations in the present study.

Moreover, it is possible that the qualitative data set obtained by the conducted interviews could be interpreted differently in comparison to contemporary cross-case study since this problem is common for qualitative studies (Yin, 1981). Overall, the findings derived within the current study should be seen with attention. The limitations mentioned earlier might have decisive impacts on the quality and representativeness of the findings and may lead to mistaken identification, assessment, and generalization of results.

5.4. Avenues for Future Research

Although the current study contributes to the literature of M&A and acquisitions of innovation undertaken by family firms, there still exist various research avenues that should be followed in future research to gain a comprehensive and representative understanding of family firms and their acquisition goals as well as the role of innovation in acquisitions. Since the sample size of family firms in the research design of the current qualitative study is limited in several aspects, future research should extend the sample by including a larger number or family firms with high similarities. Therefore, the current study advises scholars to consider more family firms that are more consistent in terms of revenue, industry, and employees as well as concentrated on a specific geographic location in order to identify, assess, and generalize patterns for groups of family firms characterized by the aspects mentioned above. Hence, future research can lead to representative and significant insights into the family firms' acquisition goals and the role of innovation in acquisitions. Moreover, future research should also use quantitative methods to carefully examine the testable propositions that emerged within the current qualitative study, thereby analyzing the significance of the observed patterns. Besides, this study should inspire other scholars to carry out comprehensive case studies and apply and validate the findings of the present study to extend the insights into family firms. Lastly, future research should incorporate conceptual methods to provide models assessing the family firm's M&A behavior, the acquisition goals, and the role of innovation to show the interaction of these aspects as well as implying the ideal acquisition goals for family firms. Figure 5 illustrates the connection between the limitations and future research.

6. Conclusion

By following the call from contemporary literature to analyze the acquisition goals of family firms (Angwin, 2007; Bower, 2001; Cartwright & Schoenberg, 2006; Walter & Barney, 1990), the current study, which employs a qualitative approach of interviewing 15 family firms, enriches the current literature by complementary and profound insights into the M&A behavior of family firms. The study's findings show that the business-owning family is considerably influencing the family firm by transmitting the family interests and preferences to the firm. Notably, the family firms preference for long-term survival points to the importance of growth, namely, inorganic growth. In this context, the interviewed family firms highlight that the acquisition of other firms is a valid alternative to obtain inorganic growth and thus a strategic approach to accelerate the firm's overall growth. Furthermore, the study concludes that acquisition goals related to the goal categories expansion, market competitiveness, and innovation are the primary driver for acquisitions undertaken by family firms. In particular, the goal category innovation, regardless of being in the third place of the three most common goal categories, appears to be a crucial driver of acquisitions. It refers to the acquisition of technology expertise and the complementing of internal by external knowledge. As a result of this, the acquisition of innovation displays a strategic and continuous process for creating value for customers and thus leads to the success of family firms. Lastly, the acquisition of innovation indicates that achieving innovativeness is not the final goal, but a means to accomplish other goals such as the survival of the family firm.

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A Signaling Theory Perspective on Building Supportive Responses to Organizational Change: An Experimental Study

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Abstract

Organizations are frequently unsuccessful in creating employee support for change. Research has asserted that one important reason for change resistance is employee uncertainty. Yet despite wide consensus that leadership and communication are key vehicles to influence employees' change reactions, employee uncertainty concerning the leader of the change, and how this uncertainty can be addressed have been largely disregarded. Drawing on signaling theory, I propose that leaders who signal their charisma and change commitment when announcing change can alleviate uncertainty by assuring employees about the leader's characteristics and intentions, and thereby foster supportive responses to change. Specifically, I test the main and interactive influence of leader charisma and change commitment signals in determining employees' affective and normative commitment to, and behavioral support for, organizational change. In line with the proposition that charismatic signaling is inherently values-based and needs to be morally validated by followers, I investigate its effect on follower change commitment as a function of followers' openness to change and self-transcendence values. My findings from an experimental vignette study in a sample of 284 US employees reveal that in particular leader charisma signaling, and weakly leader change commitment signaling, have positive main, but non-interactive effects on follower behavioral support for change, which do not operate indirectly through follower affective and normative change commitment. Further, I report that followers' behavioral support for change elicited by leader charisma and change commitment signaling varies as a function of followers' openness to change and self-transcendence values. Above and beyond effects concerning behavioral change support, leader charisma signaling is revealed to increase followers' expression of openness to change, conservation, and self-transcendence values when advocating organizational change. I discuss implications for theory and practice in managing employee responses to organizational change.

Keywords: Organizational change; leadership; charisma; signaling; commitment.

1. Introduction

A well-known line states: "The only thing constant within organizations is continual change." (Elving, 2005: 129). However, a staggering two thirds of change projects fail (Beer & Nohria, 2000; W. Burke & Biggart, 1997). The causes are often considered to be rooted in change implementation (Klein & Sorra, 1996; Kotter, 1995, 1996): because organizational change can only succeed through individual behavior modification, employee support for change is increasingly emphasized as critical (R. Evans, 1994; Jones, Jimmieson, & Griffiths, 2005; O'Connor, 1993; Porras & Robertson, 1992; Tetenbaum, 1998). One of the most important antecedents of support for change is change commitment (Beer, Eisenstat, & Spector, 1990; Conner & Patterson, 1982; Herscovitch & Meyer, 2002), "a mind-set that binds an individual to a course of action deemed necessary for the successful implementation of a change initiative" (Herscovitch & Meyer, 2002: 475). Yet employees are often reluctant to commit to and support change. The challenge of managing change, and thus also employee reactions to change, is one of the most fundamental and enduring roles of leaders (Ahn, Adamson, & Dornbusch, 2004). One important means of leading change and creating supportive employee responses is communication (Herold, Fedor, Caldwell, & Liu, 2008; Parish, Cadwallader, & Busch, 2008; Shum, Bove, & Auh, 2008), as "change is created, sustained, and managed in and by communication" (Ford & Ford, 1995: 560).

Research on effective change communication is grounded upon the notion of managing employee uncertainty in times of change (DiFonzo & Bordia, 1998). Uncertainty, defined as "an individual's inability to predict something accurately" (Milliken, 1987: 136), is experienced by employees as a result of anticipated challenges to the status quo, and is thus inherent in organizational change (Rousseau, 1995; Wheatley, 1992; Wrzesniewski & Dutton, 2001). Importantly, employee uncertainty fundamentally impedes supportive reactions to change (J. Allen, Jimmieson, Bordia, & Irmer, 2007; Ashford, 1988; Schweiger & Denisi, 1991). Specifically, sources of subjectively experienced employee uncertainty during change have been classified into three levels: strategic (e.g. reasons for change), structural (e.g. changes to reporting structures), and job-related (e.g. changes to job roles) (Bordia, Hobman, Jones, Gallois, & Callan, 2004; Buono & Bowditch, 1989; Jackson, Schuler, & Vredenburgh, 1987).

Existing research on management communication has mainly focused on two mechanisms to reduce employee uncertainty (Bordia et al., 2004): first, by effectively providing information about the change and its process (Lewis & Seibold, 1998; Schweiger & Denisi, 1991), and second, by allowing employees to participate in the decision-making process during change (Locke & Schweiger, 1979; K. I. Miller, Ellis, Zook, & Lyles, 1990; Sagie, Elizur, & Koslowsky, 1995). Although researchers have conducted a wide range of studies on communication during organizational change over the past decades, several critical questions thus remain inconclusively answered. One of these questions is: How can leaders foster supportive employee responses when change is announced, by addressing employee uncertainty regarding the leadership of change?

Hence, I first propose a shift of focus to early phases of change communication. When employees first learn that a change will be implemented, their uncertainty can be expected to be especially pronounced (DiFonzo & Bordia, 1998). Change announcements, as the ground-laying step to inform employees and alleviate uncertainty, have been underlined in their relevance, but have received scarce research attention so far (DiFonzo & Bordia, 1998; Gioia, Nag, & Corley, 2012; Lewis, Laster, & Kulkarni, 2013). Employee change commitment in an early phase of change implementation has been demonstrated to determine change responses in later implementation phases, rendering early change support critical (Meyer, Hecht, Gill, & Toplonytsky, 2010; Meyer, Srinivas, Lal, & Topolnytsky, 2007; Neubert & Cady, 2001; Seo et al., 2012; Shin, Seo, Shapiro, & Taylor, 2015). Hence, leaders should seek to generate supportive employee reactions to change from the very announcement of change.

Second, I suggest expanding the notion of employee uncertainty during organizational change to include attributes of the change leader. Existing research on change communication implicitly revolves around reducing employee uncertainty concerning the change itself and therefore is mainly concerned with the content or process of communicating information relating to the change (Bordia et al., 2004). However, employees also face uncertainty pertaining to the leadership of those who drive the change, specifically their change-relevant characteristics and intentions (Oreg & Berson, 2011; Stouten, Rousseau, & De Cremer, 2018).

This is reflected in employees' devoted attention to leader actions and messages, and their continuous attempt to deduce a leader's intentions, preferences and qualities therefrom (Awamleh & Gardner, 1999; Huy, Corley, & Kraatz, 2014; Jacquart & Antonakis, 2015; Shamir, House, & Arthur, 1993; D. van Knippenberg, van Knippenberg, De Cremer, & Hogg, 2004), which will only become more pronounced when organizational change elevates general employee uncertainty (DiFonzo & Bordia, 1998). In times of uncertainty and change, followers seek a determined and able leader to guide them (Bastardoz & Van Vugt, 2019; Y. Choi & Mai-Dalton, 1998; Schoel, Bluemke, Mueller, & Stahlberg, 2011; van Dierendonck, Stam, Boersma, de Windt, & Alkema, 2014). Thus, employees should react positively to indications that their leader will be effective in managing the change, and will register not only the pure informational content of a change announcement (Lewis, 2006), but also infer the leader's ability and intentions. Therefore, importantly, transmitting information not solely on the change initiative itself, but also about its leadership could be expected to be an important means to foster support for change. When organizational change is announced, leaders can use this communication vehicle to create supportive employee responses to change (Arnestad, Selart, & Lines, 2019; DiFonzo & Bordia, 1998) by signaling their appropriate characteristics and intentions. Consequently, I propose a signaling theory perspective to the study of leader communication during change. Signaling theory is insightful to understand behavior when one party holds private information that is relevant the other party (Connelly, Certo, Ireland, & Reutzel, 2011; Stiglitz, 2002). Resolving this information asymmetry is the fundamental concern of signaling theory (Spence, 2002; Stiglitz, 2002): Signals are measures taken by the party holding the private information (signaler) aimed at conveying the unobservable characteristic or intention to the receiver (Connelly et al., 2011; Spence, 1973).

To deduce which signaled leader attributes may be particularly conducive to generating employee change support, I examine existing leadership research. There are two general, largely non-intersecting approaches, which have been used to understand the influence of leaders in shaping followers' reactions to organizational change (Herold et al., 2008). The first approach, rooted in leadership literature, considers situational contingencies determining the effectiveness of certain leadership styles.

Charismatic or transformational leadership¹ has been posited to be especially effective in situations of change

¹Transformational leadership is defined more broadly and incorporates influence based on an individualized developmental and empowering leadership focus, as well as intellectually stimulating influence, whereas charismatic leadership is centered around symbolic influence (Antonakis, Fenley, & Liechti, 2011).

(Bass & Avolio, 1990; House & Aditya, 1997; Shamir & Howell, 1999; Waldman, Ramirez, House, & Puranam, 2001), and has received significant research attention in the past decades. Numerous studies have demonstrated the positive influence charismatic or transformational leaders exert on follower change responses (e.g. Michaelis, Stegmaier, & Sonntag, 2010; Nohe, Michaelis, Menges, Zhang, & Sonntag, 2013; Oreg & Berson, 2011; Seo et al., 2012; Shin et al., 2015). Therefore, signaled leader charisma may constitute a particularly effective signal of leader attributes in times of organizational change.

The second approach to the role of leaders in generating change support, rooted in organizational change and practitioner literature, identifies and recommends change-specific behaviors leaders should engage in depending on the particular phase of organizational change (e.g. Beer, 1980; Brockner et al., 1994; Kanter, Stein, & Jick, 1992; Kotter, 1996; Lewin, 1947; Schweiger & Denisi, 1991). Thus, these change leadership recommendations refer to the specific change at hand and how the leader can handle it from a tactical point of view (House & Aditya, 1997), e.g. by creating a sense of urgency, providing support, building coalitions, showing commitment, and allowing for employee inputs (Herold et al., 2008; Stouten et al., 2018). For the first phase of organizational change, its introduction by the organization's management (Lewin, 1947), the importance of employees' perception that the leaders are committed to the upcoming change is frequently mentioned in passing, and remains uncontested (e.g. A. A. Armenakis, Bernerth, Pitts, & Walker, 2007; Ford & Ford, 1995; Holt, Armenakis, Feild, & Harris, 2007; Kanter et al., 1992; Kotter, 1995), although perceptions of leader change commitment have not previously been the subject of systematic and theoretically integrated research. Therefore, signaled leader change commitment may prove a specifically effective signal of leader attributes in times of organizational change.

Furthermore, recent evidence suggests that the perception of signals may be a function of personal characteristics (Connelly et al., 2011). Since the inception of social sciences, personal values have been essential in explaining social and personal organization and change (Durkheim, 1912; Schwartz, 2012; Weber, 1905). Values can be defined as cognitive representations of motivational goals, and serve as lifeguiding principles (Schwartz, 1992).

In recent decades, scholars have begun to explore how personal values may impact individual psychological reactions to organizational change (e.g. Blankenship & Wegener, 2008; Ledford, Mohrman, Mohrman, & Lawler, 1989; Neves & Caetano, 2009), but our understanding still remains limited (Groves, 2020). Leader charisma signaling inherently transmits values, and thus requires follower validation of those values to unfold its positive effect on followers (Antonakis, Bastardoz, Jacquart, & Shamir, 2016; Keyes, 2002; Tucker, 1968). Therefore, in this study, I also assess whether the effect of leader charisma signaling on follower change commitment is moderated by followers' openness to change and self-transcendence values (Schwartz, 1992), two value dimensions that can be expected to be conveyed in the charisma signal (Antonakis et al., 2016; Bass, 1985; D. van Knippenberg et al., 2004; Yukl, 1999). Charisma signaling should be more effective in creating supportive responses to change in followers who place importance on these values (Antonakis et al., 2011; Cable & Edwards, 2004; Meglino & Ravlin, 1998).

The purpose of this thesis hence is twofold. First, I use a signaling theory perspective, drawing from both leadership and organizational change literature, to examine how leaders can effectively foster supportive follower change responses when announcing organizational change. In this regard, I suggest that leaders can foster follower affective and normative commitment to change by signaling charisma and change commitment. I also expect a positive interactive effect of both signals in increasing follower affective and normative change commitment. In turn, increased follower commitment to change should translate into stronger intended and expressed behavioral support for change. Second, I explore the role of followers' personal values in the signaling process. Specifically, I examine whether the effect of leader charisma signaling on follower change commitment is moderated followers' openness to change and self-transcendence values. I address these questions conceptually and empirically in an experimental vignette study involving different change announcements in which signaled leader charisma and change commitment are manipulated. In addition to answering a survey, participants are asked to write a change-supportive message.

I report three main sets of findings. First, I do not find significant main or interaction effects of leader charisma and change commitment signaling on follower affective and normative change commitment. However, affective and normative change commitment significantly predict intended, and partly predict expressed behavioral support for change.

Furthermore, I find significant positive direct effects of signaled leader charisma on followers' expressed behavioral support for change, as captured by both quantitative and qualitative effort in producing change-supportive messages. Also, I report a weakly significant positive direct effect of signaled change commitment on qualitative change support effort. Second, followers' self-transcendence and openness to change values are found to moderate expressed and intended behavioral support ensuing from received leader charisma and change commitment signals. Third, my results reveal that leader charisma signaling induces followers to express more openness to change, conservation, and self-transcendence values when explaining why the change initiative should be supported.

The main contributions of this research are threefold. First, by showing that reducing employee uncertainty relating to change leadership by signaling leader charisma and change commitment in change announcements can play an important role in creating employee change support, this research adds to the literature investigating how change communication can create employee change support – a perspective that has predominantly focused on the

content and process of disseminating information concerning the change itself during its implementation (e.g. Bordia et al., 2004; Buono & Bowditch, 1989; Jackson et al., 1987), largely disregarding leadership-related employee uncertainty. It also adds to the literature that has adopted a signaling perspective in exploring the impact of leadership behaviors on followers – a perspective that has only recently emerged and has not been applied in a change context so far (e.g. Amabile, Schatzel, Moneta, & Kramer, 2004; Detert & Burris, 2007; Karakowsky, Podolsky, & Elangovan, 2019; A. Towler, Watson, & Surface, 2014). Second, by demonstrating that followers' personal values play a crucial role in interpreting and validating leader signals of charisma and change commitment, this research advances our underdeveloped understanding of how follower values in general (e.g. Sverdlik & Oreg, 2009, 2015) and specifically value congruence between leader and followers (Antonakis et al., 2016; Burns, 1978; Conger, 1999; Weber, 1947) can shape follower reactions to change and leadership thereof - a perspective in need of corroborating empirical evidence. Third, by revealing that followers express the openness to change, conservation, and self-transcendence values transmitted by the charisma signal when advocating change, my findings help illuminate the phenomenon of the adoption of values displayed by charismatic leaders - a theoretical assertion (Bass, 1985; Shamir et al., 1993; D. van Knippenberg et al., 2004; Yukl, 1999) with so far very limited empirical examination (Groves, 2020; Hannah, Schaubroeck, & Peng, 2016; Hoffman, Bynum, Piccolo, & Sutton, 2011).

I have organized this thesis as follows. First, in section two, I review prior research on signaling theory, charismatic leadership, leader change commitment, and personal values, based on which I develop my hypotheses. Section three discusses the methodology I apply for this study, while section four presents the empirical results. Section five discusses the obtained results, as well as implications for future research and practice. Section six concludes this thesis.

2. Theoretical Background and Hypotheses

2.1. Signaling Theory

Every decision is influenced by available information (Stiglitz, 2002). Signaling theory revolves around reducing information asymmetry, which typically pertains to one party's characteristics (quality or ability) or intents (behavior or behavioral intentions) that are unobservable but relevant for the decision-making of the other party (Bird & Smith, 2005; Elitzur & Gavious, 2003; Spence, 2002; Stiglitz, 2000; Zahavi, 1975). Typically, the sender (signaler) will choose whether and how to convey the information (signal) about characteristics or intents that the recipient (receiver) lacks, who will then choose how to interpret the signal and will react accordingly (Connelly et al., 2011). Simply stated, "signals are things one does that are visible and that are in part designed to communicate" (Spence, 2002: 434). Signaling theory's central tenets can be traced back to Spence (1973) and Ross (1977) work, who are widely credited for laying the foundation for the wider application of signaling theory (Connelly et al., 2011). Spence (1973), for a classic example, illustrated a selection problem employers face: their uncertainty concerning the quality, i.e. individual ability, of potential employees complicates their recruitment efforts. High-quality job applicants can differentiate themselves from low-quality job applicants by pursuing a rigorous higher education, which low-quality candidates are assumed to be unfit for. By engaging in this costly signaling, high-quality prospects can convey their characteristic to potential employers and thereby increase their chances to be hired (Connelly et al., 2011; Spence, 1973).

The main focus of signaling theory is, hence, how the party holding the private information (sender) can act in order to credibly signal its positive but unobservable characteristics or intents to the receiver (Certo, 2003; Connelly et al., 2011; Filatotchev & Bishop, 2002). For signals to be credible, i.e. reliable, there must thus be a guarantee that the communicated information honestly reflects the unobservable attribute of interest (Bird & Smith, 2005; Davila, Foster, & Gupta, 2003; Van Schaik, 2016). Credible signals thus share two main characteristics: observability and cost. First, as a necessary but not sufficient condition, the signal must be observable by the receiver, i.e. the receiver must be able to notice the signal (Ross, 1977; Spence, 1973). Second, signaling theory's central tenet requires the signal to be costly to produce (Bird & Smith, 2005; Connelly et al., 2011; Ndofor & Levitas, 2004): For signals to be credible, the cost of producing them must be sufficiently high so that dishonest signals do not pay, so that the specific signal is only produced by individuals truly having the signaled characteristic or intent (Bird & Smith, 2005; Connelly et al., 2011; Gintis, Smith, & Bowles, 2001; Grafen, 1990). In other words, the marginal cost, or difficulty so to speak, of signaling must be negatively correlated with the signaler's characteristic or intent of interest (Bird & Smith, 2005).

2.2. Leader Signaling and Employee Commitment to Change

The disappointing outcomes of many organizational change implementations (Attaran, 2004; Marks, 2006; Paper & Chang, 2005) are indicative of the fact that organizations frequently fail to achieve the required levels of employee commitment to change. Herscovitch and Meyer (2002) define commitment to change as "a force (mind-set) that binds an individual to a course of action deemed necessary for the successful implementation of a change initiative" (Herscovitch & Meyer, 2002: 475). Change commitment goes beyond a positive attitude toward change to include a proactive behavioral intention to work toward a change on behalf of its successful implementation (Fedor, Caldwell, & Herold, 2006; Kotter & Schlesinger, 1979; Piderit, 2000). As such, commitment to change constitutes an individual's willingness and desire to support a change (Herscovitch & Meyer, 2002) and a psychological attachment to change (Bouckenooghe, 2012). For this study, I investigate two distinct dimensions of the commitment to change construct: affective and normative commitment to change.

Both dimensions have been consistently found to predict active discretionary behavioral support for change that goes beyond mere compliance (Bouckenooghe, Schwarz, & Minbashian, 2015; Herscovitch & Meyer, 2002; Meyer et al., 2007; Parish et al., 2008).² Importantly, these two dimensions of change commitment develop through separate psychological mechanisms (N. J. Allen & Meyer, 1990; Herscovitch & Meyer, 2002). On the one hand, affective commitment to change is rooted in a desire to provide support for the change based on a belief in and anticipation of its inherent benefits, and is likely to be developed when employees see value in the change and understand its advantages. Normative commitment to change, on the other hand, derives from a sense of obligation to provide support for the change that results from a sense of needing to reciprocate positive treatment and / or a sense of moral duty (Meyer & Allen, 1997; Meyer & Parfyonova, 2009). Hence, affective commitment reflects a positive emotional attachment and willingness to support a change because of perceived benefits of the change for the organization and its members, whereas normative commitment originates from a belief that it is loyal and / or morally right to support the change (Bouckenooghe et al., 2015).

Note that for this study, I will not distinguish between the terms leader and manager, since these terms are often used interchangeably in literature (Yukl & Van Fleet, 1992). The same applies for the terms follower and employee. Further, for this experimental study, I will examine the role of the chief executive officer (CEO) as the leader in question. A focus on top management is important because organizational change is typically initiated and introduced by the CEO and his or her management team (Kotter, 1995; Nadler & Tushman, 1995). The CEO is a central source of information regarding the change (A. A. Armenakis & Bedeian, 1999; A. A. Armenakis & Harris, 2002; Barrett, 2002) and plays a crucial role as he or she is ultimately responsible for any change initiative (Gilley, McMillan, & Gilley, 2009).

Also, researchers have tended to examine charisma as somewhat more appealing at higher organizational positions (Agle, Nagarajan, Sonnenfeld, & Srinivasan, 2006; House, Spangler, & Woycke, 1990; Tosi, Misangyi, Fanelli, Waldman, & Yammarino, 2004) and have highlighted the importance of CEO change commitment (Kotter, 1995).³

- 2.3. Signaled Leader Charisma and Employee Responses to Change
- 2.3.1. Literature Background on Leader Charisma

The term charisma (from the Greek word for gift, " $\chi \dot{\alpha} \rho \iota \sigma \mu \alpha$ " dates back to antiquity (Antonakis & Bastardoz, 2016; Grabo, Spisak, & van Vugt, 2017; Maclachlan, 1996). Most researchers credit sociologist Max Weber for modern resurgence of interest in charismatic leadership (Antonakis, 2017; Grabo et al., 2017; Weber, 1947). Weber conceived of charismatic leaders as being "endowed with supernatural, superhuman, or at least specifically exceptional powers or qualities" (Weber, 1947: 358), emerging in times of crisis, and bringing about revolutionary change (Weber, 1968). The wave of research that followed formed the basis for more modern studies of charismatic leadership (e.g. Avolio & Bass, 1995; Bass, 1985; Conger & Kanungo, 1987, 1998; W. L. Gardner & Avolio, 1998; House & Howell, 1992; Shamir et al., 1993; Waldman & Yammarino, 1999). For the purposes of this thesis, I will refrain from reflecting on the long history of the scientific study of charisma (see Antonakis et al., 2016; D. van Knippenberg & Sitkin, 2013; Yukl, 1999 for excellent reviews and critiques). Suffice it to say that since the Weberian beginnings of charisma research, neocharismatic scholars have redefined the focus to the study of the more "tame" forms of organizational charisma (House & Shamir, 1993; Shamir, 1999; Shamir, Arthur, & House, 1994), understanding charisma, rather than a larger-thanlife supernaturally granted gift, as a trait related to charm, magnetism or likeability (Beyer, 1999; Grabo et al., 2017), which also does not require crisis to emerge (Conger & Kanungo, 1998; Etzioni, 1961; House, 1999; Jacquart & Antonakis, 2015; Shamir & Howell, 1999).

Yet scholars agree that charismatic leaders are still highly influential (Antonakis et al., 2011): Charismatic leaders are regarded by followers as strong and confident, are typically idealized, highly trusted and respected (Antonakis & House, 2002), and elicit loyal responses from followers to the leader's cause (Bass, 1985). Based on the criticism that charisma is still conceptualized as a gift or charm inaccessible to most leaders, and that charisma is typically defined tautologically by its outcomes or antecedents, a stream of neocharismatic research has sought to address these problems (Antonakis et al., 2016, 2011; MacKenzie, 2003; D. van Knippenberg & Sitkin, 2013; Yukl, 1999), and defines charisma as "values-based, symbolic, and emotionladen leader signaling" (Antonakis et al., 2016: 304). The authors lay out that a charismatic leader is one who communicates and influences followers by means of symbolic power rooted in emotional and ideological foundations, as opposed to reward, coercive, or expert power indicative of transactional or task-focused leadership (Antonakis et al., 2011; Antonakis & House, 2002; Etzioni, 1964; French & Raven, 1968). That is, the effect of charismatic leadership

²Herscovitch and Meyer (2002) proposed a third type of change commitment: continuance change commitment, which is rooted in recognition of perceived costs of failure to support the change. I exclude continuance commitment to change for this study because it was neither conceptually nor empirically related to discretionary behavioral support, which I assess as a primary outcome (Herscovitch & Meyer, 2002; Meyer et al., 2007). As Herscovitch and Meyer (2002) point out, precisely the different implications for behavior are an important reason for distinguishing among the three types of commitment.

³Still, researchers have asserted that charismatic leadership is not a phenomenon that is contingent on any specific organizational position, but a universal process of influence (Antonakis et al., 2016). Change commit-

ment as well, can be expected to be a relevant signal across management levels (Sirkin, Keenan, & Jackson, 2005).

on followers stems from "the leader (a) justifying the mission by appealing to values that distinguish right from wrong; (b) communicating in symbolic ways to make the message clear and vivid, and also symbolizing and embodying the moral unity of the collective per se; and (c) demonstrating conviction and passion for the mission via emotional displays" (Antonakis et al., 2016, 2011: 304). Charismatic leaders are suggested to use specific communication and image-buildings tactics (House, 1977). The use of these tactics, or signals of charisma, has been shown to be strongly predictive of charisma-affected leader outcomes (Antonakis et al., 2011; Awamleh & Gardner, 1999; Frese, Beimel, & Schoenborn, 2003; Howell & Frost, 1989; Jacquart & Antonakis, 2015; A. J. Towler, 2003). Specifically, charismatic leaders use charismatic leadership tactics (CLTs) to a) frame information in a way to center attention on the key issues (framing category: comprising metaphors, stories and anecdotes, rhetorical questions, contrasts, and three-part lists), b) provide substance to justify the message (substance category: displaying moral conviction, sharing the sentiments of the collective, setting high and ambitious goals, and demonstrating confidence these goals can be achieved), and c) convey the message in a lively manner (delivery category: body gestures, facial expressions, and an animated tone of voice) (Antonakis, 2017). See Appendix A for a more detailed description of all CLTs and their effects. Therefore, CLTs can be used to signal charisma as a leader. The concept of CLTs renders the notion of charisma less elusive and allows for more objective measurement of leader charisma that is independent of rater inferences or attributions (Antonakis, 2017).

Importantly, whether the charismatic effect, i.e. the emotional connection between leader and followers, actually occurs then depends on followers' judgment and acceptance of the values the leader' message reflects (Antonakis et al., 2016; Keyes, 2002; Tucker, 1968). Charisma thus needs to be validated by followers' perceptions (Antonakis et al., 2011). If leaders achieve the charismatic effect and succeed in creating an emotional connection with their followers, they will more potently communicate their vision and goals, motivate followers, and thus become more effective leaders (Antonakis, Fenley, & Liechti, 2012; DeGroot, Kiker, & Cross, 2009; House, 1996; House & Shamir, 1993; Shamir et al., 1993).

2.3.2. Signaled Leader Charisma and Affective and Normative Employee Change Commitment

As I have laid out, charisma can be signaled to followers by appropriate use of CLTs. As both cognitive and affective processes are crucial to understanding the charismatic effect on followers (Bass, 1988; House, Woycke, & Fodor, 1988; Pescosolido, 2002), in the following, I illustrate two mechanisms, the first more cognitive, the second affective in nature, via which signaled leader charisma can be expected to influence follower affective and normative change commitment.

Signaled Leader Charisma as a Signal for Leader Ability and Intent

Perceived leadership competence is arguably important in change implementation (Babalola, Stouten, & Euwema, 2016; Battilana, Gilmartin, Sengul, Pache, & Alexander, 2010; Oreg, Vakola, & Armenakis, 2011). Although a charisma signal itself carries no certainty about the leader's ability or moral righteousness (Antonakis et al., 2016; Howell, 1988), the signal will likely still be used to infer these attributes of the leader (Antonakis et al., 2016; Jacquart & Antonakis, 2015). A new stream of research has recently provided an evolutionary psychology perspective on charismatic leadership, proposing that charisma evolved as a signal of a person's leadership ability and intent as an adaptive response to selective pressures arising from various situations of coordination challenges (Bastardoz, n.d.; Grabo et al., 2017; King, Johnson, & Van Vugt, 2009; Van Vugt & Ahuja, 2011; Van Vugt, Hogan, & Kaiser, 2008).

Grabo et al. (2017) suggest that followers are susceptible to charisma signals particularly when faced with novel challenges, as is the case during organizational change. There are two mechanisms through which charisma signals effective leadership (Bastardoz, n.d., forthcoming; Grabo et al., 2017; Van Vugt, 2006).

First, charismatic leaders demonstrate rhetorical and symbolic thinking prowess by using framing CLTs (Antonakis et al., 2016; Grabo et al., 2017). Rhetorical skills are most likely interpreted by followers as a signal of intelligence, since the ability to craft memorable contrasts (e.g. John F. Kennedy's famous "Ask not what your country can do for you-ask what you can do for your country") and creative metaphors are visible representations of a leader's intelligence (Bastardoz, n.d. forthcoming; Silvia & Beaty, 2012). As Aristotle put it: "But the greatest thing by far is to have a command of metaphor [...], it is the mark of genius" (Aristotle & Butcher, 2008: 44). A positive relation between leader intelligence and charisma was also found in a current meta-analysis (Banks, Engemann, Williams, Gooty, & McCauley, 2017). Thus, we can assume that charismatic leaders' rhetoric is a credible signal of leadership ability, since it can be learned at a lesser cost by more able leaders, as learning costs depend directly on largely heritable endowments of intelligence (Antonakis et al., 2016; Bouchard & Loehlin, 2001; Bouchard & McGue, 2003).

Second, charismatic leaders reify their vision by reinforcing norms and moral as they relate to the situation, and by invoking shared values and emotions with their message (Bulbulia & Frean, 2010; Grabo et al., 2017). Substance CLTs reflect the essence of the leader's vision and mirror his or her intention to act on specific values and group emotions, which will affect how much effort followers will consequently exert in the task (Bastardoz, n.d., forthcoming). Communicating values is costly in the sense that leaders risk alienating potential supporters who do not share these values (Grabo et al., 2017). Further, especially in environments with repeated interaction, signals of intent are costly for leaders, since they risk losing their credibility if they fail to act on what they indicated (Bastardoz, n.d., forthcoming). Therefore, the portrayal of shared values, moral and emotions serves as a credible signal of leadership intentions.

I propose that follower perceptions of leader ability and intentions to lead based on group values and emotions will consequently build trust⁴ in the leader.

There are three critical antecedents of trust, which each add a unique perceptual perspective: another's ability, benevolence, and integrity (R. C. Mayer et al., 1995). First, as discussed above, charisma conveys leadership ability. Hence, by definition, perceptions of leader ability induced by a charisma signal should lead to increased follower trust toward the leader. Second, benevolence is "the perception of a positive orientation of the trustee toward the trustor" (R. C. Mayer et al., 1995: 719). Thus, followers' perceptions of their leader's trustworthiness is also grounded upon their level of confidence in the leader's intentions and motives toward them (Bartram & Casimir, 2007). The leader charisma signal demonstrates an intention to lead based on group emotions and values. This should instill trust in the leader's motives toward his or her followers regarding the planned change, as the leader conveys concern for and empathic understanding of follower needs and emotions, for instance by expressing the sentiments of the collective (Bass & Avolio, 1990; J. Choi, 2006; Conger, Kanungo, & Menon, 2000; Jung & Avolio, 2000; Kirkpatrick & Locke, 1991; Pillai, Williams, Lowe, & Jung, 2003; Salovey & Mayer, 1990). Therefore, charisma signaling can be expected to also build trust in the leader based on follower perceptions of benevolence.

Trust in the leader, in turn, is an often cited critical determinant for change reactions (Bouckenooghe, 2012; Eby, Adams, Russell, & Gaby, 2009; Korsgaard, Schweiger, & Sapienza, 1995; Oreg, 2006; Oreg et al., 2011; Rousseau & Tijoriwala, 1999). Trust in the leader is suggested to result in increased follower commitment to the goals set and decisions made by the leader (Dirks & Ferrin, 2002), and therefore enhanced affective and normative commitment to change (Bouckenooghe, 2012). First, the importance of trust in leadership in terms of accepting and believing the reasons offered for change, and the formation of a favorable attitude toward change (Dirks & Ferrin, 2002; Lau & Woodman, 1995; Rousseau & Tijoriwala, 1999; Stouten et al., 2018), is well established in literature. For instance, trust in the leader was found to reduce perceived uncertainty and threat associated with change (McLain & Hackman, 1999; Stouten et al., 2018) and to contribute to followers' belief in leaders' good intentions to create organizational benefits with the change (Harvey, Kelloway, & Duncan-Leiper, 2003; Michaelis, Stegmaier, & Sonntag, 2009). Therefore, trust in leadership can be expected to increase affective commitment to change. Second, since the leader signals the intention to lead based on these shared values and emotions, and followers can be expected to trust the leader in this intent, feelings

of duty to support a change of morally valuable nature should ensue.

When leaders make these normative calls to support a change in appealing to emotions and values, employees have been found to shift their attention to group well-being and feeling obliged to pursue group interests (Colbert, Kristof-Brown, Bradley, & Barrick, 2008). Consequently, trust in leadership should also increase normative commitment to change, as is also supported by literature (Bouckenooghe, 2012).

Cumulatively, I propose that a leader charisma signal elicits follower perceptions of leader ability and intention to lead based on group values, which build trust in the leader, and thereby increase follower affective and normative change commitment.

In addition; I propose that signaled leader charisma, above and beyond its cognitive component, will inherently appeal to followers' emotions and induce positive affect. I develop this argument below.

Signaled Leader Charisma as Inducement of Positive Follower Affect

Emotions are a key determinant for employee responses to organizational change (Bartunek, 1984; Buono & Bowditch, 1989; Fugate, Kinicki, & Prussia, 2008; Seo et al., 2012), and can be categorized on two core dimensions: positive and negative affect (Watson, Clark, & Tellegen, 1988; Watson & Tellegen, 1985).⁵ Researchers have continuously advised change leaders to create high levels of positive emotions, such as employee excitement and enthusiasm (Cooperrider, 1990; Cooperrider & Srivastva, 1987; Huy, 2002; Watkins & Mohr, 2001). "Emotions are deeply intertwined with the process of leading" (Gooty, Connelly, Griffith, & Gupta, 2010: 979). This has been particularly emphasized in the realm of charismatic leadership, as is evident from the very notion of charisma as "values-based, symbolic, and emotion-laden leader signaling" (Antonakis et al., 2016: 304). Charismatic leaders' signaling positively energizes followers around a common goal because the leader's message resonates at a deeper emotional level that goes beyond just comprehension (Emrich, Brower, Feldman, & Garland, 2001). In other words, an important effect of charismatic leadership is eliciting positive follower affect (W. L. Gardner & Avolio, 1998) by transmitting positive emotion (Bono & Ilies, 2006), both in a verbal and a more abstract manner.

First, the specific rhetorical style that constitutes the charismatic signal has been shown to be emotion-inducing. Specifically, employing rich emotional language is especially conducive to transmitting emotion (Buck, Miller, & Caul, 1974). The same has been found for the use of symbolic language, since rhetoric that readily evokes images is more closely associated with emotional stimuli from our own past

⁴Trust has been defined as "the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party" (R. C. Mayer, Davis, & Schoorman, 1995: 712). Nevertheless, there is not one unanimously accepted definition.

⁵Note that I use the terms affect, feelings and emotions interchangeably in this thesis.

(Skinner, 1957), and generally elicits more intense emotional responses (Campos, 1989; D. W. Miller & Marks, 1997). Thus, signal recipients are likely to assume the affective state reflected in the signal's rhetoric.

Second, a charismatic signal induces affective experiences through the mechanism of emotion contagion⁶ (Hatfield et al., 1994). Charismatic signaling entails painting an enthusiastic and optimistic view of the future (Bass, 1985; Conger, 1989). For instance, by setting high goals and expressing confidence that they can be achieved, charismatic leaders display excitement and confidence (Antonakis et al., 2011; Barsade & Gibson, 2007). Through emotion contagion, leader expressions of positive affect, such as optimism, evoke positive affect in followers, as the leader's affect is emulated by followers (Barsade, 2002; Bono & Ilies, 2006; Erez, Misangyi, Johnson, LePine, & Halverson, 2008; Sy, Côté, & Saavedra, 2005). Consequently, a leader's charisma signal can be expected to induce positive emotions in followers.

Emotions, in turn, have been found to be crucial in individuals' appraisal of situations such as organizational change (Frijda, 1996; Huy, 2002; Lazarus, 1991). Specifically, emotion research suggests two mechanisms that illustrate how employees' affective experiences may impact commitment to change by coloring information processing. First, feelings-asinformation theory (Schwarz, 1990; Schwarz & Clore, 2003) proposes a direct infusion effect: In the case of organizational change, employees' positive feelings serve as positive information used to judge the change, for instance how desirable the change outcomes will be. That is, individuals' experienced positive affect is used as immediate information to evaluate the change more positively, thereby increasing affective change (Seo et al., 2012). Likewise, positive affect can be expected to be used as information regarding how the change is managed and how benevolently employees will be treated during the course of it (Seo et al., 2012).

As a result, positive affect should strengthen employees' perceived obligation to support the change because of a desire to reciprocate anticipated positive treatment, increasing normative change commitment (Meyer & Parfyonova, 2009).

Second and complementarily, the mood congruence recall effect (Blaney, 1986; Bower, 1981; J. D. Mayer, 1986; J. D. Mayer, Gayle, Meehan, & Haarman, 1990; Rinck, Glowalla, & Schneider, 1992), denotes the individual tendency to more easily learn and recall materials that match one's affective state in valence. When individuals experience positive affect while being informed about a change initiative, the mood congruence recall effect predicts that they will learn and later recall positively perceived materials more easily. As information recollection from memory forms the basis for evaluative judgment, these individuals can be expected to evaluate the change initiative and their treatment concerning the change more positively, since they disproportionately recall positively perceived aspects from the change communication they received. Therefore, employees experiencing more positive affect likely develop stronger affective and normative change commitment (Seo et al., 2012; Shin, Taylor, & Seo, 2012).⁷

To conclude, I propose that leader charismatic signaling will induce positive affect in followers, which will in turn foster stronger follower affective and normative commitment to change.

Cumulatively, I hypothesize the following:

Hypothesis 1a. A charismatic leadership signal results in stronger follower affective commitment to change.

Hypothesis 1b. A charismatic leadership signal results in stronger follower normative commitment to change.

I now turn to developing hypotheses regarding the relationships between leaders' signaled commitment to a change initiative and follower commitment to change.

- 2.4. Signaled Leader Change Commitment and Employee Responses to Change⁸
- 2.4.1. Literature Background on Leader Change Commitment

A great amount of attention has been dedicated to providing implementation process recommendations to change leaders (e.g. Beer, 1980; Brockner et al., 1994; Kotter, 1996; Lewin, 1947; Schweiger & Denisi, 1991), a role frequently ascribed to top managers, including CEOs (Huy et al., 2014). Yet specific employee perceptions about their CEO during organizational change have been seldomly and less systematically addressed. As I will lay out in the following, an inspection of practitioner publications on the issue of employee perceptions of the CEO during change seems to suggest a particular necessity for change success: perceived CEO change commitment. For the purpose of this study, I use the term leader change commitment in accordance with the definition of Herscovitch and Meyer (2002) to capture the abstract employee perception that a leader is committed to a change, i.e. is in favor of the change and personally backs it. Although the notion of change commitment carries a propensity and willingness to support a change (Herscovitch & Meyer, 2002), change support is not a prerequisite for commitment, but rather a likely consequence.⁹

⁶Emotion contagion denotes processes of transferring of emotions from one individual to another (Hatfield, Cacioppo, & Rapson, 1994). The contagion of emotional states can be triggered by both emotional and cognitive cues (Douglas et al., 2008; Hillebrandt & Barclay, 2017; Kelly & Barsade, 2001) and can include conscious or unconscious processing (Hess & Fischer, 2013; Kahneman, 2003).

⁷Note that both phenomena, the feelings-as-information and the mood congruence recall effects, occur primarily at the moment when positive or negative affect is felt, for instance during the relatively short period an individual experiences an affective response to a leader communication message (Barsade & Gibson, 2007). Nevertheless, the mood congruence recall effect will still impact later recollection and judgment of the change.

⁸For the following section, I will use the terms leader and CEO interchangeably.

⁹The distinction of leader change commitment and support has not been consistent in literature. Some authors have used both terms seemingly in-
Scholars and practitioners seem to agree on the importance of leader commitment to a change for it to succeed (A. A. Armenakis, Harris, & Mossholder, 1993; Caldwell, Herold, & Fedor, 2004; Coyle-Shapiro & Morrow, 2003; Hackman & Wageman, 1995; Kanter, 1999; Kanter et al., 1992; Lewis & Seibold, 1998; Quinn, 1985; Stouten et al., 2018). Practical literature has consistently shown top management's perceived commitment to a change initiative to be one of the most important empirical predictors of change program success across industries (Sirkin et al., 2005) and CEO change commitment has even been suggested to be a sine qua non for change success (Kotter, 1995). Specifically in order to foster employee commitment to change, visible backing of a change initiative by influential leaders is argued to be crucial (Sirkin et al., 2005).

In academic research as well, perceived top management commitment has been proposed to be conducive to supportive change recipient reactions (e.g. A. A. Armenakis et al., 2007; Thong et al., 1996). Scholars also include the importance of perceived management commitment to a proposed change as an antecedent of employee change attitudes, for instance in the constructs of change cynicism and readiness for change (A. Armenakis, Harris, & Feild, 1999; A. A. Armenakis et al., 1993; Holt et al., 2007).¹⁰ Moreover, leader activities demonstrating commitment to a change initiative are explicitly advised (A. Armenakis et al., 1999; A. A. Armenakis & Harris, 2002). However, the development of leader change commitment perceptions as well as the underlying mechanisms of its effect on employee commitment remain largely unexplored.

Despite its arguable importance in creating supportive responses to change, perceived CEO change commitment is not self-evident. In a 2017 global survey by McKinsey & Company, only two thirds of respondents agreed that leaders in their organization demonstrate true ownership and commitment to making the change happen (Lindsay, Smit, & Waugh, 2018). Executives may sometimes be reluctant to show commitment for initiatives, which e.g. include layoffs or other negatively perceived consequences for employees (Sirkin et al., 2005). Moreover, even when leaders are in fact committed to a change program, employee perceptions might fall behind top managers' perception of sufficiently conveying their commitment to employees (Sirkin et al., 2005). Employees will thus face uncertainty and information asymmetry concerning CEO commitment to a change program.

Therefore, I examine leader change commitment signaling, i.e. the manner in which a leader can credibly convey to followers that he or she is committed to a change initiative. Making top management level commitment visible with actual behavior is underlined to be crucial for organizational change outcomes (Kotter, 2005; Sirkin et al., 2005). In particular, behaviors such as going beyond managerial duty to realize a change project or devoting a lot of personal time have been proposed to demonstrate leader change commitment (Huy, 2002). Investing significant work time can be considered especially costly for top managers, who are involved in a variety of courses of action and thus face high opportunity costs of dedicating time to any particular project (Porter & Nohria, 2018).

Thus, such a signal of commitment can be considered credible, as only leaders who are indeed committed can be expected to be willing to incur these costs (Connelly et al., 2011; Spence, 1973). In other words, for CEOs, time is their scarcest resource, rendering time investment for change a particularly costly, hence credible, means of signaling change commitment.

I extend this line of reasoning by hypothesizing that signaled leader change commitment will increase follower affective and normative commitment to change.

2.4.2. Signaled Leader Change Commitment and Affective and Normative Employee Change Commitment

Recall that I refer to signaled leader change commitment as discretionary behavior that credibly conveys that a leader is bound to and stands behind a change initiative. As research has not yet addressed the underlying mechanisms indepth, I elucidate two processes via which signaled leader change commitment may influence follower affective and normative change commitment. Specifically, I propose that signaled leader change commitment will also signal a change program's organizational importance and the leader's change support intentions.

Signaled Leader Change Commitment as a Signal for Change Importance

In today's environment of recurring changes, which seem to have become the new reality of organizational life (Tsoukas & Chia, 2002; Weick & Quinn, 1999), employees may justifiably be generally skeptical of and attentive to the level of CEO commitment for and priority of any new change initiative (A. A. Armenakis & Harris, 2002). As a result, credibly demonstrating leader commitment to a newly proposed change should help focus employees' attention as well as bring clarity to the priority of a new change. Signaling theory has been held to provide a useful framework for considering how management conveys expectations to employees concerning courses of actions they view as important (Connelly et al., 2011; Pfeffer, 1981). Hermalin's (1998) economic perspective on leadership emphasizes the

terchangeably (e.g. Holt et al., 2007; Kotter & Schlesinger, 1979; Sirkin et al., 2005) to describe a leader's backing of a change project. Others have used the term of leader change support to comprise change management activities, such as planning, funding, or implementing activities (e.g. Coyle-Shapiro, 2002; Lok, Hung, Walsh, Wang, & Crawford, 2005; Thong, Yap, & Raman, 1996), whereas other authors have used the term for social support for employees, such as listening to concerns (e.g. Dirks & Ferrin, 2002; Iverson, 1996; Logan & Ganster, 2007; Rafferty & Griffin, 2006).

¹⁰Change cynicism is defined as "a pessimistic viewpoint about change efforts being successful because those responsible for making change are blamed for being unmotivated, incompetent, or both" (Wanous, Reichers, & Austin, 2000: 133), alluding to negative reactions as a result of leaders' perceived lack of change commitment. Readiness for change also features top managers' standing behind a change as one of five dimensions of change readiness, termed senior leadership support, i.e. "the belief that the organizational leaders were committed to the change" (Holt et al., 2007: 251).

informational aspect of leadership, and points to the leadership problem of inducing followers to expend more effort in organizational courses of action that are the most important.

Information asymmetry between the leader and followers concerning the anticipated organizational return to effort from a particular organizational initiative causes followers to observe the leader's actions for signals concerning the importance of exerting effort for a specific initiative (Hermalin, 1998). Leaders thus have to appropriately signal which actions the collective should invest in (Antonakis et al., 2016). Therefore, a costly signal of leader commitment to a change program (conveyed e.g. by investing a significant amount of personal time for it) can be indicative of the leader's, and thus organizational, priority assigned to the program, convincing followers to contribute as well (A. A. Armenakis et al., 1993; Hermalin, 1998; Potters, Sefton, & Vesterlund, 2007). Consequently, followers should perceive the change program the leader signaled to be committed to as beneficial and important to the organization.

Therefore, first, followers' affective commitment to change, i.e. their belief in the change's inherent benefits to the organization, should be increased, since an organization's initiatives can be expected to be prioritized in importance as a result of their respective expected strategic impact for organizational success (Nieto-Rodriguez, 2016).

Second, followers should feel obligated to contribute to centrally important initiatives. A significant stream of research has revolved around individuals' social identity¹¹, and specifically organizational identification in more recent decades (e.g. Albert & Whetten, 1985; Ashforth, Harrison, & Corley, 2008; Ashforth & Mael, 1989; Dutton, Dukerich, & Harquail, 1994; Pratt, Rockmann, & Kaufmann, 2006). Scholarly work on organizational identification influentially holds that individual identity emerges from organizational membership, namely the essences of roles and collectives the individual is a member of (Ashforth et al., 2008; Postmes, Baray, Haslam, Morton, & Swaab, 2006). Because employees have an inherent need for organizational identification (Glynn, 1998; Kreiner & Ashforth, 2004) and seek to feel positively about their organizational membership, they are highly likely to find sources of positive affect and pride in their organizations (Ashforth et al., 2008). As a result, employees generally tend to identify with their employer organization. Organizational identification, as the psychological bond between the organization and individual, is a key mechanism for explaining employees' work towards the strategic interest of the organization (M. R. Edwards, 2005; Riketta, 2005).

Consequently, employees expectedly feel a sense of obligation to contribute toward organizational initiatives that are deemed important and most central to the organization's interests, and therefore experience normative commitment to change (Meyer & Parfyonova, 2009).

To conclude, a leader's signaled change commitment will convey a change initiative's organizational importance and therefore likely foster follower affective and normative commitment to change.

Signaled Leader Change Commitment as a Signal of Leader Change Support

Further, I posit that signaled leader commitment will also signal the leader's intention to behaviorally support the change. Behavioral support intentions are an essential component of the definition of commitment to change (Herscovitch & Meyer, 2002) and have been convincingly found to be a consequence of change commitment in previous research (Bouckenooghe et al., 2015). Hence, if a leader credibly demonstrates that he or she stands behind the change, employees presumably will also anticipate considerable leader support for the change as a result. Following previous work (e.g. Coyle-Shapiro, 2002; Lok et al., 2005; Thong et al., 1996) and for clarity in the distinction from leader commitment, I refer to leader support for change as change-supportive involvement in change management activities, such as planning, funding, or implementing change-related activities. Since an organization's CEO holds a powerful position in allocating organizational resources, such as personnel and capital, as well as guiding strategic planning and implementation, leader support for change is arguably crucial for change success. For instance, in a 2017 global survey conducted by McKinsey, organizations reporting successful change agreed at more than double the rate that their organizations were endowed with sufficient resources and capabilities to execute the change (Lindsay et al., 2018). Indeed, practitioner publications recommend that CEOs quickly make sufficient funding available for change programs, secure resources and expertise by allocating suitable employees to implement the change initiative, as well as create other organizational conditions conducive to change success such as suitable incentive systems, stakeholder engagement and strategic planning (e.g. Bürkner, Faeste, & Hemerling, 2015; Johnston, Lefort, & Tesvic, 2017; Lindsay et al., 2018).

Further, committed CEOs can be expected to be willing to use their power and energy to overcome problems and obstacles that might occur during change implementation. An examination of academic literature also yields insights on the role of resources in organizational change. As a case in point, organizational ecological theory (Hannan & Freeman, 1977, 1984, 1989) holds that organizational change is limited by strong inertial pressures, including resource constraints and internal political constraints of vested interests. Consequently, a CEO supporting organizational change and dedicating needed resources to the change rather than other organizational courses of action should aid change efforts. Thus, the CEO's commitment to a change initiative, by determining proactive support intentions, holds large impact potential in helping change implementation succeed.

¹¹Social identity was famously defined as "that part of an individual's selfconcept which derives from his knowledge of his membership of a social group (or groups) together with the value and emotional significance attached to that membership" (Tajfel, 1978: 63).

The majority of change efforts fail to achieve their intended results (Beer & Nohria, 2000; W. Burke & Biggart, 1997). Signaled leader commitment to a proposed change, by allowing inferences about change success via anticipated leader change support, should therefore alleviate possible employee concerns and increase change commitment. Expectancy theory (Vroom, 1964) is insightful here because beliefs about the likelihood of successful change are similar to beliefs that good performance will result from personal efforts (i.e. the expectancy component in expectancy theory) (Wanous et al., 2000). As leader support, such as securing necessary resources, increases the probability of change success, the anticipated likelihood of successful change resulting from the efforts of those responsible should also be increased. When subordinates feel that the coming change is expected to succeed with a higher probability, they should be more likely to commit to achieving the goal of change (Locke & Latham, 2002). As anticipated inherent benefits of an initiated change are expected to occur at a higher probability, follower affective commitment to change (the desire to support a change based on a belief in its benefits) should be fostered.

Further, followers' normative commitment to change is also likely to be increased as a result of anticipating leader change support, as individuals learn acceptable, normative attitudes and behavior by considering others' behavior (Bandura, 1986). Leaders can, via the actions they signal to value and put emphasis on, affect follower behavior and beliefs about how others in the organization may act (Antonakis et al., 2016). By observing the leader's response to the change initiative and anticipating his or her supportive behavior, followers infer what kinds of attitudes are socially expected, and which behaviors concerning the change should be developed by organization members (Antonakis et al., 2016; Coyle-Shapiro & Morrow, 2003).

As a result of anticipating positive consequences, such as favorable social reactions by other organizational members, positive behavior toward the change will be positively reinforced (Mahoney, 1974; Manz & Sims, 1981). Hence, anticipated leader change support should induce normative commitment to change in followers, as they are likely to derive a sense of obligation to support a change from the internalization of this normative social influence (Herscovitch & Meyer, 2002; Meyer & Allen, 1991).

Consequently, I posit that signaled leader change commitment, via anticipated leader change support, will enhance followers' affective and normative commitment to change.

Cumulatively, based on previous research findings I discussed, I conclude with the following hypotheses:

Hypothesis 2a. A signal of leader commitment to the proposed change results in stronger follower affective commitment to change.

Hypothesis 2b. A signal of leader commitment to the proposed change results in stronger follower normative commitment to change.

In the previous sections I have set out which main effects

of signaled leader charisma and change commitment on follower change commitment I expect. As I will lay out in the following, I further suggest both signals will positively interact in their effect on follower affective and normative change commitment.

2.5. Interaction Effect between Leader Charisma and Change Commitment Signals

Leaders need to "walk the talk", as advised by one of the most ubiquitous business aphorisms (Taylor, 2014). In fact, this notion has also been argued for in the context of charisma signaling (Bastardoz, n.d., forthcoming). In order to reinforce their charisma signal, leaders need to stand for the values and emotions they have signaled rhetorically and act accordingly. Charismatic leadership theory contends that role modeling is a major way through which leaders encourage followers to contribute to the common goal (e.g. Bass, 1985; Conger & Kanungo, 1987; House, 1977; Shamir et al., 1993). Exemplary behaviors refer to the leader's display of a commitment to the collective values and goals, increasing followers' intrinsic valence of efforts on behalf of the common goal (Shamir et al., 1993; Shamir, Zakay, Breinin, & Popper, 1998; Yaffe & Kark, 2011). In contrast, leaders who pledge something, such as the benefits of a change and call for supporting it, and then do not act accordingly, risk losing their followers' trust and willingness to exert effort, and thus their legitimacy as a leader (Bastardoz, n.d., forthcoming; De Cremer, 2003; Dineen, Lewicki, & Tomlinson, 2006; Simons, Tomlinson, & Leroy, 2011). As the author of a threeyear field study in a large technology company concludes, "the perceived gap between the CEO's rhetoric and his actions generated much negative emotion and mistrust that ultimately led to the failure of this cultural [change] initiative" (Huy, 2011: 1399).

Drawing from behavioral integrity¹² theory (Simons, 2002), I therefore argue that perceived consistency between a leader's charisma signal, entailing an emotional and values-based argumentation in favor of a change, and a commitment signal, entailing a costly demonstration of change commitment, will be especially successful in creating follower affective and normative change commitment. An alignment between both signals will likely be perceived as coherence between rhetoric (i.e. espoused values) and actions (i.e. enacted values), and therefore as a display of behavioral integrity. According to R. C. Mayer et al. (1995), trust is determined by three critical antecedents: perceptions of another's ability, benevolence, and integrity. As I have posited previously, a signal of charisma itself engenders perceptions of leader ability and benevolence, instilling trust in the leader. Moreover, I propose that by aligning the charisma signal with enacting the communicated intention,

¹²Behavioral integrity refers to "the perceived pattern of alignment between an actor's words and deeds" (Simons, 2002: 19). The ascription of behavioral integrity bears no judgment on the morality of espoused and enacted principles, however.

values, and goals (by also signaling commitment to the proposed change), ascriptions of leader integrity, as the third antecedent, should further strengthen trust in the leader (R. C. Mayer et al., 1995).

In turn, increased trust will instill confidence in the merits of the leader's messages and goals, instigate perceptions of a positive social exchange between leader and followers, fostering follower willingness to reciprocate, and hence induce more follower affective and normative commitment to the collective goal (Braun, Peus, Weisweiler, & Frey, 2013; C. S. Burke, Sims, Lazzara, & Salas, 2007; Simons, 2002; Simons, Leroy, Collewaert, & Masschelein, 2015).

This leads me to the following strengthening moderation (R. G. Gardner, Harris, Li, Kirkman, & Mathieu, 2017) hypotheses:

Hypothesis 3a. The leader commitment signal moderates the positive relationship between the leader charisma signal and follower affective commitment to change such that the relationship becomes stronger when the leader commitment signal is also received.

Hypothesis 3b. The leader commitment signal moderates the positive relationship between the leader charisma signal and follower normative commitment to change such that the relationship becomes stronger when the leader commitment signal is also received.

2.6. The Moderating Role of Followers' Personal Values

How are signals perceived? The answer may be: it depends on the individual. Receiver interpretation - the process of translating a signal into perceived meaning (Connelly et al., 2011) - may differ according to receivers' personal characteristics (Perkins & Hendry, 2005; Srivastava, 2001). Signaling scholars thus have recently begun to include the receiver's perspective (e.g. Suazo, Martínez, & Sandoval, 2009; Turban & Greening, 1996). For instance, signals may be assigned different strengths or even different meanings, based on personal values, priorities, and principles (Branzei, Ursacki-Bryant, Vertinsky, & Zhang, 2004; Ehrhart & Ziegert, 2005; Highhouse, Thornbury, & Little, 2007). In reflecting on the charismatic leadership literature, Yukl (2002) specifically calls for scholars to investigate the role of values in the charismatic leadership process. A recent McKinsey survey, concluding that two thirds of change initiatives fail due, in part, to the quality of leadership and nature of congruence between leader and employee values during organizational changes (McKinsey & Company, 2008), also underlines the importance of followers accepting leaders' values during change.

Personal values can be defined as cognitive representations of motivational goals, which serve as guiding principles in people's lives (Schwartz, 1992). As such, values transcend contexts and time (Rokeach, 1973; Schwartz & Bilsky, 1987). Research has shown that values influence the most basic ways in which individuals perceive their environment (Fischer & Smith, 2004; Schwartz, Sagiv, & Boehnke, 2000), in turn affecting how individuals interpret events and correspondingly form attitudes (Bardi & Schwartz, 2003; Meglino & Ravlin, 1998; Oreg & Berson, 2011). Each individual holds numerous values, to which varying levels of importance are attached (Rokeach, 1973). The Schwartz theory of basic values (Schwartz, 1992) defines ten broad values which can be arrayed in a two-dimensional circular space. The two dimensions are based on two fundamental conflicts (Rohan, 2000; Schwartz, 1992). Openness to change versus conservation constitutes the first dimension, reflecting the conflict between the motivation to follow one's intellectual and emotional interests in uncertain directions, emphasizing the search for stimulation, novelty and change (high openness) versus the motivation to preserve the status-quo and the certainty resulting from conformity to norms (low openness). The second dimension is termed self-transcendence versus self-enhancement. It juxtaposes values in terms of the conflict between the motivation to promote the welfare of others and collective interests (high self-transcendence) versus the motivation to enhance personal outcomes and interests (low self-transcendence).

Charismatic leadership as "values-based, symbolic, and emotion-laden leader signaling" (Antonakis et al., 2016: 304) is inextricably linked to the concept of personal values. The effect of charismatic leadership is prominently based on appealing to followers' values and creating an emotional bond between leader and followers (Antonakis et al., 2016; Antonakis & House, 2002; Etzioni, 1964; French & Raven, 1968; Shamir et al., 1993). Importantly, the effect of charismatic signaling on followers only occurs if followers accept the values conveyed by the leader's message and perceive them to be congruent to their own personal values (Antonakis et al., 2016; Keyes, 2002; Shamir et al., 1993; Tucker, 1968). Consequently, a charismatic leader signal should be more effective if followers share the values transmitted in the signal. I further propose that a charismatic signal will convey a leader's own and appeal to followers' self-transcendence and openness to change values.

First, inducing followers to transcend their self-interests for the benefit of the organization has been referred to as "the essence of charismatic leadership" (D. van Knippenberg et al., 2004: 830). Charismatic leaders influence followers to make self-sacrifices and inspire them to transcend self-interests and lower-level motivational needs in favor of a collective valueladen vision centered around organizational interests during times of change (Bass, 1985; Burns, 1978; House, 1977; Yukl, 1999). Hence, charismatic leaders signal their own self-transcendence values and also appeal to followers' selftranscendence values. Individuals who place importance on self-transcendence values grounded on collective-oriented values likely perceive organizational change as an opportunity to transcend self-interests in favor of collective interests (Groves, 2020). In contrast, self-enhancement oriented individuals may be primarily concerned with loss of power and / or valued possession due to the change (Piderit, 2000; Tushman, Newman, & Romanelli, 1986), leading to less inclination to sacrifice their personal interests in favor of collective interests. Therefore, a charismatic leader's message emphasizing collective efforts toward a common goal should especially resonate with followers who share and relate to these self-transcendence values (Meyer & Parfyonova, 2009), rendering the leader's charismatic signal particularly effective for these followers.

As a result, I set forth in the following strengthening moderation (R. G. Gardner et al., 2017) hypotheses:

Hypothesis 4a. Follower self-transcendence moderates the positive relationship between a charismatic leadership signal and follower affective commitment to change such that the relationship becomes stronger as follower selftranscendence increases.

Hypothesis 4b. Follower self-transcendence moderates the positive relationship between a charismatic leadership signal and follower normative commitment to change such that the relationship becomes stronger as follower selftranscendence increases.

Second, a charismatic leader signal entails stimulating and inspiring followers by offering a compelling vision of future changes in the organization (Bass, 1985). Charismatic leaders craft an emotional and values-laden vision of how the status quo should be changed (Antonakis et al., 2016; Sosik, 2005). In other words, charismatic leaders espouse a need for change and articulate it in a vision of a better future for followers, framing the change as an opportunity for renewal and growth rather than a threat. A charismatic leader signal thus likely is perceived to reflect the leader's openness to change values (Schwartz, 1992; Sosik, 2005). In turn, followers who place importance on openness to change values can be expected to be more attracted to the leader's charismatic message. Individuals with high openness to change values generally tend to view changes as opportunities for growth, renewal, and stimulation, and thus are likely to be readily engaged by the leader's message (Groves, 2020). In contrast, employees with high conservation values may be less likely to accept even the possibility that a change will benefit the organization or themselves (Groves, 2020). Hence, followers with high rather than low openness to change values should respond more positively to the leader's charisma signal, and thus should develop stronger affective and normative commitment to change, as the charisma signal expectedly takes stronger effect, as depicted in the following strengthening moderation (R. G. Gardner et al., 2017) hypotheses:

Hypothesis 5a. Follower openness to change moderates the positive relationship between a charismatic leadership signal and follower affective commitment to change such that the relationship becomes stronger as follower openness to change increases.

Hypothesis 5b. Follower openness to change moderates the positive relationship between a

charismatic leadership signal and follower normative commitment to change such that the relationship becomes stronger as follower openness to change increases.

2.7. Change Commitment and Behavioral Support for Change

Employee behavioral support for change denotes employees' discretionary behavioral demonstration of support for a change by exerting extra effort and going above what is formally required to ensure the success of the change (Herscovitch & Meyer, 2002; Meyer et al., 2007). Prior research emphasizes that employees' behavioral support is important for the successful implementation of change initiatives (Heifetz & Laurie, 2001; Herscovitch & Meyer, 2002; Kotter & Cohen, 2002). Conceptually, employees who believe in the inherent benefits of the change and want to contribute to its success (strong affective commitment) or who feel a sense of obligation to support the change (strong normative commitment) should be willing to go beyond what is required of them and personally exert effort in order to benefit the change, even if it involves some personal cost (e.g. working extra hours) (Meyer et al., 2007). Consistently, there is ample research evidence that affective and normative commitment to change are significant precursors of behavioral support for change as found by a recent meta-analysis (Bouckenooghe et al., 2015). Therefore, I seek to replicate the established relationship between affective and normative commitment and behavioral change support intentions.

Beyond replicating this finding, my study extends previous knowledge by examining the effect with a behavioral measure. Research has pointed out that almost all measures of the change support construct focus on the intention to support the change, i.e. the subjective probability of engaging in discretionary behavior, rather than capturing actual behavior when confronted with change (Cinite & Duxbury, 2018).

Yet researchers have named their reliance on self-report measures for change support a limitation, and have called for more objective measures of actual behavioral support in future studies (Antonakis et al., 2016; M. Choi, 2011; Herscovitch & Meyer, 2002; Meyer et al., 2007). Moreover, a behavioral measure of commitment offers the general advantage of complementing self-report measures of behavior and mitigating associated problems such as self-serving bias or common method variance (Herscovitch & Meyer, 2002; Meyer et al., 2007).

Therefore, I posit:

Hypothesis 6a. Follower affective commitment is positively associated with intended behavioral support for change.

Hypothesis 6b. Follower normative commitment is positively associated with intended behavioral support for change.

Hypothesis 6c. Follower affective commitment is positively associated with expressed behavioral support for change.

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Hypothesis 6d. Follower normative commitment is positively associated with expressed behavioral support for change.

Taken together, the predictions I have proposed can be translated into the model depicted in Figure 1.

3. Method

3.1. Study Design and Procedure

To test my hypotheses, I used an experimental vignette methodology (Devos, Buelens, & Bouckenooghe, 2007; Lau & Woodman, 1995; Schultz, Utz, & Göritz, 2011; Thomas, Clark, & Gioia, 1993) in which participants were informed about an organizational change. In recent years, there have been increasing calls to implement research designs that secure internal validity and improve our knowledge about causal relationships in management research, specifically in change and leadership research (Aguinis & Bradley, 2014; D. G. Allen, Hancock, Vardaman, & Mckee, 2014; Antonakis et al., 2016; Casper, Eby, Bordeaux, Lockwood, & Lambert, 2007; Devos et al., 2007; N. P. Podsakoff, Podsakoff, MacKenzie, Maynes, & Spoelma, 2014; Scandura & Williams, 2000). The experimental vignette methodology permits experimental control over the independent variables, which are manipulated in carefully designed and realistic scenarios to examine dependent variables such as intentions, attitudes and behaviors (Aguinis & Bradley, 2014). As such, experimental vignette studies enable isolating causal effects between study variables (internal validity), while also enhancing experimental realism (external validity) (Atzmüller & Steiner, 2010; Hox, Kreft, & Hermkens, 1991).

The present study followed a 2 (high vs. low signaled CEO charisma) x 2 (high vs. low signaled CEO change commitment) between-subject independent factorial design, resulting in four change announcement vignettes, which were specifically designed for high experimental realism (Morales, Amir, & Lee, 2017). Participants learned that the study involved an organizational communication scenario and that the experimenter was interested in the reactions of participants concerning the scenario. Participants were guaranteed anonymity and indicated informed consent electronically. Before the main part of the study, participants' personal values were measured. Thereafter, each participant received the same short description of a setting involving the fictitious US technological company HT-Corp., which was loosely based on previous research (Helpap, 2016). See Appendix B for the general setting and full vignettes. Participants were asked to assume the position of an employee in the fictitious firm and to imagine experiencing the situation described.

Depending on the condition they were randomly assigned to, participants then read one of four change announcement e-mails ostensibly written by the firm's CEO to all employees, which is a typical first contact point of employees with a new change program and generally common organizational communication channel (Beatty, 2015; McKinsey Global Institute, 2016; Men, 2014), aiding experimental realism. I took additional measures to further increase realism by visually designing the e-mail as realistically as possible, including an e-mail header and author signature featuring a fictitious HT logo. The e-mail first introduced HT's recent situation. Participants learned that the market has been changing and experiencing new technological developments, and that HT should therefore adapt. As a result, a new change initiative called "Boost HT" would be implemented in the firm. The subject of the change initiative was digital transformation. I selected this change situation because of the ubiquity of change prompted by technological advancements, its continuing cross-industry relevance, and its broad potential to increase profitability (Bughin, LaBerge, & Mellbye, 2018; By, 2005; Stouten et al., 2018). As such, pursuing a digital strategy should be relevant to the majority of companies, contributing to experimental realism. The CEO in the e-mail then went on to describe the goals and main measures of the new change program. The exact implementation from the scenario was based on recommendations described in recent McKinsey & Company publications on digital transformation (Bollard, Larrea, Singla, & Sood, 2018; Bughin et al., 2018; Dias, Hamilton, Khanna, Paquette, & Sood, 2018; Goran, LaBerge, & Srinivasan, 2018; Hancock, Lazaroff-Puck, & Rutherford, 2020). Concrete "Boost HT" measures would comprise a business unit reorganization, a new digital business unit, process redesigns, and a corporate digital education program. In order to mitigate potential participant apprehension and highly negative emotional reactions, I refrained from incorporating employee lay-offs in the scenario for more generalizable results. After the change program description, the leader change commitment signal was introduced. The CEO announced a kick-off event that was organized to explain the change program in more detail to the employees. Conducting such events, often called "town hall" meetings, in which top managers explain and discuss a new change program to and with employees is a very common change management practice, as evidenced by McKinsey and Boston Consulting Group publications and numerous mentions in change management field studies (Aiken & Keller, 2009; Bürkner et al., 2015; C. E. Cunningham et al., 2002; Meyer et al., 2010, 2007; Richardson & Denton, 1996). Finally, the CEO closed the e-mail with a reminder of HT's company history and priorities, an appeal for collaboration to achieve the common goals of the change program, and a call for action.

After having read the e-mail, participants responded to a series of measures assessing their change commitment and behavioral support intentions, and were asked to perform a writing task, which was framed as an opportunity to express support for the change and used as a behavioral measure of change support. The experiment closed with some demographic questions. After the experiment, the participants were thanked and provided a contact possibility for further questions.

All vignettes were professionally proofread and refined in discussions with management scholars as well as change management consulting experts. Further, I conducted three



Figure 1: Conceptual Model.

pretests and a manipulation check in February and March of 2020 to finalize the vignettes for the main data collection.

3.2. Sample

For my main experimental study conducted in May of 2020¹³, I recruited participants on the Prolific crowdsourcing platform. To be eligible for this study, participants needed to be located in the US and be full-time employed. A total of 384 participants completed the 15 to 20-minute study. The participants were then screened on appropriate control questions and memory checks regarding the content of the vignettes, following recommendations for data obtained from online participant crowdsourcing platforms (Chmielewski & Kucker, 2019; Hauser, Paolacci, & Chandler, n.d.; Kapelner & Chandler, 2010; Mason & Suri, 2012) in order to ensure a pool of subjects who participated in a serious way. See Appendix E for more details on this process. These precautions should serve to mitigate possible data quality concerns to an acceptable degree (Chmielewski & Kucker, 2019; Hauser et al., n.d.). Analyses were based on a final sample of 284 participants (with n = 68 in the high charisma, high commitment signals condition, n = 64 in the high charisma, low commitment signals condition, n = 81 in the low charisma, high commitment signals condition, and n = 71 in the low charisma, low commitment signals condition). Participants in the final sample ranged in age between 19 and 64 years (M = 35.4; SD = 9.9).

Most (83.1%) indicated having received at least a bachelor degree. Gender identification was mostly given as male (59.9%), followed by female (39.4%) and other (0.7%). 47.2% occupied positions involving leadership responsibility.

3.3. Measures

3.3.1. Independent Variables

All constructs, if not otherwise noted, are measured on a 7-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = neither agree nor disagree, 5 = somewhat agree, 6 = agree, 7 = strongly agree). I modeled the items to fit the current context where necessary, for instance by adapting the tense used. Scores on scale items are averaged to index participants' scores on the constructs of interest, if not otherwise noted.

CEO Charisma Signal Manipulation

When conclusive information about past performance is unavailable, employees will mostly rely on inferential reasoning to evaluate a leader (Jacquart & Antonakis, 2015). For a newly appointed CEO, as in this setting, employees will lack any information about the CEO's characteristics, intentions or past performance. Therefore, they will pay particular attention to the CEO's actions and messages in order to make inferences about his qualities and intentions (Awamleh & Gardner, 1999; Huy et al., 2014; Jacquart & Antonakis, 2015; Shamir et al., 1993; D. van Knippenberg et al., 2004). For charismatic leadership, the CEO's communication style will therefore act as a signal, as individuals often use only slivers of information (e.g. of charisma) as a basis to classify a target under a particular label (e.g. charismatic) (Jacquart & Antonakis, 2015; Tversky & Kahneman, 1974) and as leaders' typical way of conveying charisma is by communicating their messages to their audience in an attractive way (W. L. Gardner & Avolio, 1998). Because crafting a charismatic message is substantially easier (i.e. less costly) for more charismatic leaders as a result of their skillful impression management dramaturgy, and expressive and inspiring articulation,

¹³Note that data collection took place during the global COVID-19 pandemic. The consequences of COVID-19 in the USA have been far-reaching, as the USA were the country hit hardest on both confirmed cases and deaths as of June, 2020 (Statista, 2020; The Guardian, 2020). Economically, as well, the consequences have been substantial for many, as almost 40 million Americans have lost their jobs due to COVID-19 (as of May 27, 2020), corresponding to roughly 20% of the working population, which was unparalleled since the Great Depression of the 1930s (The Guardian, 2020).

a charismatic leader message will likely serve as a credible signal for charismatic leadership (Conger & Kanungo, 1987; Connelly et al., 2011; W. L. Gardner & Avolio, 1998).

Prior research has also documented the link between leader communication style and broader charismatic leadership perceptions in experimental settings (Antonakis, D'Adda, Weber, & Zehnder, 2019; Antonakis et al., 2011; Awamleh & Gardner, 1999; Jacquart & Antonakis, 2015). For the low and high signaled charisma conditions, I therefore used a standard change announcement and a substantively congruent change announcement, which was phrased more charismatically. Both change announcements contain the same number of words (804) and convey very similar content and the same information about the change itself. Yet, the high charisma change announcement strongly relies on the use of CLTs. As the change announcement was delivered in an e-mail, only the two verbal CLT categories (framing and substance) are included. See Appendix C for coded CLTs in the vignettes. Given the realistic context, it is important to point out that the low charisma signal condition was still, in absolute terms, a solid speech without total absence of rhetorical techniques. This design is necessary to ensure the speech is realistic (to actually compare low and high charisma signals instead of positive and negative charisma signals) and consistent with the change announcement content, as well as to ensure a fair comparison between conditions (Cooper & Richardson, 1986).

Following previous charismatic leadership research, I conducted two types of manipulation checks (Antonakis et al., 2019). As an objective manipulation check of charismatic communication, I coded all conditions at the sentence level for the absolute presence of CLTs (see Appendix C). For the high leader change commitment signal conditions, the number of CLTs used as a proportion of the total number of sentences in the low-charisma e-mail was 15.21% (i.e., 7 tactics over 46 sentences), and that of the high-charisma e-mail was 60.46% (i.e., 33 tactics over 52 sentences). This difference in proportions is highly significant (z = 4.85, se = .09, p < .001, (Koopman, 1984)).¹⁴

As a subjective manipulation check, I conducted a pretest to assess whether the high charisma conditions were also perceived as more charismatic. I recruited 104 participants (US location, full-time employees) via the Prolific platform, which were randomly assigned to one of the four conditions and asked them to rate the author of the change announcement, the fictitious CEO, in order to gauge their leader charisma perception.

For this purpose, I created a measure consisting of three items ("The CEO appeals to values that distinguish right from wrong.", "The CEO expresses emotional passion and conviction.", and "The CEO communicates in symbolic ways that make the message clear and vivid.") ($\alpha = .61$). This measure is based on the following definition of the charismatic signal: "the charismatic effect [...] stems from the leader (a) justifying the mission by appealing to values that distinguish right from wrong, (b) communicating in symbolic ways to make the message clear and vivid, and also symbolizing and embodying the moral unity of the collective per se, and (c) demonstrating conviction and passion for the mission via emotional displays" (Antonakis & Bastardoz, 2016: 304; Antonakis et al., 2011).¹⁵ An independent samples ttest yielded that participants who had read either of the high leader charisma signal vignettes (M = 5.323; SD = .815 for these two conditions combined) compared to those who had read either of the low leader charisma signal vignettes (M =4.703; SD = 1.057 for these two conditions combined) perceived the CEO to be a significantly more charismatic leader (t(100) = -3.387; p = .001; Cohen's d = .660; r = .314). A complementary OLS regression analysis supports these findings (cf. Appendix D for additional information on all pretest findings). Thus, I conclude that the leader charisma signal manipulation was successful.

CEO Change Commitment Signal Manipulation

Conducting meetings in which a planned change program is explained and discussed (often called "townhalls"), and especially visiting many corporate locations with such a format, has been proposed as an important means to convey top management change commitment in practice (Feloni, 2015; Sirkin et al., 2005). Interestingly, management initiatives such as townhalls have also been implied by scholars to potentially increase affective and normative employee change commitment without theorizing on the underlying causal relationships (Meyer et al., 2007). Thus, I used kick-off events conducted by the CEO in the format of townhalls as a manipulation of the CEO change commitment signal. The e-mail gives notice of the kick-off events and clarifies they will be held to lay out the next steps of the proposed change, explain what employees can expect, and answer employee questions.

Therefore, because of the highly realistic CEO change commitment signal manipulation, there should be high signal fit (Connelly et al., 2011). To manipulate the strength of the CEO change commitment signal, I vary the personal time sacrificed by the CEO (i.e. signal cost) to conduct the kick-off events (Bird & Smith, 2005; Connelly et al., 2011), while keeping constant the kick-off event format and purpose. In the high change commitment signal condition, kickoff events will be held personally by the CEO in all 18 HT company locations. The CEO also underlines that he made some changes to his time schedule to ensure that he can host

¹⁴If we compare the two low leader change commitment signal conditions, the proportion of CLTs in the low-charisma e-mail was 14.58% (i.e., 7 tactics over 48 sentences), and that of the high-charisma e-mail was 61.11% (i.e., 33 tactics over 54 sentences). This difference in proportion is also highly significant (z = 4.80, se = .1, p < .001 (Koopman, 1984)).

¹⁵As existing measures of charismatic leadership have been harshly criticized for endogeneity problems and rater biases (Antonakis, 2017; Antonakis et al., 2016), I follow Antonakis and colleagues' recommendations in mapping the charisma measure rather closely to charisma markers that have been manipulated in the experiment. That is, I aim to measure charisma in a specific way that is less prone to rater bias, but not too specific as to challenge participants' recollection of specific rhetorical devices used (Antonakis et al., 2016).

the events personally. In the low change commitment signal condition, a single kick-off event in HT's headquarters will be hosted not by the CEO, because he has other HT obligations, but by the CFO instead (on the CEO's request). In order to mitigate participants feeling left out by the single event, the e-mail also mentions a parallel livestream of the event. I did not design the low commitment signal conditions with events in all HT locations as to not convey a negatively low CEO commitment: I assume that in case the CEO did not find the time to participate personally in at least one or more of the events, this could be perceived quite negatively, while also possibly confusing participants why he would participate in some but not others, hindering fair treatment comparisons (Cooper & Richardson, 1986). As manipulated in this study, the low CEO change commitment signal should not be perceived negatively but more neutral, as he nevertheless organized and asked the CFO to represent him because of time constraints. For a more detailed overview of the manipulated commitment cost aspects, see Appendix C.

The manipulation check of whether low and high leader change commitment signals in the change announcement email actually varied in individuals' perceived signal cost was conducted along with the subjective manipulation check of perceived leader charisma described above. To gauge individuals' perception of the cost of leader's commitment signal, I developed a scale comprising three items ("The CEO invests a lot of personal time to drive this change.", "The CEO puts in substantial effort to change this organization.", and "The CEO is willing to make sacrifices to support this change.") ($\alpha = .822$). I reason that, following signaling theory, a costlier signal will be perceived as more credible and consequently should result in stronger perceptions of CEO change commitment (Connelly et al., 2011). An independent samples t-test yielded that participants who had read either of the high leader commitment signal vignettes (M = 5.923; SD = .813 for these two conditions combined) compared to those who had read either of the low leader commitment signal vignettes (M = 4.731; SD = 1.143 for these two conditions combined) perceived the CEO to be significantly more committed to the proposed change (t(92) =-6.129; p = .000; Cohen's d = 1.202; r = .515).

A complementary OLS regression analysis supports these findings (see Appendix D). These results indicate that the leader change commitment signal manipulation was also successful.

3.3.2. Dependent Variables

A list of all items included in the respective scales is included in Appendix F.

Affective Commitment to Change

I assessed followers' affective change commitment using four items of the affective commitment to change scale developed and validated by Herscovitch and Meyer (2002). Their affective and normative change commitment scales are widely used and well established in the context of organizational change research (A. A. Armenakis et al., 2007; G. B. Cunningham, 2006; Hill, Seo, Kang, & Taylor, 2012; Oreg et al., 2011). The specific items from the scales were selected because they exhibited the highest factor loadings with the affective and normative commitment to change, respectively, based on the factor analysis results reported in Herscovitch and Meyer (2002). (Sample item: "I believe in the value of this change."; $\alpha = .88$).

Normative Commitment to Change

Normative change commitment, accordingly, was measured using four items of the normative change commitment scale by the same authors (Herscovitch & Meyer, 2002). (Sample item: "I feel a sense of duty to work toward this change."; $\alpha = .78$).

Intended Behavioral Support for Change

Behavioral support for change was operationalized as championing behavior (Herscovitch & Meyer, 2002; Meyer et al., 2007). Championing is characterized by exerting discretionary effort, promoting the value of the change to others, and being willing to make personal sacrifices (such as working extra hours) in order to benefit the change initiative.¹⁶

Championing occurs when an individual is intrinsically motivated about a goal and is enthusiastic about it (Falbe & Yukl, 1992), and has been repeatedly linked to affective and normative change commitment (Bouckenooghe et al., 2015). Thus, intended behavioral support for change was assessed using three adapted items of the championing scale by Herscovitch and Meyer (2002). Items were selected based on fit with and applicability in the experimental context. (Sample item: "I would go above and beyond what is required to ensure the success of the change"; $\alpha = .89$).

Expressed Behavioral Support for Change

In addition, I extend previous work on behavioral support for change by answering the call to use an objective measure capturing actual change-related behavioral support (Antonakis et al., 2016; M. Choi, 2011; Cinite & Duxbury, 2018; Herscovitch & Meyer, 2002; Meyer et al., 2007). In developing the behavioral change support measure for this study, I followed general recommendations (e.g. Morales et al., 2017) and relied on previous experimental research employing behavioral measures (e.g. Stam, van Knippenberg, & Wisse, 2010; Venus, Stam, & van Knippenberg, 2013, 2019). Recall that the change announcements stressed that the success of the change was contingent on employee support. Therefore, I provided participants an opportunity to express their support for the change by helping a fictitious colleague, a

¹⁶Herscovitch and Meyer (2002) distinguish between compliance, cooperation, and championing. Compliance means demonstrating minimum support by reluctantly going along with the requirements of the change, whereas cooperation refers to passively demonstrating support by exerting effort concerning the change and going along with the spirit of the change. Following previous work (e.g. Seo et al., 2012), I only examine championing as the most active form of behavioral support for change (Fugate & Soenen, 2017).

member of the company ambassador network supporting the change, who is collecting employee statements about the change. Specifically, participants are asked to craft a message in order to increase awareness of the change program's importance with the specific goal of requesting employee support (adapted from Venus et al., 2019). Ambassador networks, consisting of volunteering employees who seek to help a given change succeed, have recently become more widespread (e.g. Bharat, 2017; Volkswagen AG, 2019) and are grounded on the idea of employee participation in internal change communication and management (e.g. Groysberg & Slind, 2012). The task was again presented in a highly realistic e-mail format ostensibly written by the respective colleague, aiding experimental realism. Accordingly, participants read that they could express their support for the change by writing a supportive message about the change. I reasoned that to the extent participants supported the introduced change, they should be willing to invest time and effort in writing a message for the ambassador network convincing others of the change, following the definition of championing laid out above. In conversations with change management consultants, the task was refined and confirmed to be high in experimental realism.

The variance in participants' effort in responding supports the validity of this indicator. While the vast majority of messages reflected agreement with the proposed change, individual effort in crafting the messages varied greatly. Following previous research employing behavioral support measures (e.g. Venus et al., 2019), I thus used the number of characters in the written message (M = 368.7, SD = 207.5) as an objective behavioral indicator of the construct of expressed (quantitative) behavioral change support.¹⁷ However, this measure was highly positively skewed (*skewness* = 1.15, SE = .15). I therefore relied on Box-Cox power transformation procedures to normalize the data (Cohen, Cohen, West, & Aiken, 2003). The Box-Cox transformation is defined as $Y_i^{\text{Transformed}} = (Y_i^{\lambda} - 1) / \lambda$, where λ signifies the optimal transformation parameter (Cohen et al., 2003: 237). A maximum-likelihood test for the Box-Cox power transformation indicated that the maximum normality could be attained at 0.40 for character length, which was consequently used for the transformation procedure.¹⁸

3.3.3. Moderators and Control Variables

Personal Values

To make efficient use of survey time and space, I employ the Short Schwartz's Value scale developed and validated by Lindeman and Verkasalo (2005). The scale comprises all 10 values of the Schwartz theory of basic values (Schwartz, 1992), which were rated on personal importance on a 7-point Likert scale (1 = against my principles, 2 = not important, 3 = somewhat important, 4 = important, 5 = quite important, 6 = very important, 7 = of supreme importance). By the procedure of weighting all individual values recommended by the authors, individuals' scores for the higher order value dimensions self-transcendence and conservation were then calculated (Lindeman & Verkasalo, 2005). Theoretically, these values form a bi-polar dimension in which the motivations underlying one pole of the dimension should mirror the motivations underlying the other pole. In other words, the more value a person places on one pole, the less she or he will value the opposite pole.

Control Variables

I follow recent recommendations for the inclusion of control variables (Aguinis & Bradley, 2014; Atinc, Simmering, & Kroll, 2012; Spector & Brannick, 2011). Variables were considered potential controls when there was theoretical ground suggesting that they could account for any of our proposed relationships (e.g. Atinc et al., 2012) and / or when they were typically included in previous research on organizational change reactions (e.g. in Armstrong-Stassen, 1998; Caldwell et al., 2004; Iverson, 1996; Oreg & Berson, 2011). Particularly personal change history has convincingly been shown to shape general change attitudes and reactions (Bordia, Restubog, Jimmieson, & Irmer, 2011; Bouckenooghe, 2012; Devos, Vanderheyden, & Van den Broeck, 2001; Lau & Woodman, 1995; Rafferty & Restubog, 2010, 2017; van der Smissen, Schalk, & Freese, 2013) and can therefore be considered a potentially important control variable. Thus, I treated age (in years), gender (male / female / other), leadership responsibility (yes / no) and personal history of change experiences as potential controls because these variables possibly share variance with both affective and normative commitment to change and support for change. Personal change history was assessed using three items of the change management history scale introduced by (Bordia et al., 2011). (Sample item: "Organizational change has been positive"; $\alpha = .854$). Further, I inspected zero-order correlations to identify variables sharing significant variance with our focal variables of interest, namely affective and normative commitment to change as well as intended behavioral support for change (Becker, 2005; Carlson & Wu, 2012; Spector & Brannick, 2011). This procedure led to the inclusion of personal change history based on zero-order correlations (affective change commitment: r = .40, p < .01; normative change commitment: r = .31, p < .01; support intention: r = .524, p < .01). Age was also included as a control because of significant overlap with normative commitment to change (r = .12, p < .05) and support intention (r = .14, p < .05), as well as leadership responsibility because of significant overlap with affective commitment to change (r = .16, p < .01) and support intention (r = .18, p < .01). Gender was omitted as a control variable because it did not share any significant variance with our focal variables of interest and because it has not been found

¹⁷In post-hoc analyses, I later also introduced a behavioral measure of expressed qualitative change support.

¹⁸Ultimate analyses reveal very similar results when the original behavioral support measure was transformed using a natural logarithm. As an additional robustness check, I used time spent writing the message as an alternative objective measure of expressed quantitative behavioral support, yielding essentially comparable overall results.

to predict change reactions (Armstrong-Stassen, 1998).

4. Results

4.1. Descriptive Statistics

Table 1 presents the means, standard deviations, ranges and zero-order correlations of the study variables.

None of the correlations were extremely high; thus, there appears to be no major risk of multicollinearity (Anderson, Sweeney, & Williams, 1996). I now turn to formally testing the proposed hypotheses.

4.2. Test of Hypotheses

For all analyses, follower age, personal change history, and leadership responsibility were entered as control variables, if not otherwise noted.

4.2.1. Effects of Leader Charisma and Change Commitment Signals on Follower Affective and Normative Change Commitment

To test the first two hypotheses, which predict that the conditions entailing high (vs. low) leader charisma and high (vs. low) leader charisma end high (vs. low) leader change commitment signals will each, respectively, be more successful in creating affective and normative follower change commitment, I conduct a hierarchical multiple regression analysis. Control variables are entered in step 1 and dependent variables, in this case indicator variables for conditions, included in step 2. I apply the same general approach for all following hierarchical multiple regressions. Note that the variables "High Charisma Signal" and "High Commitment Signal" are indicator variables for treatments in all regressions.

However, the depicted correlations above show no significant linear relation between the study conditions and affective or normative change commitment, giving a first indication that the conditions were not successful in eliciting significantly different follower affective and normative change commitment. Figure 2 depicts mean affective and normative change commitment scores by experimental condition and gives a similar impression.

Table 2 gives the results of the hierarchical multiple regression analyses.

Models 1b and 2b indeed reveal that there was no significant effect of either leader signal on follower affective and normative change commitment (*p*-values were all above .25). Therefore, hypotheses 1a, 1b, 2a and 2b are not supported.

4.2.2. Moderating Effect of Leader Change Commitment Signal

All moderation analyses were conducted using the PRO-CESS macro for SPSS, an existing computational tool for estimating and probing interactions (Hayes & Matthes, 2009). By default, PROCESS generates 95% bias-corrected bootstrap (5000 samples) confidence intervals for all indirect effects. Non-categorical variables were centered for moderation analyses, and a heteroscedasticity consistent standard error and covariance matrix estimator was used (Davidson & MacKinnon, 1993; Hayes & Cai, 2007).

Hypotheses 3a and 3b predict a strengthening moderation effect (R. G. Gardner et al., 2017) of the leader change commitment signal on the relationship between the leader charisma signal and follower affective and normative change commitment, respectively. Results of the moderated multiple regression analyses are depicted in table 3.

Since the interaction term fails to reach statistical significance in both model 1 and 2 (*p*-values were above .15 and simple slopes yielded no regions of significance), the interaction between leader signals does not explain significant incremental variance in the respective criterion variables beyond that accounted for by the main effects of the leader signals alone (R. G. Gardner et al., 2017). It can thus be concluded that there is no significant interactive effect of leader charisma and change commitment signals on follower affective and normative change commitment. Hence, hypotheses 3a and 3b are not supported.

4.2.3. Moderating Effect of Follower Self-Transcendence and Conservation

Hypotheses 4 and 5 propose strengthening moderation effects of followers' personal self-transcendence and openness values on the relationship between the leader charisma signal and ensuing follower affective and normative change commitment, respectively (R. G. Gardner et al., 2017). I first present the moderated multiple regression results for follower self-transcendence values in table 4.

Since the interaction term of self-transcendence and the charisma signal indicator variable fails to reach statistical significance in both models (*p*-values were above .40), I do not find evidence that follower self-transcendence moderates the effect of leader charisma signaling on follower affective and normative change commitment. Therefore, hypotheses 4a and 4b are not supported.

Table 5 presents the moderated multiple regression results for follower conservation values as a moderator. Similarly, as the interaction term of conservation and the charisma signal indicator variable also fails to reach statistical significance in both models (*p*-values were above .60), I do not find evidence that follower openness moderates the effect of leader charisma signaling on affective and normative change commitment either. Therefore, hypotheses 5a and 5b are not supported.

4.2.4. Effects of Follower Affective and Normative Change Commitment on Intended and Expressed Behavioral Support for Change

To test hypotheses 6a through 6d, which predict that follower affective and normative change commitment will be positively associated with intended and expressed behavioral support for change, I conduct a hierarchical multiple regression analysis. Results are depicted in table 6.

 Table 1: Descriptive Statistics and Inter-Correlations among Study Variables.

Variable	Mean	SD	Min	Max	1	2	3	4	5	6	7	8	9	10	11
1. Age (years)	35.41	9.89	119	64	1										
2. Leadership Responsibility (yes /	.47	.50	0	1	.128*	1									
no)															
3. Personal Change History	4.66	1.19	1	7	.003	.134*	1								
4. High Charisma Condition (yes /	.46	.50	0	1	.038	.061	.050	1							
no)															
5. High Change Commitment Condi-	.52	.50	0	1	.040	.109	.017	.018	1						
tion (yes / no)															
6. Affective Commitment to Change	5.46	1.12	1	7	.012	.156**	.400**	.088	.053	1					
7. Normative Commitment to Change	4.76	1.20	1	7	.123*	.065	.313**	.024	.073	.489**	1				
8. Intended Behavioral Support for	5.28	1.12	1	7	.143*	.175**	.524**	.004	.024	.580**	.531**	1			
Change															
9. Expressed Behavioral Support for	369	207	7	1267	.057	.123*	.079	.145*	.022	.064	.097	.149*	1		
Change (number of characters in writ-															
ing task, untransformed)															
10. Self-Transcendence	.54	.98	-3.56	2.05	.253**	.037	.108	.019	.007	.022	.037	.057	.001	1	
11. Conservation	.21	1.35	-3.51	3.72	.079	.034	.210**	.005	.043	.054	.228**	.213*	.024	.020	1

N = 284

*p<.05; **p<.01 (two-tailed)





Model 1b shows that both follower affective and normative change commitment predict intended behavioral support for change in such a way that intended behavioral support increases as affective ($\beta = .319, t(278) = 6.27, SE = .051, p < .01$) and normative change commitment ($\beta = .263, t(278) = 5.35, SE = .046, p < .01$) increase. Therefore, both types of change commitment uniquely contribute to behavioral support intentions. Affective and normative change commitment also explain a significant proportion of the variance in intended behavioral support above and beyond the entered control variables ($\Delta R^2 = .21, F(2, 278) = 58.61, p < .01$).

This evidence thus fully supports hypothesis 6a and 6b. Model 2b, however, reveals that the relationships between affective and normative change commitment and expressed behavioral support as measured by the quantity of written signs were nonsignificant.¹⁹ Thus, hypotheses 6c and 6d are not supported.

4.3. Post-hoc Analyses

In addition to formal testing of hypotheses, I conduct supplementary post-hoc analyses to further examine the effects of leader charisma and change commitment signaling

¹⁹As I will lay out in more detail in my post-hoc analyses, when measuring expressed behavioral support qualitatively, I do find support for hypothesis 6d, as, controlling for follower age, change history and leadership responsibility, normative change commitment predicts expressed qualitative behavioral support for change in such a way that behavioral support increases as normative change commitment ($\beta = .132, t(278) = 1.90, SE = .079, p = .058$) increases. Therefore, overall, I find mixed support for hypothesis 6d.

Dependent Variable	Affective Ch	ange Commitment	Normative Change Commitment		
Dependent variable.	Model la	Model lb	Model 2a	Model 2b	
Age	.003	.002	.121*	.118*	
	(.006)	(.006)	(.007)	(.007)	
Change History	.386**	.385**	.312**	.309**	
	(.051)	(.051)	(.057)	(.057)	
Leadership Responsibility	$.105^{+}$.096+	.008	.016	
	(.123)	(.124)	(.137)	(.139)	
High Charisma Signal		.063		.005	
		(.122)		(.136)	
High Commitment Signal		.048		.064	
		(.122)		(.136)	
Constant	3.678**	3.699**	2.773**	2.878**	
	(.326)	(.344)	(.363)	(.384)	
Observations	284	284	284	284	
R-squared	.171	.177	.113	.117	

 Table 2: Hierarchical Multiple Regression Results with Affective and Normative Change Commitment as Dependent Variables and Leader Signals as Independent Variables.

Standardized regression coefficients (β) are reported. Standard errors given in parentheses. **p < .01, *p < .05, +p < .10

 Table 3: Moderated Multiple Regression Results with Affective and Normative Change Commitment as Dependent Variables and Commitment Signal as a Moderator.

Dependent Variable	Affective Change Commitment	Normative Change Commitment
Dependent variable.	Model 1	Model 2
Age	.000	.015+
-	(.006)	(.008)
Change History	.358**	.315**
	(.066)	(.063)
Leadership Responsibility	$.221^{+}$.022
	(.122)	(.142)
High Charisma Signal	.234	.197
	(.199)	(.205)
High Commitment Signal	.021	.033
	(.156)	(.188)
High Commitment Signal	.180	.397
x High Charisma Signal	(.250)	(.277)
Constant	3.753**	2.759**
	(.386)	(.381)
Observations	284	284
R-squared	.179	.124

Unstandardized regression coefficients (B) are reported. Standard errors given in parentheses. *p < .01, *p < .05, +p < .10

on change reactions as well as the moderating role of followers' personal values.

First, above and beyond the hypothesized effects of leader charisma and change commitment signals on follower change commitment, I assess potential direct effects of both signals on intended and expressed behavioral change support. Figures 3 and 4 depict mean intended and expressed behavioral support by the leader signals received in the respective experimental condition.

While there do not seem to be significant differences

Dependent Variable	Affective Change Commitment	Normative Change Commitment
Dependent variable.	Model 1	Model 2
Age	.002	.013
-	(.006)	(.008)
Change History	.368**	.317**
	(.067)	(.064)
Leadership Responsibility	$.232^{+}$.026
	(.123)	(.141)
High Charisma Signal	.138	.007
	(.124)	(.138)
Self-Transcendence (centered)	.125	.045
	(.095)	(.115)
High Charisma Signal	.093	.019
x Self-Transcendence	(.126)	(.163)
Constant	3.784**	2.807**
	(.369)	(.379)
Observations	284	284
R-squared	.182	.115

Table 4: Moderated Multiple Regression Results with Affective and Normative Change Commitment as Dependent Variables and Self-Transcendence as a Moderator.

Unstandardized regression coefficients (B) are reported. Standard errors given in parentheses. **p < .01, *p < .05, +p < .10

 Table 5: Moderated Multiple Regression Results with Affective and Normative Change Commitment as Dependent Variables and Conservation as a Moderator.

Dependent Variable	Affective Change Commitment	Normative Change Commitment
Dependent variable.	Model 1	Model 2
Age	.000	.013+
	(.006)	(.008)
Change History	.363**	.277**
	(.066)	(.062)
Leadership Responsibility	$.222^{+}$.047
	(.124)	(.139)
High Charisma Signal	.141	.011
	(.124)	(.136)
Conservation (centered)	.012	.165*
	(.060)	(.076)
High Charisma Signal	.018	.043
x Conservation	(.091)	(.105)
Constant	3.732**	2.985**
	(.384)	(.376)
Observations	284	284
R-squared	.176	.139

Unstandardized regression coefficients (B) are reported. Standard errors given in parentheses. ** p < .01, * p < .05, $^+p < .10$

among conditions concerning intended behavioral change support, there seems to be a significant main effect of charisma signaling on expressed behavioral change support. To confirm those impressions, I conduct a hierarchical multiple regression analysis. Results are given in table 7.

As evident in model 1b, leader charisma and change

Dependent Variable:	Intended Be	havioral Support	Expressed Behavioral Support		
Dependent variable.	Model la	Model lb	Model 2a	Model 2b	
Age	.130*	.099*	$.107^{+}$	$.118^{+}$	
	(.006)	(.005)	(.014)	(.015)	
Change History	.512**	.306**	.051	.016	
	(.047)	(.044)	(.119)	(.131)	
Leadership Responsibility	$.090^{+}$.054	.141*	.138*	
	(.114)	(.097)	(.287)	(.289)	
Affective Change Commitment		.319**		.017	
		(.051)		(.153)	
Normative Change Commitment		.263**		.091	
		(.046)		(.138)	
Constant	2.425**	.559+	10.350**	9.710**	
	(.302)	(.310)	(.760)	(.926)	
Observations	284	284	284	284	
R-squared	302	509	032	041	

Table 6: Hierarchical Multiple Regression Results with Intended and Expressed Behavioral Change Support as Dependent Variables and Affective and Normative Change Commitment as Independent Variables.

Standardized regression coefficients (β) are reported. Standard errors given in parentheses. **p < .01, *p < .05, +p < .10



Error bars represent standard errors of the means (95% confidence interval).



commitment signals do not exert significant influence on intended behavioral support for change. Further, model 2b shows that a high leader charisma signal does predict expressed behavioral support for change in such a way that expressed behavioral support (as measured by the quantity of produced text) increases when a high leader charisma signal is received ($\beta = .135, t(278) = 2.29, SE = .282, p < .05$),

whereas the effect of signaled leader change commitment is not statistically significant. Leader charisma signaling also explains a significant proportion of the variance in expressed behavioral support above and beyond the entered control variables ($\Delta R^2 = .02, F(1, 279) = 5.26, p < .05$). Therefore, a high leader charisma signal significantly predicts expressed quantitative behavioral support, while a high leader change



Error bars represent standard errors of the means (95% confidence interval).

Figure 4:	Expressed	Behavioral S	upport	for Change	(transformed)	by Condition.
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Table 7: Hierarchical Multiple Regression Results with Intended and Expressed Behavior as Dependent Variables and Leader

 Signals as Independent Variables.

Dependent Variable	Intended Be	ehavioral Support	Expressed Behavioral Support		
Dependent variable.	Model la	Model lb	Model 2a	Model 2b	
Age	.130*	.132**	.107**	$.101^{+}$	
	(.006)	(.006)	(.014)	(.014)	
Change History	.512**	.514**	.051	.057	
	(.047)	(.048)	(.119)	(.119)	
Leadership Responsibility	$.090^{+}$	$.088^{+}$.141*	.145*	
	(.114)	(.115)	(.287)	(.288)	
High Charisma Signal		.032		.135*	
		(.113)		(.282)	
High Commitment Signal		.029		.023	
		(.113)		(.283)	
Constant	2.425**	2.338**	9.875**	9.875**	
	(.302)	(.319)	(.797)	(.797)	
Observations	284	284	284	284	
R-squared	.302	.304	.032	.050	

Standardized regression coefficients (β) are reported. Standard errors given in parentheses. **p < .01, *p < .05, *p < .10

commitment signal does not.

Second, I assess the moderating role of followers' personal values in the effect of leader signaling on intended and expressed behavioral change support. Table 8 depicts the moderated multiple regression results.

Models 1a and 1b reveal that for both types of leader signaling, there is a significant moderation effect of conservation values on the relationship between leader signaling and intended behavioral support, while this is not the case for expressed behavioral support (cf. models 2a and 2b). I conduct simple slopes analyses (cf. Appendix G) and use the Johnson-Neyman technique to interpret the moderation effects.

The Johnson-Neyman technique (Johnson & Neyman, 1936) can identify ranges of values of conservation for which the interaction effect between charismatic signaling and conservation is significant (Hayes, 2013). This tech-

Dependent Variable:	Intended Behavioral Support		Expressed Behavioral Support		
	Model la	Model lb	Model 2a	Model 2b	
Age	$.015^{+}$.014*	.026	.026	
	(.005)	(.006)	(.018)	(.018)	
Change History	.462**	.462**	.119	.113	
	(.060)	(.060)	(.125)	(.124)	
Leadership Responsibility	$.219^{+}$.188	.709*	.618*	
	(.115)	(.116)	(.291)	(.298)	
Conservation (centered)	.163**	.014	.160	.194	
	(.057)	(.068)	(.144)	(.162)	
High Charisma Signal	.071		.645*		
	(.113)		(.288)		
High Charisma Signal	$.158^{+}$.272		
x Conservation	(.082)		(.202)		
High Commitment Signal		.056		.11	
		(.115)		(.162)	
High Commitment Signal		.177*		.291	
x Conservation		(.087)		(.209)	
Constant	2.473**	2.532**	9.966**	10.259**	
	(.364)	(.386)	(.828)	(.865)	
Observations	284	284	284	284	
R-squared	.323	.324	.056	.039	

Table 8: Moderated Multiple Regression Results with Intended and Expressed Behavioral Support as Dependent Variables and Conservation as a Moderator.

Unstandardized regression coefficients (B) are reported. Standard errors given in parentheses. **p < .01, *p < .05, +p < .10

nique indicates that the region of significant moderation (p < .10) of conservation values on the relationship between charisma signaling and intended behavioral support lies between -3.718 and -1.354 (centered) values of conservation. Therefore, approximately, for values of conservation 1 to 3 standard deviations below the (centered) mean (that is, high openness to change values (Lindeman & Verkasalo, 2005)), there is a significant positive relationship between leader charisma signaling and intended behavioral support (p < .10). For the moderating effect of conservation values on the relationship between leader change commitment signaling and intended behavioral support, the boundaries of the zone of significance (p < .05) are 1.404 and 3.516 (centered) values of conservation. Hence, approximately, for values of conservation 1 to 3 standard deviations above the (centered) mean (that is, low openness to change values (Lindeman & Verkasalo, 2005)), there is a significant positive relationship between leader change commitment signaling and intended behavioral support (p < .05).

Next, I examine follower self-transcendence. I summarize moderated multiple regression results in table 9.

Model 1a shows a significant interaction effect between charisma signaling and self-transcendence, whereas the interaction terms included in models 1b, 2a and 2b fail to reach statistical significance. Via the Johnson-Neyman technique, I find that the region of significant moderation (p < .10) of self-transcendence values on the relationship between charisma signaling and intended behavioral support lies between -3.021 and -1.057 (centered) values of conservation. Therefore, approximately, for values of self-transcendence 1 to 3 standard deviations below the (centered) mean (that is, high self-enhancement values (Lindeman & Verkasalo, 2005)), there is a significant positive relationship between leader charisma signaling and intended behavioral support (p < .10).

Third, I conduct an in-depth analysis of the changesupportive messages created by participants in the writing task to provide deeper insights into the conditions' effects above and beyond those on self-reported support intentions and objectively measured quantitative support effort (character length). Specifically, I examine two qualitative content indicators. Firstly, I examine CLT use in the written messages to determine which conditions are most conducive to qualitative effort reflected in producing rhetorically well-crafted messages above and beyond quantitative effort reflected in character length. Hence, I differentiate between the effort of producing a long message and the effort of producing a message containing figurative and emotional language

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Table 9: Moderated Multiple Regression Results with Intended and Expressed Behavioral Support as Dependent Var	riables and
Self-Transcendence as a Moderator.	

Dependent Variable	Intended Be	ehavioral Support	Expressed Behavioral Support		
Dependent variable.	Model la	Model lb	Model 2a	Model 2b	
Age	.013*	.012*	.028	.029	
	(.006)	(.006)	(.019)	(.020)	
Change History	.497**	.493**	.132	.118	
	(.060)	(.060)	(.127)	(.126)	
Leadership Responsibility	$.208^{+}$	$.222^{+}$.719*	.695*	
	(.117)	(.120)	(.297)	(.305)	
Self-Transcendence	.203*	.020	.237	.081	
(centered)	(.086)	(.098)	(.223)	(.243)	
High Charisma Signal	.075		.651*		
	(.114)		(.289)		
High Charisma Signal	$.215^{+}$		(.179		
x Self-Transcendence	(.116)		(.304)		
High Commitment Signal		.059		.091	
		(.115)		(.291)	
High Commitment Signal		.144		.115	
x Self-Transcendence		(.123)		(.314)	
Constant	2.380**	2.413**	9975**	10.343**	
	(.351)	(.368)	(.807)	(.834)	
Observations	284	284	284	284	
R-squared	.320	.314	.055	.036	

Unstandardized regression coefficients (B) are reported. Standard errors given in parentheses. **p < .01, *p < .05, +p < .10

Table 10: Hierarchical Multiple Regression Results with Expressed Qualitative Behavior as Dependent Variables and Affective and Normative Change Commitment as Independent Variables.

Dependent Variable	Expressed Qualitative Behavioral Support		
	Model la	Model lb	
Age	.097	.113+	
	(.008)	(.008)	
Change History	.009	.027	
	(.068)	(.075)	
Leadership Responsibility	.053	.053	
	(.165)	(.166)	
Affective Change Commitment		.014	
		(.088)	
Normative Change Commitment		$.132^{+}$	
		(.079)	
Constant	1.605**	1.250**	
	(.436)	(.530)	
Observations	284	284	
R-squared	.011	.025	

Standardized regression coefficients (β) are reported. Standard errors given in parentheses. **p < .01, *p < .05, ⁺p < .10

Dependent Variable:	Expressed Qualitative Behavioral Support			
Dependent variable.	Model la	Model lb	Model 2a	Model 2b
Age	.014	.013	.015	.013
	(.009)	(.008)	(.009)	(.009)
Change History	.037	.013	.02	.006
	(.064)	(.065)	(.065)	(.067)
Leadership Responsibility	.173	.183	.131	.102
	(.163)	(.164)	(.175)	(.169)
Self-Transcendence	.222*		.048	
(centered)	(.108)		(.113)	
Conservation (centered)		.037		.061
		(.088)		(.119)
High Charisma Signal	.643**	.640**		
	(.161)	(.163)		
High Charisma Signal	$.304^{+}$			
x Self-Transcendence	(.166)			
High Charisma Signal		.003		
x Conservation		(.131)		
High Commitment Signal			.211	.213
			(.168)	(.168)
High Commitment Signal			.045	
x Self-Transcendence			(.168)	
High Commitment Signal				.166
x Conservation				(.140)
Constant	1.172*	1.254**	1.499**	1.531**
	(.462)	(.473)	(.500)	(.506)
Observations	284	284	284	284
R-squared	.081	.067	.02	.025

 Table 11: Moderated Multiple Regression Results with Expressed Qualitative Behavioral Support as Dependent Variables and

 Self-Transcendence and Conservation as Moderators.

Unstandardized regression coefficients (B) are reported. Standard errors given in parentheses. **p < .01, *p < .05, +p < .10

(e.g. Gibbs & Colston, 2006; Kellogg, 1999).²⁰ Two independent raters who were blind to the conditions coded each message for total number of CLTs included. To test interrater agreement, I used the Intraclass Correlation Coefficient (ICC) (LeBreton & Senter, 2008). ICC estimates and their 95% confidence intervals were calculated based on a mean-rating (k = 2), consistency, two-way random-effects model. All following ICC calculations were based on this model as well. ICC(2,2) = 0.94, 95% CI [0.925, 0.953]. Thus, I conclude that interrater agreement of CLT use per message was excellent (Cicchetti, 1994; Koo & Li, 2016). I use the mean of both raters' indicated number of CLTs per message for further analyses. A multiple regression analysis with condition indicator variables entered as independent variables and CLT use as a dependent variable ($R^2 = .063$) yields a highly significant positive main effect of charismatic

signaling ($\beta = .235, SE = .158, p = .000$) and a main effect of commitment signaling significant at the 15%-level ($\beta = .091, SE = .158, p = .116$).²¹ Consequently, while charisma leader signaling significantly increases CLT use in participants' messages, commitment signaling does so to a weaker and less significant extent.

In addition, I examine whether two findings obtained for my quantitative support measure are replicated with my qualitative support measure. Thus, first, I assess whether affective and normative change commitment significantly predict qualitative follower effort (cf. hypotheses 6c, d) in change support by conducting a hierarchical multiple regression analysis. Results are depicted in table 10.

Consequently, when measuring support effort qualitatively instead of quantitatively, I find support for hypothesis 6d, which proposed that normative change commitment will

²⁰Both measures of expended effort were relatively highly positively correlated (when the number of characters was untransformed, r = .51, p < .01; when transformed, r = .51, p < .01).

 $^{^{21}\}mathrm{I}$ did not include the previously used control variables here as they did not share any significant variance with our focal variable of interest, CLT use.

Dependent Variable:	Expressed Openness Values		Expressed Conservation Values	
	Model la	Model lb	Model 2a	Model 2b
Age	.063	.064	.094	.088
	(.004)	(.004)	(.003)	(.003)
Change History	.079	.083	.057	.063
	(.032)	(.032)	(.028)	(.028)
Leadership Responsibility	.071	.083	.003	.005
	(.077)	(.077)	(.068)	(.069)
High Charisma Signal		.135*		.080
		(.075)		(.067)
High Commitment Signal		.037		.056
		(.075)		(.067)
Constant	.161	.084	.490**	.394*
	(.203)	(.212)	(.180)	(.189)
Observations	284	284	284	284
R-squared	.018	.037	.012	.021

 Table 12: Hierarchical Multiple Regression Results with Expressed Openness and Conservation Values as Dependent Variable and Leader Signals as Independent Variables.

Standardized regression coefficients (β) are reported. Standard errors given in parentheses. **p < .01, *p < .05, +p < .10

Table 13: Hierarchical Multiple Regression Results with Expressed Self-Transcendence and Self-Enhancement Values as Dependent Variable and Leader Signals as Independent Variables.

Dependent Variable:	Expressed Self-Transcendence Values		Expressed Self-Enhancement Values	
	Model la	Model lb	Model 2a	Model 2b
Age	.058	.059	.035	.037
	(.003)	(.003)	(.004)	(.004)
Change History	.002	.000	.021	.024
	(.028)	(.028)	(.037)	(.037)
Leadership Responsibility	.032	.039	.052	.047
	(.068)	(.069)	(.089)	(.090)
High Charisma Signal		.079		.080
		(.067)		(.088)
High Commitment Signal		.028		.009
		(.067)		(.089)
Constant	.281	.246	.600*	.664**
	(.180)	(.190)	(.236)	(.249)
Observations	284	284	284	284
R-squared	.005	.012	.004	.01

Standardized regression coefficients (β) are reported. Standard errors given in parentheses. **p < .01, *p < .05, +p < .10

be positively associated with behavioral support for change. Overall, there is thus mixed support for hypothesis 6d.

Further, second, I determine whether followers' personal values also moderate not only their intended, but also their qualitative change support effort in response to leader signaling. To this end, I calculate multiple moderated regressions. I depict results for leader charisma signaling in models 1a, b and leader change commitment signaling in models 2a, b in table 11.

Models 1a through 2b reveal that only for charisma signaling, there is a significant moderation effect of selftranscendence values on the relationship between leader signaling and expressed qualitative behavioral support. The Johnson-Neyman technique indicates that the region of significant moderation (p < .05) of self-transcendence values on the relationship between charisma signaling and expressed qualitative behavioral support lies between -3.021 and -0.764 (centered) values of self-transcendence.

Therefore, approximately, for values of self-transcendence 3 standard deviations below the (centered) mean to almost 1 standard deviation above the (centered) mean (that is, high to moderate self-enhancement values (Lindeman & Verkasalo, 2005)), there is a significant positive relationship between leader charisma signaling and expressed qualitative behavioral support (p < .05). Please refer to Appendix G for additional simple slopes analyses and graphical representations.

As a second step in my in-depth text analysis, I examine the reasons to support the change named by participants and assess which value dimensions these reasons reflect, in order to gain an indication of which value dimensions are mirrored depending on the leader signals received. Two independent raters who were blind to the conditions coded each message with regard to how often openness to change, conservation, self-transcendence, and self-enhancement values are conveyed in the message's argumentation based on Schwartz's (1992) value dimension definitions. ICC calculations were used to assess interrater agreement. The mean of both raters' value scores per message was used as input for further analyses. Expressed openness to change was found in messages motivating organizational change by emphasizing the general merits of changing and adapting to new technological circumstances. See Appendix H for detailed examples for all coded values. ICC(2,2) = 0.84,95% CI [0.798, 0.873]. This level of interrater agreement is indicative of good to excellent reliability on interrater scores of openness to change expressions (Cicchetti, 1994; Koo & Li, 2016). Conservation values were reflected in arguments to preserve the current success of HT, honor its long tradition, and retain HT's market position for the future. ICC(2, 2) = 0.76, 95% CI [0.696, 0.810]. Thus, I conclude that interrater agreement was good to excellent on scores of expressed conservation values (Cicchetti, 1994; Koo & Li, 2016). I conduct a hierarchical multiple regression to assess the influence of leader signaling on the expression of openness to change vs. conservation values. Results are presented in table 12.

Regression results show that leader commitment signaling does not significantly impact the expression of openness to change or conservation values. While leader charisma signaling does not exhibit highly significant positive influence on followers' expression of conservation values (p = .182), charisma signaling does have a significant positive effect on the expression of openness values in the writing task (p <.05). Leader signals also explain a significant proportion of the variance in expressed openness values above and beyond the entered control variables ($\Delta R^2 = .020, F(2, 277) =$ 2.82, p < .10).

Expressed self-transcendence values are found in sentences mentioning perceived advantages for the welfare of others due to the change or considering others' interests. ICC(2,2) = 0.85, 95% CI [0.815, 0.884]. This level of

interrater agreement can be classified as good to excellent for scores of expressed self-transcendence values (Cicchetti, 1994; Koo & Li, 2016). Sentences are coded to mirror self-enhancement values when perceived advantages for the self due to the change are mentioned. ICC(2, 2) = 0.93, 95% CI [0.915, 0.947].

This level of interrater agreement indicates excellent interrater agreement on self-enhancement expression scores (Cicchetti, 1994; Koo & Li, 2016). The results of the conducted hierarchical multiple regression to assess the influence of leader signaling on the expression of selftranscendence vs. self-enhancement values are depicted in table 13.

Again, leader commitment signaling does not significantly impact follower expression of self-transcendence or self-enhancement values. While leader charisma signaling also does not reach high statistical significance, we can still observe a weakly significant positive effect on selftranscendence (p = .189) and a weakly significant negative effect on self-enhancement (p = .181) expressions.²²

5. Discussion

5.1. General Discussion

Researchers are increasingly recognizing employee change support as a primary determinant of change success. Although employees attentively observe their leaders during organizational change to infer their characteristics and intentions, and although there is no disagreement on the vital roles of leadership and communication during change, communication mechanisms to address employee uncertainty regarding the leadership of change in order to foster change support remain largely unexplored so far.

This thesis, based on a signaling theory framework, investigated the effects of leader charisma and change commitment signaling on employee responses to change, as well as the role of employees' personal values in this process. The results of this thesis contribute to the discussion on effective change management by emphasizing the potential of leader signaling to foster supportive employee responses to change, and by showing the relevance of personal values in leader signaling and follower reactions thereto. I address my findings in more detail below.

As my first set of findings, I did not find support in this experimental study of leader charisma and change commitment signals' significant main or interaction effects on follower affective and normative change commitment. Concerning the role of followers' self-transcendence and openness to change values, I did not find evidence of significant moderating effects on the relationship between leader charisma signaling and affective and normative change commitment. There are

²²The obtained results on the expression of values in writing were essentially unchanged when controlling for participants' self-transcendence and openness values, which were self-reported at the beginning of the experiment. Therefore, obtained results are not due to sampling issues.

several plausible interrelated reasons why my experimental manipulations might not have been able to capture the signals' full effects. First, paper people vignette studies, lacking the nonverbal dimension, cannot fully reflect charismatic signaling (Antonakis et al., 2016). Even the high charisma signal conditions can thus only incompletely capture the nature and cost of charisma signaling. As a result, the perceived contrast between low and high charisma signals may have been insufficient to elicit the full differential charismatic effect.

Second, I suspect that participants may not have been attentive enough to the leader change commitment signal to produce its full differential effect, as the change commitment signal occupied only around 10% of the announcement's email space.²³ Therefore, even if the difference in signal cost might have been sufficient, the signal's observability (Connelly et al., 2011) may have been insufficient to capture the signal's full differential effect. Third, mainly to increase experimental realism, I chose digital transformation as the type of change and based the measures of the change program on recommendations in literature. Yet the change overall thus elicited relatively high endorsement in terms of affective and normative change commitment and intended support, as was also reflected in the written messages. Evidently, participants did not perceive the change as having any severe disadvantages to oppose. Thus, there was likely limited room for differences in change reactions between conditions to emerge. Further, these aspects may have contributed to creating a "strong" situation (Mischel, 1977), leaving limited room for individual differences to arise in terms of change commitment. Fourth, despite the potential for generating causal results and isolating effects (e.g. Weick, 1977), whether laboratory experiments can truly capture the realities of organizational life (e.g. Bedeian, 1980) remains a topic of debate, as critical voices have lamented their inability to reflect the full complexity of organizational change (Barnes, 1967; Bedeian, 1980; Skyia & Sheehan, 1977). Thus, despite my best efforts for experimental realism, participants may view a fictitious change more positively in an experimental than in a real setting, as they do not truly need to face its consequences. Together, these aspects could explain why my manipulations likely were not able to reflect the full effects of the leader signals.

For my second set of findings, I report that affective and normative change commitment both highly significantly predict intended behavioral change support. For expressed behavioral support, my findings are mixed, as only normative change commitment significantly determines qualitative change support, which is consistent with recent research documenting a more versatile and stronger effect of normative, compared to affective, change commitment on changerelated behavior (Seo et al., 2012; Shin et al., 2012). Therefore, while reported change commitment is indicative of support intentions, it does not consistently predict expressed support. Overall, I thus find a lack of consistency between reported intentions and subsequent behavior, which has been a subject of research for the past decades (Ajzen, 1985; Ajzen & Madden, 1986; Bagozzi, 1992; Fishbein, 1980; Sheeran & Abraham, 2003; Triandis, 1980).

In a classic meta-analysis, intention accounted for, on average, 28% of the variance in behavior, with a sampleweighted average correlation of .53 between intention and behavior.²⁴ In other words, we often fail to accurately predict our behavior. Therefore, while I do replicate the finding that affective and normative change commitment predict intended support (Bouckenooghe et al., 2015; Cinite & Duxbury, 2018), the same does not consistently hold true for expressed support in my observed sample.

Above and beyond formally hypothesized relationships, I report several additional insights. First, I find a significant positive direct effect of leader charisma signaling, but a nonsignificant effect of change commitment signaling, on expressed quantitative behavioral support for change. Intended behavioral support is not significantly impacted by either signal. Evidently, the influence of the received leader signals is not reflected in participants' differing intended support (which was generally high, see above), but in their expressed support. Therefore, although participants seemingly do not accurately anticipate it, leader charisma signaling elicits significantly higher expressed behavioral support. The nonsignificant finding for leader change commitment signaling likely is a result of a lack of participant attention to the commitment signal itself, as discussed above in more detail.

Second, I find that receiving a high leader charisma signal elicits significantly higher CLT use in producing a changesupportive message. Leader change commitment signaling also exhibits a weak positive effect on subsequent follower CLT use, indicating that both signals induce followers to exert qualitative effort in devising rhetorically well-crafted messages in order to gather support for organizational change. Taken together, my findings indicate that both signals, and especially the charisma signal, are successful in fostering expressed behavioral support in followers across different measures.

Third, my findings reveal that leader charisma signaling exerts highly significantly positive influence on followers' expression of openness to change values in advocating organizational change. In addition, leader charisma signaling weakly positively influences the expression of conservation and self-transcendence values, and weakly negatively influences the expression of self-enhancement values. Thus, when asked to explain why the change should be supported, followers may reflect the values transmitted by the leader signals they had received.

²³Because participants were specifically asked about the CEO's personal involvement, I could not infer from the pre-test with certainty that participants would sufficiently attend to the signal.

 $^{^{24}}$ In this sample, the correlation between the composite measure of intended support and the transformed measure of expressed support was .169 (p < .01). For the untransformed measure of expressed support, the correlation was .149 (p < .05). Generally quite high intended support and relatively low variance likely contribute to this rather low level of correlation.

My findings are thus consistent with the notion that a charisma signal can be expected to transmit openness to change and self-transcendence values. Interestingly, I also find a weak positive effect of charisma signaling on the expression of conservation values. Recent research by Venus and colleagues (Venus et al., 2019) demonstrates the positive effect of visions of change emphasizing continuity on follower change support under conditions of high uncertainty. Similarly, the manipulation of the charisma signal in this study also includes stressing the need to preserve the company's legacy and carry it into a digital future (see Appendix B for the full vignettes), framing the change as a different expression of organizational identity and legacy, which is consistent with the concept of a vision of continuity (Venus et al., 2019) and also a reflection of conservation values (Schwartz, 1992). Hence, these conveyed conservation values then likely were mirrored in followers' changesupportive messages. Another explanation could be that followers internally adopt instead of merely repeat the values modeled by the charisma signal, as proposed by recent empirical research (Groves, 2020) and charismatic leadership theory (Bass & Steidlmeier, 1999; Conger, 1999; Shamir et al., 1993). However, the exact process and timeline of value adoption still remains unclear and requires further research (Groves, 2020). Thus, I cannot infer from the content of the change-supportive messages to which degree the expressed values were indeed internalized versus repeated. Further, I do not find evidence of influence of leader change commitment signaling on followers' expression of the focal values, which may be due to the fact that a change commitment signal is inherently less values-based than a charisma signal, which per definition is inextricably linked to leaders' and followers' values (Antonakis et al., 2016).

Lastly, I find that the relationship between leader signaling and expressed behavioral support is largely not significantly moderated by followers' personal values. However, I report that the impact of charisma signaling on intended behavioral support is strengthened for followers with low selftranscendence (i.e. high self-enhancement values (Lindeman & Verkasalo, 2005)), which is corroborated by the same moderation effect for expressed qualitative effort. Intended support is also increased as a result of a leader charisma signal in followers with high openness to change (i.e. low conservation values). The latter finding is not surprising, as a charismatic leadership signal is likely interpreted as reflective of openness to change values, which should, in the case of congruence between signaled leader values and followers' personal values, result in a stronger signal effect (Antonakis et al., 2016).

The former finding, however, is somewhat surprising, since transmitting self-transcendence values has been argued to be a fundamental element of charismatic leadership (Bono & Judge, 2003; House, 1977; D. van Knippenberg et al., 2004; Yukl, 1999), in theory rendering the leader's charisma signal particularly effective for followers with strong self-transcendence values (Antonakis et al., 2016; J. R. Edwards & Cable, 2009; Kristof-Brown, Zimmerman, & Johnson,

2005). Thus, the finding that the charisma signal was particularly effective among followers with low self-transcendence values could be a result of the circumstances during data collection. Due to grave consequences for the US economy as a result of the global Covid-19 pandemic and widespread and sudden unemployment (The Guardian, 2020), employees may currently primarily view organizational change from a self-enhancement, rather than a self-transcendence perspective because fear of job loss and uncertainty about one's further career might be dominant during the current situation. Indeed, research has shown that salient fear or worries about one's welfare can shift value orientations toward selfenhancement (Konty, Duell, & Joireman, 2004; Schwartz et al., 2000), thus shifting standards of judging and processing information and justifying actions (Schwartz, 1992). Hence, employees holding high self-enhancement values might intend to support the change to a higher degree, when a high (versus low) leader charisma signal convinces them more that the change will presumably make the company more competitive and thus secure e.g. employees' jobs (a theme frequently reflected in the content of messages produced in the writing task), whereas transmitted self-transcendence values may be less attended to, rendering congruence on this value dimension less important. As I can only speculate on the underlying mechanisms, it behooves future research to examine situational moderators on the relationship between followers' personal values and leadership. For leader change commitment signaling, I do not find a moderating effect of self-transcendence values on intended behavioral support. Yet, holding low openness to change (i.e. high conservation values) increases followers' intended support for change as a reaction to leader change commitment signaling. Employees not only infer a leader's values and motives from his or her rhetoric, but also his or her actions (O'Reilly & Pfeffer, 2000). The importance and benefits of employees' perceived value congruence has also been underlined outside the realm of charismatic leadership studies (Cable & Edwards, 2004; Endler & Magnusson, 1976; Kristof-Brown et al., 2005; Pervin, 1989). On the one hand, a leader's change commitment signal could be perceived as a manifestation of openness to change by showing that he or she is willing to go beyond what is formally required to help advance the change(Conger & Kanungo, 1998; House, 1996; Sosik, 2005).

However, depending on the perceived inevitableness of the change, a change commitment signal might also be perceived as the leader's attempt to retain the status quo, i.e. the attempt to introduce organizational change to defend the company's current position - a reflection of conservation values (Schwartz, 1992). Thus, a change commitment signal might not necessarily be perceived as a manifestation of the leader's intrinsic preference for change (openness to change) as is likely with charisma signaling, since the leader's true motivation might not necessarily be very clear to followers. In the case of this study, the leader's change commitment signal thus was likely perceived as a reflection of the leader's conservation values, which would explain its increased effectiveness in fostering intended change support in followers placing value on conservation. Above and beyond specific effects, it is also interesting to note that personal values largely did not moderate expressed, but only intended behavioral support. The exact relationship between held values and enacted behavior remains elusive (Bardi & Schwartz, 2003). One primary moderator on this relationship seems to be the level of deliberate decision-making prior to a certain action: when there is conscious, careful choice involved, values are argued to be far more likely to influence behavior (McCleland, 1985). Therefore, it is not unexpected that followers' held values exert stronger influence on behavioral support within the experimental setting. Future research will hopefully gain further insights into the influence of values along different aspects of employee reactions to change.

5.2. Theoretical Implications

This research contributes to several literatures.

First, my findings add to the literature on organizational change communication in two major ways. Firstly, although research on change communication has predominantly focused on the implementation of change, namely employee participation in implementation decision-making and the continuous provision of information on the change (Bordia et al., 2004; Lewis & Seibold, 1998; K. I. Miller et al., 1990; Sagie et al., 1995), my study illuminates the phase before change implementation (Lewin, 1947) by investigating the impact of change announcements on employee change responses. Despite their importance in determining change reactions, change announcements have been lamented to receive insufficient research attention (DiFonzo & Bordia, 1998; Gioia et al., 2012; Lewis et al., 2013).

Thus, I address the gap in research attention and show that leader signaling in change announcements can be an important and suitable means to foster supportive employee responses to change at the beginning of the change process.

Further, a common theme in organizational communication literature is the notion of dealing with employee uncertainty during change (Bordia et al., 2004), which is noted to fundamentally impede supportive reactions to change (J. Allen et al., 2007; Ashford, 1988; Schweiger & Denisi, 1991). Thus, secondly, I shift attention away from a predominant focus on employee uncertainty about different aspects of the change itself (Bordia et al., 2004; Buono & Bowditch, 1989; Jackson et al., 1987), and identify a type of uncertainty previously not attended to in change communication research: uncertainty relating to the leader of the change. Therefore, I extend the organizational change communication literature by shedding light on the important role of leader signaling in communicating about change as a mechanism through which employee uncertainty about the change leader is addressed, thereby fostering supportive employee responses to change.

Second, this research contributes to the leadership literature in two distinct ways. Leadership scholars have only recently begun to adopt a signaling theory perspective to explain the diverse effects of leader behavior on employees (e.g. Amabile et al., 2004; Detert & Burris, 2007; Karakowsky et al., 2019; A. Towler et al., 2014). However, the role of signaling by leaders still remains underexplored (Bastardoz, n.d.; Karakowsky et al., 2019; Taj, 2016) and, to the best of my knowledge, has yet to be studied empirically in the context of organizational change.²⁵ Therefore, as a first contribution to the literature on leadership, specifically the part of that literature investigating the role of signaling, I demonstrate the relevance of leader signaling during organizational change, namely charisma and change commitment signaling. For the charisma signal, I add to the recent perspective of explaining charismatic leadership using signaling theory (e.g. Antonakis et al., 2016, 2011; Bastardoz, n.d., forthcoming; Grabo et al., 2017) by proposing change announcements as a suitable signaling channel for change leaders, using a paper people study (Kosloff, Greenberg, Weise, & Solomon, 2010), operationalizing the charisma signal relying on objective markers (Antonakis et al., 2016), and demonstrating its effect on follower change reactions.

Turning to change commitment, research still lacks a cohesive definition of what constitutes leader change commitment, how it can be conveyed to followers, how it affects followers' change reactions both theoretically and empirically, and what factors potentially moderate this effect. Consequently, I addressed these questions in this study and hope my investigation adds to a needed cohesive narrative around the impact of signaled leader change commitment on followers.

Despite ample theoretical indications that values are a central part of the charismatic leadership process (Antonakis et al., 2016; Bass & Avolio, 1990; Burns, 1978; Shamir et al., 1993), there is a surprising paucity of empirical evidence (Groves, 2020). Hence, as a second contribution to the leadership literature, I add to the newly emerging stream of research empirically investigating the role of followers' openness to change and self-transcendence values in determining reactions to organizational change and leadership thereof (e.g. Brown & Treviño, 2009; Groves, 2020; Hannah et al., 2016; Sverdlik & Oreg, 2009, 2015). Firstly, I find that charisma signaling increases intended support for followers with low self-transcendence and high openness to change values. While the strengthening moderation effect of follower self-enhancement values on leader charisma is somewhat surprising and might be the result of the special circumstances of data collection, the strengthening moderation effect of follower openness to change values adds an interesting perspective to the current discussion of the moderating effect of openness values on change reactions. Sverdlik & Oreg propose that for individuals with strong openness to change values undergoing imposed change, the novelty of the change is likely appreciated, while the lack of autonomy may feel threatening (Sverdlik & Oreg, 2009, 2015). Hence,

²⁵See Kraft, Sparr, & Peus, 2004 who use a qualitative design to explore the influence of leader support and availability signals on alleviating employee uncertainty and concerns during organizational change for a rare examination of leader signaling during change.

it may depend on the given change situation whether the motivation toward either novelty or autonomy will have a greater impact on individuals' reactions, and thus whether openness to change will be positively or negatively related to supportive change reactions (Sverdlik & Oreg, 2009). My results add to Sverdlik & Oreg's findings: I suggest that a leader's charisma signal in a change context appeals more readily to followers with strong openness to change values, who should be convinced more easily of and inspired by a charismatic change vision embodying openness to change values, aiding behavioral support for change. I find according empirical evidence. Thus, a person's values regarding openness to change are reflected not only in their interpretation of a given change situation (Sverdlik & Oreg, 2009), but also indirectly reflected in their reaction to values transmitted when leaders announce and motivate change.

Further, I also add to the investigation of the mediating role of followers' value adoption in charismatic leadership process. Charismatic leadership theory postulates that changing followers' values is a primary influence mechanism of charismatic leaders (Bass & Steidlmeier, 1999), as followers internalize the values transmitted by the leader's vision, inspiring followers to transcend their self-interests and embrace organizational change as an opportunity (Conger, 1999; Shamir et al., 1993). Yet, these claims currently lack empirical evidence (Groves, 2020). My findings complement Groves (2020) observation that transformational leaders' modeled openness to change and self-transcendence values were related to followers adopting those values and demonstrating support for change. Similarly, I find that individuals express values transmitted by the leader's charismatic signaling in reasoning why organizational change should be supported, corroborating Groves (2020) correlational field evidence with, to my knowledge, first experimental evidence.

Therefore, value congruence between leader and followers, in addition to being a potentially critical moderator on leadership effectiveness by determining followers' acceptance and support of the charismatic leader's change vision (Antonakis et al., 2016; Burns, 1978; Conger, 1999; Weber, 1947), could also be a potentially central mediator in explaining leadership effectiveness such that leader values are internalized by followers over time (Groves, 2020; Hannah et al., 2016; Hoffman et al., 2011) or at least viewed as congruent to followers' personal values as a result of the leader's effective framing (Klein & House, 1995). Future research is needed to corroborate and extend current knowledge on the role of personal values in explaining the effects of leadership on follower responses to organizational change.

Third, my findings contribute to the organizational change literature, primarily to the investigation of the relationship between change commitment and change-related behavior. Despite strong empirical and theoretical previous evidence that affective and normative change commitment precede behavioral reactions to change (Bouckenooghe et al., 2015; Gioia & Chittipeddi, 1991; Meyer, Stanley, Herscovitch, & Topolnytsky, 2009; Sonenshein & Dholakia, 2012), I primarily find direct effects of leader signals on behavioral responses to change. While, for reasons already discussed, this may be an artefact of limitations in the manipulation of the examined signals, my findings nevertheless lend support to the proposition that behavioral responses need not be determined by conscious belief in the benefits of change or feelings of support obligations, but may be the result of other mechanisms above and beyond change commitment.

Recent research, for instance, showed that employees' positive affective experiences directly predicted employees' behavioral responses toward the change above and beyond the indirect effect via employee change commitment (Seo et al., 2012). Future research is needed to conclusively establish the precise mechanisms through which follower change reactions can be impacted without the well documented mediation via change commitment.

Lastly, my study contributes to new methodological approaches in measuring the impact of leadership on employees' change-related behaviors and personal values.

First, I use a behavioral measure to capture real changerelated behavior. Typically studied outcomes of leadership are primarily perceptual in nature or merely measure behavioral intentions (Cinite & Duxbury, 2018), leading researchers to call for more studies to use objective and consequential measures of actual behavioral support (Antonakis et al., 2016; M. Choi, 2011; Herscovitch & Meyer, 2002; Meyer et al., 2007). Therefore, in addition to examining perceptual consequences, such as change commitment and support intentions, I assess objective behavioral outcomes of leader charisma and change commitment signaling, namely qualitative and quantitative effort expended in expressing support for change in written form. Furthermore, evaluations of and behavior toward organizational change have been shown to have a significant social component. For instance, change is perceived to be more meaningful when there is a shared sense of meaning supported by the work groups and social networks change recipients are part of (Hülsheger, Anderson, & Salgado, 2009; Rousseau & Tijoriwala, 1999). Indeed, according to social information-processing theory (Salancik & Pfeffer, 1978), individuals adapt their attitudes toward and willingness to support a change to their social context, which has also been corroborated empirically (e.g. A. A. Armenakis et al., 1993; K. I. Miller & Monge, 1985; V. D. Miller, Johnson, & Grau, 1994). Consequently, employees expressing their support for change toward colleagues and convincing them to support the change could be a potentially important multiplying mechanism for broad change support among the workforce. Therefore, the behavioral task included in this experiment can be considered realistic and consequential in nature, as well as an extension of previous operationalizations of employee change reactions.

Second, I examine employees' expressed values when arguing for organizational change. Studies on the role of values in the leadership process during organizational change largely rely on self-reported personal value questionnaires, such as Schwartz's well-established values measure (Schwartz, 1992, 1996) or different abbreviated versions of the same (e.g. Lindeman & Verkasalo, 2005; Schwartz et al., 2001; Stern, Dietz, & Guagnano, 1998), as evident in typically employed research methodologies (e.g. Brown & Treviño, 2009; Groves, 2020; Oreg & Berson, 2011; Seppälä, Lipponen, Bardi, & Pirttilä-Backman, 2012; Sosik, 2005; Sverdlik & Oreg, 2009, 2015). Only exceptionally are values objectively coded, such as in communication messages (e.g. Frese et al., 2003), allowing for an investigation of expressed values above and beyond internally held values. I thus contribute to new methodological approaches in the study of the role of values in the influence of leadership on employees during change.

5.3. Limitations and Future Directions

The major strength of this research lies in establishing causality due to its controlled experimental design (Shadish, Cook, & Campbell, 2002). The application of vignettes helps maximize the control of various factors that are important for research on organizational change, such as the content and context of change (Pettigrew, 1990), and also helps minimize disruptive factors, such as rater biases coloring leader-ship perceptions (Cantor & Mischel, 1977; Jacquart & Anton-akis, 2015; Lord, Binning, Rush, & Thomas, 1978; Meindl & Ehrlich, 1987), by manipulating leadership objectively. Thus, experimental vignette studies yield findings with high internal validity (Aguinis & Bradley, 2014).

Despite the positive attributes of this study, it is of course not without limitations and opportunities for further development. First, the major criticism of the experiments in general is the sacrifice of generalizability of obtained findings (e.g. Bedeian, 1980; Hughes & Huby, 2002). However, the experimental vignette methodology is particularly well suited to provide realistic experimental scenarios (Aguinis & Bradley, 2014).

As laid out before, I thus paid particular attention to experimental realism in designing the vignettes and writing task (Aguinis & Bradley, 2014; Atzmüller & Steiner, 2010; Hox et al., 1991), allowing for optimism in terms of external validity, although probably no laboratory experiment can ever fully shed the hypothetical nature of the situation participants are placed in.

Second, because some of the data is self-reported and collected within one survey, common method and common source variance may be potential concerns. Note, however, that the main effects of the conditions on quantitative and qualitative behavioral support, as well as expressed values in arguing for change, were assessed with different behavioral measures as dependent variables in the experimental setup, which do not underlie common method and common source variance. Further, while common method variance tends to inflate main effects, it tends to deflate interaction effects (Schriesheim & DeNisi, 1981). Thus, the revealed significant moderation effects of followers' personal values and leadership responsibility indicate that method bias cannot account for these findings (M. G. Evans, 1985; P. M. Podsakoff, MacKenzie, & Podsakoff, 2012; Siemsen, Roth, & Oliveira, 2010).

Third, there are some likely limitations specific to my vignette design that should be addressed in future extensions of this study. As previously discussed, I suspect that my manipulations could not fully capture the effects of the investigated leader signals. To address those concerns, I propose corroborating and extending the findings obtained in this study. For one, the experimental change setting could be adapted to elicit more mixed reactions from the onset and thus leave more room for individual differences and condition effects to emerge. For instance, the change could entail more controversial measures, such as strict cost-cutting, or a more critically regarded change context. Further, a different leader signaling format could be used to capture the signals' effects more completely. For instance, future vignettes could consist of a video message from the leader about the upcoming change to signal charisma. Having a trained actor portray both low and high charisma signal conditions would allow to control for any person-related effects and include all (also nonverbal) CLTs as objective markers for charisma (Antonakis et al., 2016, 2019, 2011). The video message could, for instance, be accompanied by a supposed Intranet article announcing the planned kick-off events to signal leader change commitment. By focusing the article solely on the change commitment signal, the signal is likely to be more attended to by participants and thus become more observable. Above and beyond the format of presenting the change commitment signal, one could also test different ways to signal change commitment (Connelly et al., 2011).

For instance, for types of change requiring specific individual behavior change, such as learning new digital skills, future research could explore leader change commitment signals conveyed by visibly investing time to also learn new relevant skills and thus demonstrating commitment to the change measures.

As a further extension, it would also be insightful to explore leader signals beyond those of change commitment and charisma. For instance, leader's self-sacrificial behaviors have been proposed to help organizational members adapt to changing environments (Y. Choi & Mai-Dalton, 1998) and motivate followers to support the leader's initiatives (De Cremer & van Knippenberg, 2005; B. van Knippenberg & van Knippenberg, 2005), but lack conclusive causal evidence, to my knowledge. For instance, for change initiatives including cost-cutting measures, a costly way of signaling self-sacrificial leadership as a leader could be to voluntarily cut one's salary.

Methodologically, this research should also be extended to be studied a field setting. The combination of different research methods offers the potential of providing a balance of external and internal validity (Dipboye, 1990). For instance, one could gather correlational data in firms currently undergoing change by assessing employee-reported signaled leader charisma and change commitment, as well as supervisor-rated employee support for change, to demonstrate the relevance of signaled leader characteristics during change. One could also assess signaled charisma and change commitment in change announcements across organizations and compare employees' change responses among organizations. Further, field experiments could be promising venues for future research. For example, in a multi-location organization in which a leader is planning to conduct townhall meetings to explain the change to employees in a subset of all locations, one could randomly assign locations to either the townhall or no townhall treatment and assess differences in employees' support for change.

Above and beyond specific extensions to this study, approaching the study of leadership during change through a signaling perspective opens new interesting starting points for future research directions.

First, we know very little about the dynamic and temporal dimension of leader signaling during change. A general cue to assess the honesty of signals is the consistency of signaling over time (Connelly et al., 2011). Thus, a leader who repeatedly signals the same attribute or intention in a costly and consistent manner should be more likely to be perceived as possessing the signaled attribute or intention than a leader who signals only once or even sends conflicting signals. However, I expect a too-much-of-a-good-thing-effect of too frequent signaling such that leaders who over-signal may ineffectively convey their positive attributes and intentions, e.g. by emotionally exhausting followers (Kim, Hornung, & Rousseau, 2011). Longitudinal study designs could help shed light on the benefits of repeated signaling. Rather than a simple linear or curvilinear relationship between the frequency of signaling repetition and signaling effectiveness, I would anticipate a more complex, oscillating relationship so that periodically repeated signals in order to keep the signals sufficiently salient should prove most effective. Hence, I hope future research will attempt to answer questions relating to the optimal pattern of leader signaling over time.

Second, future research could examine the dynamics between leaders' signals. Since "all management actions send signals to employees that affect perceptions and influence behavior" (Baldwin & Magjuka, 1991: 26), it is important to understand how different signals might interact in their effects on followers. Which signals are mutually reinforcing? Which signals are inhibiting each other? Which signals do followers most attend to? Which signals are most effective in fostering supportive follower change reactions? Evidently, these questions can only be addressed in-depth by future research.

Third, social dynamics of signal interpretation could be explored. An employee's environment can be expected to shape how he or she perceives and interprets a leader's signals (Connelly et al., 2011). Especially when an individual is not certain about how a signal is to be interpreted, he or she may imitate how others make sense of the signal (Sliwka, 2007). Yet, we still know relatively little about how organizational members influence each other in the interpretation of leader signals. One could raise several important questions. How do signal interpretations diffuse in groups? Do leaders benefit from influential employees quickly validating their signal to set a precedent for others? How does signal interpretation cascade throughout organizational hierarchies?

As a shared sense of understanding within work groups

and organizational relevant social networks appear to catalyze perceptions of meaning in employees (Hülsheger et al., 2009; Rousseau & Tijoriwala, 1999), one could infer that a shared interpretation of a leader signal will likely strengthen its effects on followers. Further, middle managers are often central nodes in cascading information within the organization and implementing organizational change (Balogun, 2003). Some evidence also suggests that middle managers' behavior and leadership significantly shape employees' change reactions (Balogun & Johnson, 2004; Herold et al., 2008; Huy, 2002; Seo et al., 2012). It could thus also be a promising area of future research to examine how signal interpretation may vary across and cascade through hierarchical levels, for instance due to different reference points regarding baseline levels of specific leader attributes and intentions against which signals are evaluated.

Lastly, what are the boundaries of signal effectiveness in the context of organizational change? What kind of employee reactions can leader signals elicit that enhance the probability of change success? It would be valuable to see whether future research could extend my findings to other change-relevant outcomes, such as employee satisfaction or turnover intentions. Above and beyond that, future research could extend behavioral measures of change responses to include other consequential outcomes, such as effects on productivity in changed work processes or organizational citizenship behaviors. Longitudinal designs could also help illuminate the effect of leader signals on followers' openness to change and self-transcendence values, and other potential long-term effects. Attempts should further be made to deepen our understanding of the mediating mechanisms of the effects specific leader signals exert on followers.

5.4. Practical Implications

My findings may also yield important practical implications for fostering employee support when implementing organizational change.

Thus, first, leaders should profit from recognizing uncertainties employees face during organizational change pertaining to the change itself and its leaders. Leaders should expect employees to observe their behavior and draw conclusions based on that. Thus, by signaling their change commitment, and especially their charisma, leaders can foster follower change support by conveying information that followers care about in their change leaders. Therefore, leaders should learn to increase their awareness about their personal characteristics (e.g. Church, 1997), be attentive to and actively manage which signals they send to followers, and find creative ways to signal their desirable attributes and intentions in a credible manner. Leaders should also reflect on the values they transmit to followers when advocating change and signaling their attributes or intentions, and be aware that these values will likely be picked up or even internalized by followers who try to make sense of the change and understand why it is needed. In the end, "the genius of leadership lies in the manner in which leaders see and act on their own and their follower's values" (Burns, 1978: 19).

Second, my findings suggest that leaders should not assume that employees will respond to leader signaling in the same manner. Although my results suggest that, in general, signaling leader change commitment, and especially leader charisma, will foster follower change support, followers' personal values (Cable & Edwards, 2004; Meglino & Ravlin, 1998; Meyer & Parfyonova, 2009) will likely determine to what extent they will support the change initiative as a response to the leader's signals. Thus, leaders should recognize the potentially critical role of followers' personal values in shaping responses to change. To identify their employees' levels of openness to change and self-transcendence values, leaders could use focus groups as well as employee surveys and other measures in order to better understand the values held within the organization, and be attentive to their subordinates' expressed values to gauge how these values may influence responses to change. Leaders could thereby identify followers who more readily accept and adapt to change and are willing to transcend their self-interests to advance the change vision, and encourage them to take an active role in the common change effort, e.g. by supporting their peers who might find the change more difficult to adjust to, or advocating the change to colleagues.

6. Conclusion

While the importance of leadership and communication during change seem to be universally agreed upon, the current state of research leaves us in the dark about how change leaders can and why they should signal their characteristics and intentions in order to address employee uncertainty. To study the potential of leader signaling to foster supportive change responses in employees, I introduced two distinct signals in change announcements: those of leader charisma and commitment to the proposed change. This study gives first indications that both signals, and particularly the one of leader charisma, are effective in creating supportive behavioral responses to change, as evidenced by quantitative and qualitative follower effort exerted in advocating the change. I do not find that these effects on change-related behavior are indirect and operate through follower affective and change commitment. I also do not find both signals to be interactive in their effects on followers. Above and beyond effects concerning follower effort, I also find leader charisma signaling to increase the expression of openness to change, conservation, and self-transcendence values when explaining why the change initiative should be supported. Further, I report that followers' personal values moderate the influence of leader signals on expressed and intended behavioral reactions to change, respectively.

Ultimately, when employees decide how much effort to invest in supporting a change initiative, they seem to rely on their perceptions of the leader advocating the change. They might process questions such as: Is the leader's vision for change appealing? Do I share the values the leader stands for? Is the leader able to lead this change and how will his or her leadership look like? Do I trust the leader? Is the leader really committed to the vision he or she communicates? Will the leader support the change? How important is this change for the organization? It is up to the change leader to find ways to credibly signal their characteristics and intentions in order to alleviate employee uncertainty and achieve support for change, since "if there is one generalization we can make about leadership and change it is this: No change can occur without willing and supportive followers." (Bennis, 2000: 117). Although this study adds to the knowledge about the mechanisms and effects of leader signaling during organizational change, it is only a beginning for what ultimately needs to be understood.

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Factors Influencing Developers' Acceptance of Native Development Environments: An Expansion of the Technology Acceptance Model

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Abstract

Mobile operating systems opening up their development environments to third-party developers evoke skyrocketing supply of mobile applications. This study investigates factors influencing the acceptance of third-party developers to adopt native development environments for creating mobile apps. Based on an extensive literature review, the author proposes a research model, built on the technology acceptance model created by Davis. Through the data collected from an online questionnaire completed by third-party app developers, the model was tested using structural equation modeling. Findings indicate a significant effect of the proposed constructs: self-efficacy, output quality, subjective norm, perceived enjoyment, perception of external control, developer community and training. This analysis confirms that the intention to use a native development environment is significantly affected by perceived ease of use and perceived usefulness, whereby the effect size of perceived usefulness is noticeably stronger. Managerial implications suggest to promote high usefulness rather than primarily focusing on an easy to use interface.

Keywords: Native development environment; third-party develope; mobile app development; technology acceptance.

1. Introduction

The launch of smartphones and the related growth of mobile applications (hereafter, apps) revolutionized how the mobile phone industry operates. The key players are not only smartphone vendors, but also operating system providers. Apple's iOS and Google's Android facilitate mobile app distribution for third-party developers via an app market. It is essential to respond to the fast-changing customers' demand for volume and diversity of mobile apps as this is the main value channel for mobile phone end-users. Since operating system providers seek to provide the best app solution for all foreseeable needs, external contributions becomes crucial. Leveraging innovation by not only using internal resources but also relying on external ideas has been gaining popularity during the last few years. Chesbrough and Appleyard (2007) even argue this strategy to be an essential determinant of success. As a response, external developer platforms have emerged as an approach to accommodate external contributions. Thereby, a global network of highly skilled thirdparty developers connect and develop complement products or services on top of the organization's core set of resources

(Parker, Van Alstyne, & Jiang, 2017).

Opening up the application development environment to third-party developers and allowing them distributing their apps via the respective app market, enable operating system providers to reduce their cost of development and, at the same time, leverage an enormous pool of innovation (Ghazawneh, 2012). The development environments hosted by the operating system providers itself are called native development environments (hereafter, NDEs). Among other emerging development environments for mobile apps, NDEs are the default tools and facilitate close integration to the end device. Encouraging third-party developers to create mobile apps on the NDE is essential to increase the value of the smartphone (Cusumano, 2010). Drastic consequences can be witnessed by the decline of Nokia and Blackberry that missed to provide a diversity of mobile apps (Goldbach, Kemper, & Benlian, 2014).

Despite this being an area of considerable interest, there is missing literature on why third-party developers accept an NDE for developing mobile apps. Researchers urge the examination of third-party developers (Basole & Karla, 2011) and to search related literature regarding social factors that may influence developers in other contexts (Steglich et al., 2019). Although previous investigations discuss some factors influencing third-party developers (Hilkert, Benlian, & Hess, 2010; Lee, Kim, & Hong, 2016), few studies quantify the actual impact on the usage behavior. This analysis explores this gap and examines possible factors through an in-depth literature review and validates them quantitatively.

The prominent technology acceptance model (from now on TAM) by Davis serves as a basis for the proposed research model. TAM evaluates the users' acceptance and hence the usage of a technology by assessing the perceived usefulness and the perceived ease to use (Davis, 1989; Davis, Bagozzi, & Warshaw, 1989). Over the years, TAM has been widely used and adapted in various fields by adding external constructs. A modified TAM, adopted to NDEs, is proposed while addressing the following research question:

Which factors are influencing developers' acceptance of native development environments?

The purpose of this analysis is to complement and further expand existing literature on external contribution focusing on mobile app development on NDEs, as well as to validate and to expand TAM. The remainder of this paper is structured as follows. First, the characteristics of mobile app development are described as an essential background for the remaining paper. Second, an in-depth literature review is conducted to formulate concrete hypotheses. The methodology is described in the section that follows. Subsequently, the data analysis from the questionnaire responses is presented. The study closes with a discussion on managerial implications, limitations, and suggestions for further research as well as a precise conclusion.

2. The Characteristics of Mobile App Development

Mobile apps are small software programs running on mobile devices that perform a wide variety of tasks (Taylor, Voelker, & Pentina, 2011). To facilitate the external development of apps, mobile operating system providers publish resources like application programming interfaces (APIs) and software development kits (SDKs) (Ghazawneh, 2012), also referred to as technical boundary resources (Bianco, Myllarniemi, Komssi, & Raatikainen, 2014). APIs are codebased specifications to access the core assets of the platform (Ghazawneh, 2012), and SDKs are program resources, which help developers to program, test, and maintain the applications (Bianco et al., 2014). The development of apps can take place on native development environments provided by the operating system providers itself or on non-native environments such as web-based or cross-platform environments. Non-native development environments facilitate to develop an app once and run it on several platforms without writing it in different programming languages. The app is then published via the app market of the operating system providers. However, non-native development environments often lack in features and compatibility with the operating systems. By contrast, native development environments are tightly integrated and work with the latest and native features (Amatya & Kurti, 2014). Through the homogenous development tools, optimal app development can be achieved and is thus preferred by most developers. Therefore, this analysis will primarily focus on native development environments as default tool to develop mobile apps. While various operating systems have emerged, Google's Android and Appel's iOS dominate the market with a market share of 74.13% and 24.79% respectively (StatCounter, 2020). Due to the supremacy of these two operating systems, only their respective NDEs are considered for relevance reasons.

Coming from the music and personal computer industry, Apple disrupted the mobile industry by introducing iOS and the App Store (Boudreau & Lakhani, 2009). Today, 12 years later, 1.8 million apps are available for the end-users (Clement, 2020). The goal of opening up the development environment to third-party developers (while initially being closed to a small team of in-house developers) was to increase the cross-sales of its high-margin products by providing complements (Ghazawneh, 2012). To develop apps for iOS, third-party developers register on a fee-based NDE and get thereby access to the technical boundary resources. Apps are built using the programming languages objective-C or swift using Xcode. Apple will review the app before publishing it via the App Store. For paid apps, Apple keeps 30% share of the app sales, while the third-party developers can keep 70%. By shifting to a more dynamic and flexible approach, Apple triggered contributions by third-party developers to a wide variety of apps (Pisano & Verganti, 2008).

Google followed the successful strategy of Apple by introducing Android OS first on HTC and later for various mobile device manufacturers. Android uses an open-source model, to allow third-party developers to download SDKs for free and without registration (Boudreau & Lakhani, 2009). Native apps for Android are written in Java or Kotlin and commonly built using Android Studio. The application approval process before introducing the app to the market (via Google Play Store) is relatively simple and fully automated. Google charges developers a registration fee to access Google Play Store and later (similar to Apple) keeps 30% of unit sales (Sadi, Dai, & Yu, 2015). Today 2.5 million apps are available for the end-users of Android devices (Clement, 2020).

3. Literature Review and Hypotheses Development

3.1. Definition of the Research Process

For building a research model on factors influencing developers' acceptance of NDEs, this research builds on the established technology acceptance model (TAM). Thus, in a first step, most prominent TAM studies were scanned to analyze possible constructs. Based on a Web of Science and Google Scholar search, four primary studies defining the main TAM constructs were selected (summarized in Appendix A1).

In a second step, a thorough literature review, the main TAM constructs were analyzed for relevance in the context of mobile app development on NDEs. Thereby, the approach recommended by Webster and Watson (2002) was applied. First, a database-driven keyword search using the EBSCO Business Source Complete database was conducted. The following search string was used: "AB ("develop* environment" or "ios" or "android" or "mobile ecosystem" or xcode or android-studio) AND AB ("third-party developer*" or "external developer*" or "app* developer*") AND TX ("useful*" or "ease of use" or "easy to use" or "subjective norm" or "job relevance" or image or "output quality" or "result demonstrability" or "self-efficacy" "external control" or anxiet* or playful* or enjoy* or "objective usability")". The author considered only publications in peer-reviewed journals from the years 2007 to 2020. This resulted in 97 papers that were evaluated for their relevance by scanning the abstracts and identifying 11 articles that were considered for full reading. Secondly, further research was revised by reviewing articles references. Lastly, further literature was identified by reviewing articles citing the previous selected literature. By scanning the abstracts of articles identified in step two and three, ten further studies were classified as potentially relevant. Finally, out of the 21 potentially relevant studies, 6 were selected as applicable.

As the call for research by Basole and Karla (2011) and Steglich et al. (2019) suggest, the literature on thirdparty developers in a related context was also considered. Hilkert et al. (2010) confirm that third-party developers creating complementary applications for different softwareplatforms, are influenced by similar factors. Thus, the author selected studies examining third-party developers' acceptance of different development environments for developing complementary apps (summarized in Appendix A2).

Identified literature serves to define external constructs while also formulating concrete hypotheses and proposing a research model.

3.2. Technology Acceptance Model

TAM was first introduced by Davis and evaluates the users' acceptance of technologies by assessing usage behavior (Davis, 1989). Usage behavior (UB) refers to how often a system is used, measured as self-reported current usage (Davis, 1989). Based on the theory of reasoned action by Fishbein and Ajzen (1977), TAM introduces "perceived usefulness (PU)" and "perceived ease of use (PEOU)" as the two constructs influencing the intention to use a technology, which has been linked to subsequent usage behavior (Davis, 1989). PU is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989), whereas PEOU is defined as "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989). The definition of intention to use (IU) a system is based on Fishbein's and Ajzen's definition "the strength of one's intention to perform a specified behavior" (Fishbein & Ajzen, 1977).

Furthermore, TAM theorizes that perceived usefulness is also influenced by perceived ease of use, as the easier a technology to use, the more useful it can be (Venkatesh, 2000). TAM originally included a mediator, namely attitude, but as later studies confirm the accuracy of omitting this construct (Davis, 1989; Venkatesh, 2000; Venkatesh & Davis, 2000), this analysis will proceed to do so. TAM explains around 40% of the variance in intention to use and usage behavior and thus compares favorably with alternative models like the theory of planned behavior or theory of reasoned action (Venkatesh & Davis, 2000). TAM was intended to apply to different settings by identifying external constructs influencing the users of a system. Thereby, the effect of external constructs on intention to use is mediated by perceived usefulness and perceived ease of use (Venkatesh & Davis, 2000). Figure 1 illustrates TAM as the basis for the proposed research model.

The rationale for using TAM rather than other models is that it has been validated many times, and it remains flexible regarding application in different technology settings (Venkatesh & Davis, 2000). Furthermore, ease of use and usefulness are found to be essential concepts when analyzing the acceptance of development environments (Koch & Kerschbaum, 2014; Lee et al., 2016). Based on these findings, the author expects that general causalities found in TAM are also applicable in the context of this study. To verify this assumption, the following hypotheses are proposed:

H1: Intention to use NDEs positively influences usage behavior on NDEs

H2: Perceived usefulness positively influences intention to use NDEs

H3a: Perceived ease of use positively influences intention to use NDEs

H3b: Perceived ease of use positively influences perceived usefulness of NDEs

3.3. External Constructs within the NDE Context

For identifying external constructs, those defined by Venkatesh (2000) and Venkatesh and Davis (2000) serve as a basis. The author analyzed each construct for relevance by searching in NDE related literature. Venkatesh and Davis (2000) identified constructs influencing perceived usefulness. The following are adopted to this study and described in greater detail in this section: subjective norm, job relevance, image, and output quality. Furthermore, Venkatesh (2000) defined constructs influencing perceived ease of use, of which the following three are adopted to this study: selfefficacy, perception of external control, and perceived enjoyment. In addition, two constructs, not defined by the underlying TAM studies, are introduced and included in the proposed research model, as they were identified as important by analyzing NDE related literature. Constructs defined by Venkatesh and Davis (2000) and Davis (2000), which are



Figure 1: TAM based on Venkatesh and Davis (2000).

not mentioned in any NDE related literature, are excluded from this study (overview in Appendix A3).

Subjective norm (SN), an individual's perception that people who are important to oneself think one should or should not use a specific technology, influences perceived usefulness (Venkatesh & Davis, 2000). Hertel, Niedner, and Herrmann (2003) identify subjective norm as the "reactions of significant others" as one of the main motivational factors for third-party developers. The motivation to contribute to a development environment is higher the more positive in proportion to the expected reaction of e.g., family members, friends, or colleagues (Hertel et al., 2003). Based on these findings, the author proposes following hypothesis:

H4: Subjective norm positively influences perceived usefulness of NDEs

Image (IM), the degree to which using a technology is perceived to enhance one's status in one's social system, influences the perceived usefulness (Venkatesh & Davis, 2000). Several studies confirm that developing apps can establish reputation and signal talent among their own community (Hilkert et al., 2010; Steglich et al., 2019) or even potential employers (Koch & Kerschbaum, 2014). The gain in reputation motivates third-party developers to contribute through mobile app development (Steglich et al., 2019). Thus, the author expects that the following hypothesis holds:

> H5: Image positively influences perceived usefulness of NDEs

Job relevance (JR), an individual's perception regarding the degree to which a system is relevant for one's job, determines the perceived usefulness (Venkatesh & Davis, 2000). Some developers are hired for specific app development tasks and thus rely on the usage of NDEs for their salary (Hilkert et al., 2010; Koch & Kerschbaum, 2014). Therefore, the perception regarding the financial return is, in this study, associated with job relevance. The research of Lee et al. (2016) indicates that an adequate financial return is a main attraction factor on mobile app development environments. Based on these findings, the author expects that the following hypothesis holds:

H6: Job relevance positively influences perceived usefulness of NDEs Output quality (OQ), the degree to which a person believes that the system produces good work, influences the perceived usefulness (Venkatesh & Davis, 2000). A comparison of development environments for developing mobile apps reveals high quality of apps developed on NDEs as they facilitate neat integration (Huy & Van Thanh, 2012). Furthermore, developers perceive NDEs as supportive when striving for best developing performance (Steglich et al., 2019). Therefore, the author proposes the following hypothesis:

> H7: Output quality positively influences perceived usefulness of NDEs

Developer community (DC), the degree to which an individual benefits from the size and engagement of the developer community using the same NDE, is assumed to influence perceived usefulness. Although not defined as an external construct by Venkatesh and Davis (2000) and Venkatesh (2000), the developer community must also be considered in this study's context. Steglich et al. (2019) identified that from a developers' perspective, a large developer community is perceived as a primary advantage of NDEs. The discussions and forums within the community can be exciting and useful for third-party developers (Steglich et al., 2019). Koch and Kerschbaum (2014) confirm that in choosing which ecosystem to join, the size of the developer community increases the NDEs attractiveness. Based on these findings, DC is argued to be a crucial external construct and will be tested in this study. The author suggests the following hypothesis:

H8: Developer community positively influences perceived usefulness of NDEs

Training (TR), learning facilities to enhance developers' skills and know-how provided by the NDE, is a main motivational driver for third-party developers (Koch & Kerschbaum, 2014). When introducing external constructs of TAM, Venkatesh and Davis (2000) explicitly called for future research examining the effect of training. NDEs offer online training material and training events to support efficient development. This training attracts third-party developers as they acquire specific skills that can also be used elsewhere (Hilkert et al., 2010; Steglich et al., 2019). Lee et al. (2016) found that developers are more likely to accept an NDE if training is offered. Following hypothesis is proposed:

H9: Training positively influences perceived ease of use of NDEs

Self-efficacy (SE), the degree to which an individual believes that one has the ability to use a system, influences the perceived ease of use (Venkatesh, 2000). Hertel et al. (2003) identify "a high sense of personal self-efficacy" as an essential factor influencing third-party developers. When a developer can use an NDE without any help, the motivation to contribute is higher (Hertel et al., 2003). Based on this finding, the author proposes the following hypothesis:

H10: Self-efficacy positively influences perceived ease of use of NDEs

Perception of external control (PEC), the degree to which an individual believes that organizational and technical resources exist to support the use of the system, influences perceived ease of use (Venkatesh, 2000). From a third-party developers' perspective, NDEs must provide a variety of technical resources such as SDKs and APIs (Lee et al., 2016). The toolkit quality can be identified as one of the essential factors in choosing a development environment (Koch & Kerschbaum, 2014). Furthermore, the organizational resources, and thereby the platform openness, is critical to facilitate the usage of the NDE (Lee et al., 2016) and also serves as a decision criteria when choosing a development environment. Therefore, the following hypothesis is introduced:

H11: Perception of external control positively influences perceived ease of use of NDEs

Perceived enjoyment (PE), the degree to which the usage of a system is perceived to be enjoyable, influences perceived ease of use (Venkatesh, 2000). Enjoyment during the development process is a crucial factor for third-party developers (Steglich et al., 2019). Koch and Kerschbaum (2014) found that the intellectual stimulation of the innovation process itself is a primary reason for developers to join a smartphone ecosystem. The following hypothesis will be tested:

H12: Perceived enjoyment positively influences perceived ease of use of NDEs

4. Methodology

As outlined above, existing literature suggests several factors influencing third-party developers' acceptance of NDEs. Based on these findings, the author proposes a research model, illustrated in Figure 2.

To test the proposed research model (Figure 2), an online survey (Appendix B1) was conducted and the resulting data analyzed. A quantitative study was chosen, as previous research already suggests concrete constructs and call for quantitative validation (Lee et al., 2016). Furthermore, it facilitates to include a higher number of variables and a more appropriate generalization compared to qualitative studies (Wagner & Hering, 2014). Combining a qualitative literature review with quantitative research emphasizes high quality of social investigation (Zanón & Paz, 2009).

An online survey has several advantages compared to other survey methods. Respondents can be reached over long distances and across borders at the same time, which can counteract the methodological effect of different survey times. Furthermore, without the interviewer, the so-called "interviewer effect" is eliminated. The main disadvantage is that online surveys often address a younger (<60 years) and male-dominated sample (Wagner & Hering, 2014), which in this study can be neglected as this corresponds to the target group.

The questionnaire comprised 45 items, measuring 14 constructs on a five-point Likert-scale (constructs and respective items are listed in Table 2). Although seven-point Likert-scales are standard, it was decided to use five points to facilitate a neat design of the questionnaire on smartphones. Questionnaire items were assembled based on the examples of underlying TAM studies (Davis, 1989; Davis et al., 1989; Venkatesh, 2000; Venkatesh & Davis, 2000). Furthermore, closed-ended questions on socio-demographics were asked to compare to prior third-party developers statistics and thus verify the sample adequacy. Additionally, it was asked which NDE is used to test the suitability of compiling the responses of the two groups (developing for Android or iOS). As suggested by Straub (1989), the author conducted pretests among five NDE users to ensure the right selection of constructs and test comprehension of the questionnaire items. Based on the feedback from the pretests, a few minor changes were made to improve the validity and understanding. The author published the link of the questionnaire via the following distribution channels: social media groups, mailing lists of informatics institutes, mobile app development companies, developer forums, and private contacts triggering the snowball principle (see Appendix B2 for more details).

The resulting data was analyzed based on the proposed research model using the partial least square (PLS) structural equation modeling (SEM) technique, with SmartPLS 3.2.1. SEM enables the specification and testing of complex path models with multiple latent constructs (Hair, Hult, Ringle, & Sarstedt, 2014). There are mainly two types of SEM: Factorbased covariance SEM (CB-SEM) and partial least square SEM (PLS-SEM) (Hair et al., 2014). The rationale for choosing PLS-SEM is, amongst others, its adequacy for testing new relationships and that it avoids factor indeterminacy (Chin, Diehl, & Norman, 1988). Further reason to choose PLS is the minimal demands on measurement scales (Hair et al., 2014). Thus, the ongoing debate on whether Likert-scales are nominal or ordinal (Boone & Boone, 2017) can be ignored, and no assumptions of multivariate normality is required (Hair et al., 2014). Through PLS-SEM, working with a medium sample size is facilitated, and measurement errors in exogenous variables are treated more appropriately when compared to other methods (Chin et al., 1988). While analyzing the data, the guidelines by Avkiran and Ringle (2018), Hair et al. (2014) and Henseler, Hubona, and Ray (2016) were followed.



Note: Rectangles represent proposed constructs. Arrows in-between represent the proposed relationship and hypothesis.

Figure 2: Proposed Research Model

5. Data Analysis and Results

5.1. Sample

In total, 163 participants completed the questionnaire, of which 141 responses were used for the analysis. Out of all responses, 22 had to be eliminated because they were incomplete (completion rate below the cut-off of 85% as recommended by Hair et al. (2014)) or lacked prior experience in mobile app development on the NDEs of iOS or Android (marked "others" at the control-question which NDE they are using). The sample can be identified as adequate, as it corresponds to previous statistics on mobile app developers (Evans Data Corporation, 2017; Jet Brains, 2019). The average age of the participants is slightly younger (30 years) compared to prior statistics (36 years) (Evans Data Corporation, 2017) but still in an acceptable range. Of the 141 valid respondents, 83% are male and only 17% are female. The predominance of male participants reflects the target group (Evans Data Corporation, 2017). Although more than 50% of the respondents are from Europe, the geographic coverage can be considered as expansive as developers from all over the world participated. The majority of mobile app developers (52.5%) create mobile apps on the NDE provided by Android, significantly less on the NDE of iOS (32.6%), and only a few (14.9%) use both development environments. On average, participants have 3.4 years of experience in developing mobile apps on the respective NDE. Table 1 highlights basic socio-demographic information on the participants.

5.2. Multigroup Analysis

The author conducted a multigroup analysis (MGA) to test the adequacy of combining the questionnaire responses of developers using the NDE by Android with those by iOS. An MGA examines the differences in path coefficients of two sample groups (Hair et al., 2014). The MGA test highlights p-values greater than 0.1 for all path coefficients (detailed results in Appendix C2). Therefore, it can be concluded that the responses of the two groups are not significantly different. Hence, questionnaire responses are jointly analyzed.

5.3. Instrument Validation

Before conducting detailed analysis, validity and reliability were tested. Convergent validity (alignment of repeated measurement of the same construct) was tested with the average variance extracted (AVE). AVE measures the amount of variance captured by the constructs in relation to the amount of variance that is attributed to the measurement error (Avkiran & Ringle, 2018). The constructs have AVEs between 0.57 and 0.86, while the cut-off for good validity is 0.5 (Avkiran & Ringle, 2018). Hence adequate validity is identified (AVEs indicated in Table 2).

To assess the discriminant validity (distinct measure of different concepts) Fornell-Larcker criterion and Heterotrait-Monotrait ratio (HTMT) were conducted (detailed results in Appendix C3). Fornell-Lacker criterion requires that the square root of the AVE exceeds the correlation with other constructs (Avkiran & Ringle, 2018). This criterion was fulfilled by all constructs, besides the construct IU. Hence, HTMT ratio was analyzed additionally to test if this construct can still be identified as valid. Generally, Heterotrait correlations should be smaller than Monotrait correlations (Avkiran & Ringle, 2018). In the given dataset HTMT ratios are between 0.43 and 0.83 and thus fulfill the criterion for proper discriminant validity (Henseler et al., 2016).

Furthermore, two reliability tests were carried out to ensure internal consistency and indicator reliability. According to Avkiran and Ringle (2018) excellent indicator reliability is achieved when loadings are higher than 0.7. Likewise, loadings between 0.4 and 0.7 can be accepted when loadings of remaining items are greater than 0.7 (Avkiran & Ringle, 2018). In the given data set, all constructs but UB show indicator loading factors between 0.72 and 0.96 and thus illustrate excellent reliability (Table 2). The construct UB reveals one loading factor slightly below 0.7. However, the remaining indicator reveals a loading factor of 0.90. Thus, the indicators can still be considered as very reliable. Internal consistency was examined by the composite reliability coefficient (CR). Generally, a CR of 0.7 is considered as a threshold for

 Table 1: Questionnaire Participants

	Count	Percentage
Average in years	30	N/A
Female	24	17%
Male	117	83%
Africa	5	3.50%
Asia	27	18.80%
Europe	77	53.50%
North-America	31	21.50%
South-America	1	0.70%
Android	74	52.50%
iOS	46	32.60%
Both	21	14.90%
Average in years	3.4	N/A
	Average in years Female Male Africa Asia Europe North-America South-America Android iOS Both Average in years	CountAverage in years30Female24Male117Africa5Asia27Europe77North-America31South-America1Android74iOS46Both21Average in years3.4

Note: N=141

adequate internal consistency (Avkiran & Ringle, 2018). The given dataset reveals CRs greater than 0.7 (Table 2). Therefore, the data suggest good internal consistency.

Altogether, the reliability and validity of the construct measures used in this study received strong support from conducted tests. Table 2 highlights the measured items and the respective reliability and validity test results as well as the mean and standard deviation (SD) range for each construct.

5.4. Descriptive Measures

To get a first impression of the constructs, mean (M) and standard deviation (SD) for each item has been calculated. As all items of the same construct indicate contiguous descriptive measures, only the range per construct is indicated (in Table 2). Overall, participants of the questionnaire are rather heavy users of the respective NDE (M = 3.5-3.6; SD = 1.2-1.3; while 5 being the highest usage and 1 lowest usage). Generally, the NDE is perceived as useful (M = 3.8-3.9; SD = 1.0-1.1) and easy to use (M = 3.6-3.7; SD = 1.0-1.1). Amongst all external constructs, the highest means can be identified for the constructs developer community (M = 3.9-4.0; SD = 0.9-1.1) and perception of external control (M = 3.9-4.2; SD = 0.9-1.1). This can be interpreted as that the developer community of the NDE provides high value to the developers and that the resources provided by the NDE are generally perceived as adequate. Lowest means are reported for image (M = 3.3-3.4; SD = 1.0-1.1) and job relevance (M = 3.3–3.5; SD = 0.9–1.1). Therefore, it could be expected that the majority of developers neither think that they enhance their image when using the NDE nor use the NDE due to salary importance. Means of the other constructs range from 3.4 to 3.7 (SD = 0.9-1.1). Interpretation of means alone should be handled with caution and will therefore only be used as a first impression.

5.5. Model Fit

Unlike in CB-SEM there is no global goodness-of-fit measure available in PLS-SEM (Henseler et al., 2016). Yet, there is a model-quality indicator based on how close the predicted values of the dependent variables are to the observed values. This criterion is called the standardized root mean square residual (SRMR). SRMR is the square root of the sum of the squared differences between the model-implied and the empirical correlation matrix (Henseler et al., 2016). A value of 0.00 indicates a perfect fit, and the cut-off value is 0.08 (Henseler et al., 2016). The proposed research model highlights an SRMR of 0.058. Therefore, the model indicates high quality.

5.6. Structural Equation Modeling

Hypotheses are tested through the size and significance of path coefficients. Additionally, the research model is evaluated based on the coefficient of determination (r^2). As recommended by Avkiran and Ringle (2018), consistent bootstrapping (with 5000 bootstrap subsamples) in a two-tailed test with a 5% significance level is used. Path coefficients can range from -1 to +1, while values closer to absolute 1 reflect strong positive paths, and values closer to 0 indicate weak positive paths (Avkiran & Ringle, 2018).

The path coefficient of intention to use on usage behavior is very strong and highly significant ($\beta = 0.73$, p < 0.01). Intention to use is positively affected by perceived usefulness $(\beta = 0.63, p < 0.01)$ and perceived ease of use $(\beta = 0.29, p < 0.01)$ p < 0.05), whereby PU has a stronger influence than PEOU. PEOU additionally affects PU ($\beta = 0.25$, p<0.01). Perceived usefulness is positively and significantly influenced by subjective norm ($\beta = 0.28$, p<0.05), output quality ($\beta = 0.30$, p < 0.01), and developer community ($\beta = 0.15$, p < 0.1), while the effect of job relevance ($\beta = 0.01$, p > 0.1) and image ($\beta = 0.07$, p > 0.1) is not significant. Perceived ease of use is positively and significantly influenced by training (β = 0.24, p < 0.05), self-efficacy ($\beta = 0.43$, p < 0.05), and perceived enjoyment ($\beta = 0.30$, p < 0.05). The effect of perception of external control on perceived ease of use (β = -0.03, p > 0.1) is not significant. Overall, 10 out of the

Table 2: Instrument Validation

Construct	Items	Mean (SD)	Loading	AVE	CR
Usage behavior (UB)	To which extent do you use the NDE to develop mo- bile apps? (I exclusively use the NDE/ I mainly use the NDE/ I sometimes use the NDE / I rarely use the NDE/ I only use the NDE if it's unavoidable)	3.5 - 3.6	0.9	0.64	0.78
	I usually develop mobile apps on the NDE*	(1.2 - 1.3)	0.68		
Intention to use (III)	I aim to use the NDE often*	3.4 - 3.7	0.79	0.57	0.73
Intention to use (10)	I intend to be a heavy user of the NDE*	(1.1 - 1.2)	0.72		
	The NDE improves my app development perfor-	3.8 - 3.9	0.83	0.75	0.9
Perceived usefulness (PU)	mance*				
	Using the NDE increases my productivity*	(1.0 - 1.1)	0.82		
	The NDE is useful for me*		0.93		
	I find it easy to use the NDE*	3.6 - 3.7	0.92	0.77	0.91
Perceived ease of use (PEOU)	Learning how to use the NDE was easy for me*	(1.0 - 1.1)	0.87		
	It is easy to become skillful at the NDE*		0.84		
	People I learn from, think I should use the NDE*	3.5 - 3.6	0.91	0.81	0.93
Subjective norm (SN)	My peers support the use of the NDE*	(1.1)	0.92		
	My social environment supports the use of NDEs*		0.86		
Image (IM)	Through developing on the NDE I signal skills and competences*	3.3 - 3.4	0.94	0.79	0.92
	I enhance my reputation through developing apps on the NDE*	(1.0 - 1.1)	0.82		
	People using the NDE receive good reputation*		0.91		
	The usage of the NDE is part of my job*	3.3 - 3.5	0.91	0.71	0.88
Job relevance (JR)	The monetary reward through the app development is important for me*	(0.9 - 1.1)	0.75		
	In my job the NDE is relevant*		0.87		
	The NDE enables me to develop good apps*	3.6	0.94	0.81	0.93
Output quality (OO)	I rate the results from the NDE to be excellent*	(0.9 - 1.1)	0.84		
	The quality of the app I get from the NDE is high*		0.91		
Developer community (DC)	I benefit from other developers using the same NDE*	3.9 - 4.0	0.96	0.84	0.94
	A community of other developers using the same NDE is valuable for me*	(0.9 - 1.1)	0.89		
	Leniov being part of the developer community*		0.9		
	Through the NDE I improve my developing skills*	36-10	0.92	0.83	0.93
Training (TR)	Learning facilities (e.g., tutorials and learning guides) of the NDE balas me getting better in app	(1.0)	0.92	0.00	0.70
	development*				
	The NDE provides training in app development*		0.86		
	Lam able to use the NDE, even if there is no one	25 27	0.00	0.67	0.96
Salf afficacy (SE)	telling me how to use it*	5.5 - 5.7	0.75	0.07	0.00
Self-efficacy (SE)	For me it's intuitive to use the NDE*	(10 - 11)	0.0		
	I have the necessary skills for using the NDE*	(1.0 - 1.1)	0.9		0.86
	On the NDE sufficient platform-specific SDKs are	30-42	0.01	0.86	0.00
Perception of external control	provided*	5.7 - 7.2	0.75	0.00	0.92
(PEC)	I have the resources necessary to use the NDE*	(0.9 - 1.1)	0.9	a	a -
	The actual process of using the NDE is enjoyable*	3.4 - 3.7	0.91	0.75	0.9
Perceived enjoyment (PE)	I have fun developing apps on the NDE* I enjoy developing apps on the NDE*	(1.0)	0.89		

Note: *measured on a five-point Likert-scale from 1 = totally disagree to 5 = totally agree; SD = standard deviation; CR = composite reliability; AVE= average variance extracted

The most commonly used measure to evaluate a structural model is the variance explained, also called the coefficient of determination (r^2) (Hair et al., 2014). While r^2 values range from 0 to 1, a higher value implies a higher level of predictive accuracy (Hair et al., 2014). According to Chin et al. (1988), constructs with an r^2 above the cutoff of 0.33 have moderate predictive power, while an r² exceeding the threshold of 0.67 means substantial predictive power. The proposed research model indicates for UB an r^2 of 0.53. This translates to around 53% of usage behaviors can be explained with the proposed model. IU indicates an r^2 of 0.74, which means that PU and PEOU explain about 74% of the variance in IU. The predictive power of PU and PEOU is 79% and 73% respectively, values which indicate substantial predictive power according to the thresholds of Chin et al. (1988).

For even more sophisticated results, the author then analyzed the effect size (f^2) of each hypothesis. The f^2 coefficient examines how much unexplained variance compensates for the r² change (Hair et al., 2014). Effect size values of 0.02, 0.15 and 0.35, respectively, represent small, medium, and large effects of the exogenous latent variable (Hair et al., 2014). Within the research model, IU on UB has the largest effect size ($f^2 = 1.12$). Noticeably is the larger effect of PU on IU ($f^2 = 0.73$), compared to PEOU on IU ($f^2 = 0.15$). In the following, external constructs and respective effect size are listed, here organized by size, beginning with the highest: self-efficacy ($f^2 = 0.21$), output quality ($f^2 = 0.16$), subjective norm ($f^2 = 0.16$), training ($f^2 = 0.11$) and developer community ($f^2 = 0.06$). In contrast, image, job relevance, and perception of external control are not considered, as hypotheses are not supported, and f² is very low. Table 3 summarizes all proposed hypotheses with respective results, corresponding f^2 and interpreted effect size.

6. Discussion and Conclusion

6.1. Overview

This analysis represents the first attempt to apply TAM in the context of native development environments for developing mobile apps. Generally, it is perceived as an appropriate underlying model as the general causalities found in previous TAM studies hold in this context. The proposed hypotheses based on the original TAM by Davis (H1, H2, H3a, H3b, H4) are all supported in this analysis.

The research model explains about 53% of the variance in usage behavior and 74% of the variance in the intention to use. Thus, it compares favorably to previous TAM studies, which explain about 40% of the variance in UB and IU (Venkatesh & Davis, 2000). Consistent with previous TAM studies, the effect of PU on IU (H2) is significantly higher than the effect of PEOU on IU (H3a). Furthermore, perceived usefulness can be well predicted by the proposed external constructs. As identified by Venkatesh and Davis (2000), subjective norm (H4) and output quality (H7) significantly influence perceived usefulness. However, the constructs image (H5) and job relevance (H6) could not be validated as an influential factor in this analysis. The additionally proposed construct developer community, based on the studies by Koch and Kerschbaum (2014) and Steglich et al. (2019), reveals as a relevant construct.

Moreover, self-efficacy (H10) and perceived enjoyment (H12), as defined by Venkatesh (2000), significantly influence developers' perceived ease of use of the NDE. The perception of external control (H11) cannot be validated within this analysis. The additionally proposed construct training (H9) reveals to influence developers acceptance of NDEs (Hilkert et al., 2010; Lee et al., 2016; Steglich et al., 2019).

6.2. Managerial Implication

This study provides various novel contributions for the following interest groups. First of all, this study is highly valuable for the current NDE providers Android and iOS to identify improvement opportunities. Second, future NDE providers, not yet having a significant market share, can get valuable insights by looking at the more prominent players. Regardless of being a current or a future NDE provider, it is deemed beneficial to understand the factors that influence third-party developers' usage behavior to provide an attractive and developer-focused environment. Furthermore, this study also provides implications for non-native development environment providers. Emerging cross-platform environments also try to attract third-party developers and can surely benefit from this analysis. Likewise, emerging developer platform providers in all kinds of different industries have a keen interest in understanding third-party developers' motivation. Based on the analysis, the author suggests the following implications:

First, an interesting point is that perceived usefulness has a more substantial influence on the intention to use than perceived ease of use. Although proven otherwise, many managers still believe that ease of use is key to success and seem to primarily focus on the design of a platform (Chin et al., 1988). Yet, the analyzed data indicates that although PEOU is important, PU is an even more important determinant of developers' intention to use an NDE. Thus determinants of PU should not be underestimated as ease of use will not compensate for an NDE that is not perceived as useful.

Second, based on the strong effect of output quality, it is advisable to promote the high quality of apps developing on a certain development environment. Especially NDE providers can take advantage of the high standards and integrality of native apps.

Third, it is suggested to provide specific learning facilities, which are fun, highlight the training effect and thereby increase the self-efficacy. Concrete projects might be hackathon events or video tutorials. In doing so, the following three



Note: ***p < 0.001, **p < 0.01, and *p < 0.05. UB = Usage behavior, IU = Intention to use, PU = Perceived usefulness, PEOU = Perceived ease of use, SN = Subjective norm, IM = Image, JR = Job relevance, OQ = Output quality, DC = Developer community, TR = Training, SE = Self-efficacy, PEC = Perception of external control, PE = Perceived enjoyment.

Figure 3: Model Results based on PLS-SEM.

Table 3: Results of Hypotheses and Effect Size

H	Hypothesis	Result	f ²	Effect size
H1	IU -> UB	Supported	1.12	High
H2	PU-> IU	Supported	0.73	High
H3a	PEOU -> IU	Supported	0.15	Moderate
H3b	PEOU -> PU	Supported	0.15	Moderate
H4	SN -> PU	Supported	0.16	Moderate
H5	$IM \rightarrow PU$	Not supported	0.01	-
H6	JR -> PU	Not supported	0.00	-
H7	OQ -> PU	Supported	0.16	Moderate
H8	DC -> PU	Supported	0.06	Small/ Moderate
H9	TR-> PEOU	Supported	0.11	Small/ Moderate
H10	SE-> PEOU	Supported	0.21	Moderate/ High
H11	PEC -> PEOU	Not supported	0.00	-
H12	PE -> PEOU	Supported	0.10	Small/ Moderate

factors, influencing developers, can be triggered at the same time: self-efficacy, training and perceived enjoyment.

Lastly, the high mean and significant effect of the developer community is worth mentioning. It is advisable to facilitate an engaging exchange amongst developers. Promoting a lively community is deemed beneficial to attract more developers to join.

6.3. Limitations and Further Studies

There are certain limitations in this analysis that create scope for future research. First, the literature review is mainly based on TAM studies. Even though TAM is an established model and has been tested many times, one may raise the concern that other models could also be used to test the usage of a technology. This limitation is linked to the fact that there might be missing constructs that could not be identified through this study's literature review. For example, TAM does not measure any direct effects on usage behavior. While the intention to use an NDE can very well be explained with PU and PEOU and respective constructs from theory, the predictive power of UB is lacking. Third-party developers might heavily use the NDE based on a group or management decision despite not finding it useful or not easy to use. Future research needs to test further constructs based on different models and also examine direct effects on usage behavior.

Additionally, collinearity and indirect effects of external constructs should be tested to reveal the overall effect of one construct. Finally, the limitation of the sample needs to be mentioned. Like in previous TAM studies, the questionnaire was conducted with a convenience sample in a contrived setting, which might go along with certain restrictions.

Besides the mentioned areas for improvement, this study identifies further areas of potential research. As identified in this study, the effect of self-efficacy, subjective norm, and output quality is undeniable and should be further examined. Specific training methods could be compared to identify concrete management implications. Also, the potential of the developer community should be studied.

6.4. Conclusion

The objective of this paper was to analyze factors influencing developers' acceptance of native development environments for developing mobile apps, based on TAM. Through an extensive literature review, possible factors were identified, and then tested quantitatively using PLS-SEM. The research is consistent with the findings of previous TAM studies (Davis, 1989; Venkatesh, 2000; Venkatesh & Davis, 2000) that perceived usefulness and perceived ease of use positively influence the intention linked to the usage of the system. One of the most significant finding is that the impact of perceived usefulness on intention to use an NDE, compared to perceived ease of use, is noticeably higher. Therefore, managers should not merely focus on a neat interface, but also promote the great usefulness. Additionally, findings indicate a significant effect of output quality, subjective norm and developer community on the perceived usefulness of an NDE. The perceived ease of use of an NDE is significantly influenced by self-efficacy, training and perceived enjoyment.

The present study adds a relevant and novel contribution to the engaging research field of technology acceptance while also proposing concrete managerial implications for development environment providers.

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The Effects of Clawback Provisions on Investment Behaviour

Die Effekte von Clawback-Klauseln auf das Investitionsverhalten

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Abstract

Clawback provisions are increasingly adopted into corporate compensation systems. So far, various effects on the behavior of managers are identified. Interestingly, unplanned and potentially dysfunctional effects of clawback provisions have been scarcely a topic in accounting research. This study investigates the effects of clawback provisions on investment behavior. In the first part of the study, a formal-analytical model is derived that describes the relationship between clawback provisions and investment behavior. The model is based on prospect theory of Kahneman und Tversky (1979). In the second part of the study two experiments with 205 participants are described, which were conducted using Amazon Mechanical Turk (MTurk). Consistent with the derived model, the results show that clawback provisions significantly affect investment behavior. The prerequisite for this is that a clawback clause influences the decision problem sufficiently. The study contributes to a better understanding of unplanned and potentially dysfunctional effects of clawback provisions. Moreover, the developed model provides a basis for further research on the topic.

Zusammenfassung

Clawback-Klauseln werden in der Unternehmenspraxis zunehmend in die Vergütungssysteme integriert. Es werden verschiedene Veränderungen im Verhalten der betroffenen Manager und Managerinnen beobachtet. Interessanterweise sind insbesondere ungeplante und potenziell dysfunktionale Effekte der Einführung von Clawback-Klauseln bisher nur wenig erforscht. In dieser Studie werden die Effekte von Clawback-Klauseln in einem Vergütungssystem auf das Investitionsverhalten untersucht. Es wird ein formal-analytisches Modell hergeleitet, welches den Zusammenhang zwischen Clawback-Klauseln und Investitionsverhalten beschreibt. Das Modell basiert auf der Prospect-Theorie von Kahneman und Tversky (1979). Die prognostizierten Zusammenhänge werden mithilfe zweier Experimente mit insgesamt 205 Teilnehmern auf Amazon Mechanical Turk (MTurk) überprüft. Übereinstimmend mit dem hergeleiteten Modell, wird ein signifikanter Effekt von Clawback-Klauseln auf das Investitionsverhalten beobachtet. Bedingung hierfür ist, dass eine Clawback-Klausel die Entscheidungssituation hinreichend beeinflusst. Die Studie trägt zum besseren Verständnis von ungeplanten und potenziell dysfunktionalen Wirkungen von Clawback-Klauseln bei. Zudem bietet das entwickelte Modell eine Basis für weitere Forschung zum Thema.

Keywords: Clawback-Klauseln; Investitionsverhalten; Entscheidungsverhalten; Prospect-Theory.

1. Einleitung

Die Entwicklung der Wirecard AG, einem elektronischen Zahlungsdienstleister, war für viele Jahre eine Erfolgsgeschichte. Bis zum Jahr 2018 wächst der Aktienkurs jährlich stets zweistellig. Am 05. September 2018 wird das Unternehmen sogar in den deutschen Leitindex DAX aufgenommen.¹ Dieser Erfolg zeigt sich auch in der Vorstandsvergütung. Allein für das Jahr 2018 erhalten die Vorstandsmitglieder eine erfolgsabhängige Vergütung in Höhe von mehreren Millionen Euro.² Im Jahr 2020 ist das Unternehmen insolvent. Es wird bekannt, dass die Bilanz des Geschäftsjahres 2019 und wahrscheinlich auch die Bilanz des Geschäftsjahres 2018

¹Vgl. Wischmeyer (2018), S. 1.

DOI: https://doi.org/10.5282/jums/v6i4pp757-789

²Vgl. Wirecard AG (2018), S. 58f.

manipuliert wurde. Insgesamt fehlt Vermögen im Wert von zwei Milliarden Euro. $^{\scriptscriptstyle 3}$

Es zeigt sich, dass die hohe erfolgsabhängige Vergütung der vorherigen Jahre nicht gerechtfertigt war. Das Unternehmen war bei weitem nicht so erfolgreich wie angenommen. Bereits aus Gründen des Anlegerschutzes wäre es naheliegend, die Vorstandsmitglieder zur Rückzahlung dieser fälschlicherweise ausgezahlten Vergütung aufzufordern. Diese Maßnahme ist jedoch oft nur durchsetzbar, wenn der jeweilige Arbeitsvertrag entsprechende Klauseln enthält.⁴ Solche Klauseln werden Clawback-Klauseln genannt.

Clawback-Klauseln werden durch definierte Ereignisse aktiviert, welche bereits in der Vergangenheit stattgefunden haben und erst zum aktuellen Zeitpunkt bekannt werden. Ein solches Ereignis ist z.B. Bilanzfälschung. Bei Aktivierung der Klausel werden betroffene Manager dazu verpflichtet bereits ausgezahlte variable Vergütung an das Unternehmen zurückzuzahlen. Des Weiteren ist das Unternehmen dazu berechtigt die bereits versprochene, aber noch nicht ausgezahlte variable Vergütung einzubehalten.⁵

Clawback-Klauseln wirken auf das jeweilige Unternehmen. So wird einerseits beobachtet, dass Unternehmen, welche Clawback-Klauseln in ihr Vergütungssystem aufnehmen, signifikant weniger nachträgliche Berichtigungen des Jahresabschlusses vornehmen müssen.⁶ Andererseits zeigen sich auch unerwartete Effekte. So reduzieren entsprechende Unternehmen ihr Investitionsvolumen und investieren eher in sichere Investitionsmöglichkeiten.⁷ Die Effekte von Clawback-Klauseln auf das Investitionsverhalten können zum aktuellen Zeitpunkt noch nicht vollständig erklärt werden. Verschiedene Autoren fordern deshalb dazu auf, die Wirkungsweise von Clawback-Klauseln auf Investitionsentscheidungen weiter zu untersuchen.⁸ Die vorliegende Arbeit greift diese Aufforderungen auf.

Die Zielsetzung der Arbeit ist die Beschreibung und der Nachweis möglicher Effekte von Clawback-Klauseln auf das Investitionsverhalten. Hierfür wird ein formal-analytisches Modell entwickelt, welches den Zusammenhang zwischen Clawback-Klauseln und Investitionsverhalten beschreibt. Aus diesem Modell werden mögliche Effekte von Clawback-Klauseln auf das Investitionsverhalten abgeleitet. Die Existenz dieser vorhergesagten Effekte wird mithilfe einer empirischen Untersuchung überprüft.

Die Arbeit ist wie folgt gegliedert. Im zweiten Kapitel wird die bisherige Literatur zu Clawback-Klauseln dargestellt. Hierbei wird auf den rechtlichen Hintergrund von Clawback-Klauseln und die bisherige betriebswirtschaftliche Forschung zu Clawback-Klauseln näher eingegangen. Im dritten Kapitel wird ein Modell hergeleitet, welches das Investitionsverhalten eines Managers beschreibt. Zu Beginn des Kapitels wird die zugrundeliegende Theorie, die Prospect Theorie von Kahneman und Tversky (1979), kurz erläutert. Darauf aufbauend wird jeweils eine Nutzenfunktion des Managers für die Investitionsentscheidung mit und ohne Clawback-Klausel entwickelt.

Im vierten Kapitel wird das hergeleitete Modell genutzt, um mögliche Effekte von Clawback-Klauseln auf das Investitionsverhalten abzuleiten. Hierbei werden zwei Forschungshypothesen hergeleitet, welche in einer empirischen Untersuchung getestet werden können. Die empirische Untersuchung wird im fünften Kapitel näher charakterisiert. Zu Beginn des Kapitels wird die Wahl von Experimenten als Untersuchungsart begründet. Außerdem wird auf das Design der Untersuchung und insbesondere die Darstellung der Entscheidungssituation näher eingegangen.

Die Ergebnisse der empirischen Untersuchung werden im sechsten Kapitel dargestellt. Im ersten Schritt wird der erhobene Datensatz beschrieben und die Randomisierung der potenziellen Störvariablen getestet. Im darauffolgenden Schritt werden die Forschungshypothesen näher untersucht. Im siebten Kapitel werden weitergehende Überlegungen zu den erhobenen Daten beschrieben. Hierbei werden zwei alternative Erklärungsansätze für das beobachtete Investitionsverhalten aufgezeigt. Abschließend wird im achten Kapitel eine Zusammenfassung der Ergebnisse der Arbeit gegeben. Außerdem wird auf zukünftige Forschungsansätze eingegangen.

2. Zusammenfassung der Literatur zu Clawback-Klauseln

Im folgenden Kapitel wird die Literatur zu Clawback-Klauseln zusammengefasst. Im ersten Unterkapitel (2.1.) werden rechtliche Regelungen und Empfehlungen zu Clawback-Klauseln erläutert. Der Fokus liegt auf den USA und auf Deutschland. Im zweiten Unterkapitel (2.2.) wird die bisherige Forschung zu Clawback-Klauseln dargestellt. Hierbei werden die existierenden Forschungsrichtungen kurz beschrieben. Auf die Forschungsrichtung, welche sich mit dem Investitionsverhalten bei Clawback-Klauseln beschäftigt, wird vertiefend eingegangen.

2.1. Der rechtliche Hintergrund von Clawback-Klauseln

Clawback-Klauseln sind ein relativ neuer Governance-Mechanismus. Die älteste identifizierte Regelung zu Clawback-Klauseln ist das Lifetime-Responsibility-Programm, welches 1998 in der Peoples Bank of China, einer der größten Banken des Landes, eingeführt wurde. Dieses Programm koppelt die Bonuszahlungen der Kreditvermittler der Bank an die langfristige Profitabilität der vergebenen Kredite. Sollte ein vergebener Kredit ausfallen, hat die Bank das Recht, bereits ausgezahlte Bonuszahlungen vom jeweiligen Kreditvermittler wieder zurückzufordern. Dies gilt auch, wenn der Kreditvermittler das Unternehmen mittlerweile verlassen hat.⁹

³Vgl. Bergermann und Zdrzalek (2020), S. 1.

⁴Vgl. Weigelt (2014), S. 1.

⁵Vgl. Müller, Rieber und Tank (2019), S. 2.

⁶Vgl. Chan, Chen und Chen (2012), S. 193f.

⁷Vgl. Chen und Vann (2017), S. 1393.

⁸Vgl. Chan, Chen, Chen und Yu (2015), S. 170; Hirsch, Reichert und Sohn (2017), S. 10.

⁹Vgl. Allen und Li (2011), S. 734.

Im westlichen Kulturkreis gehen die meisten Regelungen zu Clawback-Klauseln auf den Sarbanes-Oxley Act (SOX) aus dem Jahr 2002 zurück. Das Gesetz ist für alle Aktiengesellschaften gültig, welche an den US-amerikanischen Börsen gelistet sind und somit bei der U.S. Securities and Exchange Commission (SEC) registriert werden müssen.¹⁰ Über Section 304 des Gesetzes können der Chief Financial Officer (CFO) und der Chief Executive Officer (CEO) von der SEC dazu verpflichtet werden, die gesamten erhaltenen Bonuszahlungen der letzten zwölf Monate wieder an das Unternehmen zurückzuzahlen. Vorrausetzung hierfür ist, dass das jeweilige Unternehmen seinen Jahresabschluss aufgrund von Managementfehlern nachträglich korrigieren muss. Eine solche Maßnahme wird als Restatement bezeichnet.¹¹

In den USA wird, im Rahmen einer Erweiterung des Dodd-Frank-Act (DFA) aus dem Jahr 2010, ein weiterer Gesetzesentwurf zu Clawback-Klauseln diskutiert. Auch dieses Gesetz würde klare Vorgaben enthalten, welche angewendet werden müssen, wenn ein Restatement des Jahresabschlusses eines Unternehmens notwendig wird. Im Gegensatz zum Sarbanes-Oxley Act wäre es jedoch unerheblich, ob Managementfehler der Grund für das Restatement sind. Die vorgeschlagene Section 954 würde die SEC oder den Aufsichtsrat des Unternehmens bei einem Restatement dazu verpflichten, vergangene Bonuszahlungen der letzten drei Jahre neu zu berechnen und den irrtümlich zu viel ausgezahlten Anteil der Bonuszahlungen zurückzufordern. Dies würde nicht nur CFO und CEO betreffen, sondern alle Manager des Unternehmens, welchen in der Vergangenheit irrtümlich zu hohe Bonuszahlungen ausgezahlt wurden.¹²

In Deutschland sind Clawback-Klauseln seit dem Gesetz zur Umsetzung der zweiten Aktionärsrechterichtlinie (ARUG II) aus dem Jahr 2019 für alle Aktiengesellschaften gesetzlich vorgeschrieben. Die Aktiengesellschaften werden dadurch verpflichtet, Clawback-Klauseln in die Vergütung der Vorstandmitglieder aufzunehmen. Die Clawback-Klausel wird im Gesetzestext nicht weiter spezifiziert.¹³ Weitere Richtlinien zu Clawback-Klauseln finden sich in der Institutsvergütungsverordnung (IVV), welche für alle deutschen Finanzinstitute gesetzlich vorgeschrieben ist. Die Klauseln werden in §20, Abs. 6 genauer definiert. Hierbei wird der Aufsichtsrat dazu verpflichtet, im Falle gravierender Fehlentscheidungen eines Vorstandsmitglieds und einem resultierenden negativen Erfolgsbeitrag, bereits an das Vorstandmitglied ausgezahlte Bonuszahlungen komplett zurückzufordern. Der Bemessungszeitraum der Clawback-Klausel ist nicht eindeutig festgelegt, sondern hängt von der Art und der Schwere der Fehlentscheidung ab.14

Es zeigt sich, dass es sehr verschiedene Arten von Clawback-Klauseln gibt. Zur besseren Abgrenzung werden die verschiedenen Arten nachfolgend über den dazugehörigen Gesetzestext benannt. Clawback-Klauseln, welche auf dem Sarbanes-Oxley Act, bzw. auf dem Dodd-Frank-Act basieren, werden als SOX-Clawbacks, bzw. DFA-Clawbacks bezeichnet. Clawback-Klauseln, welche auf der zweiten Aktionärsrechterichtlinie, bzw. auf der Institutsvergütungsverordnung basieren, werden als ARUG II-Clawbacks, bzw. IVV-Clawbacks bezeichnet.

- 2.2. Übersicht über die bisherige Forschung zu Clawback-Klauseln
- 2.2.1. Die Einflussfaktoren und Effekte von Clawback-Klauseln

Clawback-Klauseln sind Gegenstand aktueller betriebswirtschaftlichen Forschung. Dies zeigt sich deutlich durch die zahlreichen und aktuellen Publikationen zum Thema. Mithilfe einer Recherche in der Datenbank EbscoHost konnten 24 qualitativ hochwertige Fachartikel identifiziert werden, welche sich thematisch mit Clawback-Klauseln in der Vergütung beschäftigen.¹⁵ Hierbei wurden 23 der 24 Fachartikel in den letzten zehn Jahren veröffentlicht.¹⁶ Abbildung 1 zeigt die Anzahl der Fachartikel je Erscheinungsjahr.¹⁷

Es fällt auf, dass in den Fachartikeln häufig eine bestimmte Forschungsmethodik verwendet wird. In 18 der 24 Fachartikel werden Clawback-Klauseln nur indirekt, über Sekundärdaten, untersucht.¹⁸ Im Gegensatz dazu werden nur in vier Fachartikeln selbst erhobene Daten genutzt. Datengrundlage ist hierbei jeweils ein Experiment. In zwei Fachartikeln wird ein formal-analytisches Modell hergeleitet. Des Weiteren muss beachtet werden, dass in 18 von 24 Fachartikeln Clawback-Klauseln untersucht werden, welche auf dem US-amerikanischen Sarbanes-Oxley Act basieren. Viele Forschungsergebnisse gelten deshalb auch nur für diese Art von Clawback-Klausel.

Insgesamt haben sich zwei verschiedene Forschungsrichtungen zu Clawback-Klauseln herausgebildet. Eine der beiden Forschungsrichtungen hat das Ziel, mögliche Einflussfaktoren für die Einführung dieser Klauseln herauszufinden. Hierbei ist der Einfluss der rechtlichen Rahmenbedingungen auffällig. Eine länderübergreifende Studie unter Fond-Managern zeigt, dass in Ländern mit schwachem Justizsystem und hoher Korruption Clawback-Klauseln bei der Vergütung von Fond-Managern deutlich verbreiteter sind, als in Ländern mit starkem Justizsystem und wenig Korruption.¹⁹

In der US-amerikanischen Wirtschaft ist ein starker Einfluss des Board of Directors erkennbar. Je unabhängiger dieses Gremium vom Chief Executive Officer und vom Chief

¹⁰Vgl. Menzies (2004), S. 13.

¹¹Vgl. Amerikanischer Kongress (2002), S. 778.

¹²Vgl. SEC (2015), S. 7f.

¹³Vgl. Deutscher Bundestag (2019), S. 2639.

¹⁴Vgl. BaFin (2018), S. 49.

¹⁵Die Qualität eines Fachartikels wird hierbei aus der Qualität der dazugehörigen Fachzeitschrift abgeleitet. Es wurden nur Fachzeitschriften, welche mindestens die Note B im aktuellen VHB-Jourqual erreichen, nach Artikeln durchsucht. Für nähere Informationen zum VHB-Jourqual vgl. VHB (2019).

¹⁶Es muss beachtet werden, dass bei der Recherche das Jahr 2020 nicht mehr berücksichtigt wird.

¹⁷Für eine komplette Übersicht der Fachartikel vgl. Anhang a).

¹⁸Für eine Definition des Begriffs "Sekundärdaten" vgl. Bryman und Bell (2011), S. 312f.

¹⁹Vgl. Johan und Najar (2010), S. 170.



Abbildung 1: Die Anzahl an Fachartikeln je Erscheinungsjahr

Financial Officer arbeitet, desto wahrscheinlicher ist die Einführung von SOX-Clawbacks.²⁰ Ein weiterer Einflussfaktor ist die Macht des CEO, bzw. CFO. Hat dieser sowohl die Möglichkeit, als auch den Anreiz den veröffentlichten Jahresabschluss zu manipulieren, wird die Einführung von SOX-Clawbacks wahrscheinlicher.²¹ Besteht z.B. die Gefahr, dass die Übernahme eines unprofitablen Unternehmens verheimlicht werden soll, werden mit erhöhter Wahrscheinlichkeit in den darauf folgenden Perioden SOX-Clawbacks für den CEO eingeführt.²²

Die andere Forschungsrichtung zu Clawback-Klauseln beschäftigt sich mit deren Wirkungen auf ein Unternehmen und seine Stakeholder. Hierbei zeigt sich ein Einfluss von SOX-Clawbacks auf die Qualität des Jahresabschlusses. Die Einführung solcher Klauseln führt in vielen Fällen dazu, dass der Jahresabschluss als qualitativ hochwertiger wahrgenommen wird.²³ Als Reaktion darauf wird das gesamte Unternehmen von seinen Stakeholdern besser bewertet und als wertvoller eingeschätzt. Dies führt zu einem signifikanten Anstieg des Aktienkurses des jeweiligen Unternehmens.²⁴ Die verbesserte Bewertung des Unternehmens ist bei der Unternehmensfinanzierung hilfreich. Unternehmen mit SOX-Clawbacks im Vergütungssystem zahlen signifikant niedrigere Kreditzinsen für neue Kredite.²⁵

Zusätzlich werden auch direkte Effekte von SOX-Clawbacks auf die Qualität des Jahresabschlusses gemessen. Es zeigt sich, dass die Einführung solcher Klauseln die Wahrscheinlichkeit für Restatements senkt.²⁶ Werden in diesem Zusammenhang, neben SOX-Clawbacks, noch weitere Arten von Clawback-Klauseln untersucht, ergibt sich ein differenzierteres Bild. Die gemessene Wirkung auf die Qualität des Jahresabschlusses hängt hierbei von der Stärke der Clawback-Klausel ab.²⁷ Nur wenn die jeweilige Clawback-Klausel einen gewissen Wert im Index zur Messung der Clawback-Stärke erreicht, führt deren Einführung auch zu einer signifikanten Reduktion der notwendigen Restatements.²⁸ Es muss beachtet werden, dass die beschriebenen Effekte sich nur auf das gesetzlich verpflichtende Reporting beziehen. Die Qualität des nicht gesetzlich vorgeschriebenen Reportings sinkt nach der Einführung von SOX-Clawbacks.²⁹

Es ist umstritten, ob die beschriebenen Effekte hinsichtlich der Qualität des Jahresabschlusses ausschließlich durch die Einführung von Clawback-Klauseln entstehen. Einerseits wird beobachtet, dass sich das Reportingverhalten verändert, wenn Clawback-Klauseln in die Vergütung aufgenommen werden.³⁰ Andererseits kann die geringere Wahrscheinlichkeit für Restatements auch mit anderen Governance-Mechanismen, oder mit einer gesunkenen Bereitschaft für Restatements seitens des CEO, bzw. CFO erklärt werden.³¹

Ein weiterer großer Forschungsschwerpunkt zu Wirkungen von Clawback-Klauseln ist die Untersuchung von ungeplanten Effekten, welche durch die Einführung solcher Klauseln entstehen. Es wird hierbei beobachtet, dass Clawback-Klauseln von den betroffenen Personen meist nicht akzeptiert und sehr schlecht bewertet werden.³² Dazu passend wird ein Anstieg der Vergütung bei betroffenen Managern nach der Einführung von SOX-Clawbacks gemessen.³³ Diese Beobachtung ist allerdings nicht sicher belegt. Vereinzelt wird kein

- ²⁹Vgl. Kyung, Lee und Marquardt (2019), S. 198.
- ³⁰Vgl. Hodge und Winn (2012), S. 27.
- ³¹Vgl. Denis (2012), S. 200; Pyzoha (2015), S. 2532f.
- ³²Vgl. Brink und Rankin (2013), S. 165f.

²⁰Vgl. Addy, Chu und Yoder (2014), S. 187; Chen und Vann (2017), S. 1393; Huang, Lim und Ng (2019), S. 24f.

²¹Vgl. Babenko, Bennett, Bizjak und Coles (2012), S. 36f.

²²Vgl. Brown, Davis-Friday, Guler und Marquardt (2015), S. 268.

²³Vgl. Dehaan, Hodge und Shevlin (2013), S. 1055f.

²⁴Vgl. Babenko et al. (2012), S. 37f.; Bakke, Mahmudi und Virani (2017), S. 41f.; Iskandar-Datta und Jia (2013), S. 195.

²⁵Vgl. Chan, Chen und Chen (2013), S. 678.

²⁶Vgl. Chan et al. (2012), S. 193f.

²⁷Für eine Erläuterung des Konzepts vgl. Erkens, Gan und Yurtoglu (2018).

²⁸Vgl. Erkens et al. (2018), S. 307.

³³Vgl. Dehaan et al. (2013), S. 1055f.; Babenko et al. (2012), S. 37, Kroos, Schabus und Verbeeten (2018), S. 232.

signifikanter Anstieg der Vergütung, oder sogar eine niedrigere Vergütung beobachtet.³⁴

2.2.2. Die beobachteten Effekte auf das Investitionsverhalten

Es zeigen sich auch Effekte im Entscheidungsverhalten der betroffenen Personen. Ein großer Fokus der Forschung liegt hierbei auf dem Investitionsverhalten der betroffenen Personen. Verschiedene Untersuchungen legen nahe, dass die Aufnahme von Clawback-Klauseln in das Vergütungssystem das Investitionsverhalten beeinflussen kann. Es werden sowohl Effekte beim Investitionsvolumen, als auch beim Investitionsrisiko beobachtet. Beim Investitionsvolumen eines Unternehmens ist ein klarer Rückgang nach der Einführung von SOX-Clawbacks zu erkennen.³⁵ Dieser Effekt wird über zwei verschiedene Ansätze erklärt. Es ist einerseits denkbar, dass das Investitionsvolumen eines Unternehmens vor der Einführung der Klauseln zu groß ist und folglich der optimale Kapitalwert verfehlt wird. Ein solches Problem ist Gegenstand der Agency Theorie und wird als Overinvestment bezeichnet.³⁶

Ein Lösungsansatz für dieses Problem ist der Abbau von Informationsasymmetrien zwischen Management und Anteilseignern, mithilfe des externen Berichtswesens. Je exakter und stimmiger dieses ist, desto unwahrscheinlicher wird Overinvestment. Nimmt man an, dass die Qualität des externen Berichtswesens nach der Einführung von SOX-Clawbacks steigt, dann sinkt gleichzeitig die Wahrscheinlichkeit für Overinvestment und somit auch das Investitionsvolumen.³⁷

Andererseits wird das geringere Investitionsvolumen nach der Einführung von SOX-Clawbacks auch als versteckte Manipulation des Unternehmensergebnisses interpretiert. Hierbei wird argumentiert, dass in vielen Fällen Anreize zu einer solchen Manipulation auftreten können, beispielsweise wenn Zielvorgaben zum Unternehmensergebnis nicht eingehalten werden können. Oft werden hierbei Forderungen des eigenen Unternehmens zu hoch bewertet. Diese Möglichkeit wird jedoch durch die Einführung von SOX-Clawbacks erschwert. Sollten die falsch bewerteten Forderungen im Nachhinein entdeckt werden, muss ein Restatement erfolgen und die manipulierende Person muss die erhaltene Bonuszahlung zurückgeben. In dieser Situation erscheint eine andere Manipulationsmöglichkeit attraktiver. Eine Verringerung beim notwendigen Investitionsvolumen reduziert Aufwendungen und verbessert das Unternehmensergebnis. Wird dies im Nachhinein entdeckt, wird, da es sich um eine rechtlich legale Entscheidung handelt, kein Restatement notwendig und die manipulierende Person darf die Bonuszahlung behalten.38

Auch beim akzeptierten Investitionsrisiko führt die Einführung von Clawback-Klauseln zu Veränderungen. Ein interessanter Spezialfall ist eine Investitionsentscheidung in einer reinen Verlustsituation, wenn also unabhängig von der gewählten Investitionsmöglichkeit sicher ein Verlust realisiert wird. In dieser Situation kann die Einführung von Clawback-Klauseln die Attraktivität riskanter Investitionsmöglichkeiten erhöhen.³⁹ Voraussetzung hierfür sind Clawback-Klauseln, welche es ermöglichen, neben dem variablen Entgelt, auch das fixe Entgelt zurückzufordern. In diesem Fall können betroffene Personen bei Verfehlung eines Ziels im Nachhinein zu einer Malus-Zahlung verpflichtet werden. Des Weiteren muss angenommen werden, dass die Höhe der Malus-Zahlung sich anteilig aus dem bei der Investitionsentscheidung entstandenen Verlust errechnet.⁴⁰ Unter diesen Bedingungen wird das Konzept der Verlustaversion aus der Prospect-Theorie relevant. Dieses Konzept beschreibt die Tendenz vieler Personen Verluste zu vermeiden, anstatt Gewinne zu maximieren.⁴¹ Wenn sich Personen zwischen einem sicheren und unsicheren Verlust entscheiden sollen, wählen die meisten Personen den unsicheren Verlust. Dieser unsichere Verlust kann deutlich größer sein als der sichere Verlust. Die meisten Personen sehen aber eher die Chance, dass der tatsächliche Verlust deutlich kleiner sein wird als der sichere Verlust.42

Bei den meisten anderen Investitionsentscheidungen zeigt sich allerdings das Gegenteil. Hierbei werden nach der Einführung von Clawback-Klauseln eher sichere Investitionsmöglichkeiten bevorzugt werden.⁴³ Diese Beobachtung wird indirekt über die Standardabweichung der Periodengewinne entsprechender Unternehmen bestätigt. Annahme ist hierbei, dass einer großen Standardabweichung der Periodengewinne ein großes Investitionsrisiko zugrunde liegt.⁴⁴ Da nach der Einführung von SOX-Clawbacks signifikant geringere Schwankungen bei den Periodengewinnen entsprechender Unternehmen beobachtet werden, muss, der Annahme folgend, das Investitionsrisiko dieser Unternehmen gesunken sein.⁴⁵

Es ist unklar, wie die beschriebenen Effekte erklärt werden können. Passend zu den beschriebenen Effekten kann angenommen werden, dass die Einführung von Clawback-Klauseln Investitionsmöglichkeiten mit einer hohen Restatement-Wahrscheinlichkeit unattraktiv macht. Wird nun angenommen, dass die Restatement-Wahrscheinlichkeit mit dem Investitionsrisiko steigt, dann werden von Clawback-Klauseln betroffene Personen eher sichere Investitionsmöglichkeiten auswählen. Andererseits ist auch gegenteiliges Verhalten denkbar. Annahme ist hierbei, dass riskante Investitionen meist komplex sind. Als Folge werden Fehler im Rechnungswesen nur sehr schwer entdeckt. Dies führt zu einer geringen Restatement-Wahrscheinlichkeit, was die Auswahl riskanter Investitionsmöglichkeiten nach Einführung

³⁴Vgl. Iskandar-Datta und Jia (2013), S. 195; Erkens et al. (2018), S. 307.

³⁵Vgl. Chan et al. (2015), S. 170; Babenko et al. (2012), S. 37f.

³⁶Vgl. Jensen (1986), S. 328f.

³⁷Vgl. Lin (2017), S. 257f.

³⁸Vgl. Chan et al. (2015), S. 150f.

³⁹Vgl. Hirsch et al. (2017), S. 9f.

⁴⁰Vgl. Hirsch et al. (2017), S. 2–4.

⁴¹Vgl. Kahneman und Tversky (1979), S. 279f.

⁴²Vgl. Hirsch et al. (2017), S. 3.

⁴³Vgl. Hirsch et al. (2017), S. 9f.

⁴⁴Vgl. Chen und Vann (2017), S. 1378.

⁴⁵Vgl. Chen und Vann (2017), S. 1393f.

von Clawback-Klauseln attraktiv macht.46

Es ist erkennbar, dass beiden Erklärungsansätzen eine limitierende Annahme zugrunde liegt. Es muss jeweils angenommen werden, dass entscheidungsbefugte Personen einen klaren Zusammenhang zwischen Clawback-Klauseln und Restatement-Wahrscheinlichkeit sehen und diesen Zusammenhang bei Investitionsentscheidungen berücksichtigen. Diese Annahme kann nur bei SOX-Clawbacks gelten und selbst dann muss dies nicht der Fall sein. In den nächsten Kapiteln wird deshalb ein alternativer Ansatz zur Erklärung des Zusammenhangs entwickelt.

3. Modellierung des Investitionsverhaltens bei Clawback-Klauseln

Im folgenden Kapitel wird ein Modell hergeleitet, welches die Investitionsentscheidung eines Managers beschreibt. In Anlehnung an die Prospect-Theorie aus Kahneman und Tversky (1979) (3.1), wird die Entscheidungssituation einer Investitionsentscheidung modelliert (3.2). Auf Basis dieser Entscheidungssituation wird eine Nutzenfunktion für die Investitionsentscheidung ohne Clawback-Klauseln aufgebaut (3.3). Abschließend werden Clawback-Klauseln in die Entscheidungssituation integriert und eine Nutzenfunktion für die Investitionsentscheidung mit Clawback-Klauseln hergeleitet (3.4). Eine übersichtliche Zusammenfassung des Modells befindet sich in Anhang b).

3.1. Die Prospect-Theorie von Kahneman und Tversky (1979)

Die Prospect-Theorie wurde in den 70er Jahren von Daniel Kahnemann und Amos Tversky veröffentlicht. Die Theorie erweitert die klassische Erwartungsnutzentheorie um viele experimentelle Befunde. So kann mit der Prospect-Theorie z.B. das Allain-Paradoxon erklärt werden, bei welchem die klassische Erwartungsnutzentheorie versagt.⁴⁷ Der starke experimentelle Einfluss führt dazu, dass die Prospect-Theorie zum heutigen Stand als zentrale deskriptive Entscheidungstheorie angesehen wird.⁴⁸ Die Theorie wurde für Entscheidungssituationen entwickelt, welche durch klar abgrenzbare Ergebnisse mit Wahrscheinlichkeiten gekennzeichnet sind. Diese Anforderungen sind insbesondere für Lotterien und finanzielle Größen erfüllt.⁴⁹ Eine solche Entscheidungssituation ist durch Entscheidungsalternativen charakterisiert, welche Prospect genannt werden.⁵⁰

In der Prospect-Theorie wird der Entscheidungsprozess in zwei Phasen, die Editing-Phase und Valuation-Phase, unterschieden. Der Entscheidungsprozess beginnt stets mit der Editing-Phase. In dieser Phase wird die zugrundeliegende Entscheidungssituation verarbeitet und je nach Komplexität mithilfe von Heuristiken vereinfacht. Die wahrgenommenen Ergebnisse und Wahrscheinlichkeiten können

⁴⁷Für eine Erklärung des Paradoxons vgl. Tank (2017), S. 75.

hierbei verändert werden. Kahneman und Tversky (1979) identifizierten die vier dominanten Heuristiken Combination, Coding, Segregation und Cancellation. Die Heuristiken werden nachfolgend näher beschrieben. Combination beschreibt eine Vereinfachung, bei welcher identische Ergebnisse eines Prospects zu einem Ergebnis zusammengefasst werden. Ist z.B. ein Prospect durch zwei Ergebnisse mit je +200€ charakterisiert, dann werden die Ergebnisse zu einem Ergebnis mit +200€ zusammengefasst und die jeweiligen Wahrscheinlichkeiten addiert.⁵¹

Unter Coding wird das gedankliche Setzen eines Referenzpunktes verstanden. Dieser bezieht sich auf die Ergebnisse des jeweiligen Prospects. Für die Bewertung des Prospects ist dann nicht die absolute Höhe des Ergebnisses, sondern die Abweichung des Ergebnisses vom Referenzpunkt relevant. Nur im Sonderfall eines Referenzpunkts von null entspricht die absolute Höhe des Ergebnisses der Abweichung vom Referenzpunkt. Wahrgenommene Ergebnisse werden stets vom Referenzpunkt definiert. Zur Verdeutlichung wird im Folgenden ein Entscheider betrachtet, welcher bereits 2.000€ erhalten hat. Das zugrundeliegende Prospect führt entweder zu einem Ergebnis von 0€ oder zu einem negativen Ergebnis von -1.000€. Liegt der Referenzpunkt bei 0€, werden entscheidende Personen das negative Ergebnis als Verlust von 1.000€ ansehen. Liegt der Referenzpunkt jedoch bei 2.000€, werden entscheidende Personen das negative Ergebnis als Gewinn von +1.000€ ansehen.⁵²

Segregation tritt auf, wenn ein Prospect in einen risikolosen und einen risikoreichen Bestandteil zerlegt werden kann. Zur Verdeutlichung wird einen Prospect mit zwei Ergebnissen betrachtet. Mit einer Wahrscheinlichkeit von 80% resultiert ein positives Ergebnis von +300€ und mit einer Wahrscheinlichkeit von 20% resultiert ein positives Ergebnis von +200€. In diesem Fall führt Segregation dazu, dass entscheidende Personen den Prospect gedanklich in einen sicheren Bestandteil mit Ergebnis +200€ und einen unsicheren Bestandteil mit Ergebnis +100€ und einer Eintrittswahrscheinlichkeit von 80% zerlegen.⁵³

Das Ignorieren bestimmter Ergebnisse aus dem Prospect wird als Cancellation, oder alternativ als Isolation-Effekt bezeichnet. Die Heuristik wird z.B. eingesetzt, wenn zwei zur Wahl stehende Prospects gleiche Ergebnisse aufweisen. In diesem Fall werden die gleichen Ergebnisse aus dem Prospect eliminiert. Cancellation äußert sich auch bei zweistufigen Prospects. Zur Verdeutlichung wird eine Lotterie betrachtet, bei welcher eine entscheidende Person nur mit einer Wahrscheinlichkeit von 25% überhaupt teilnehmen darf. Wird die erste Stufe erfolgreich abgeschlossen, hat die Person die Wahl zwischen einem sicheren Prospect mit +3.000€ und einem unsicheren Prospect, welches entweder zu einem Ergebnis von +4.000€ mit einer Wahrscheinlichkeit von 80%, oder zu einem Ergebnis von 0€ mit einer Wahrscheinlichkeit von 20% führt. Cancellation führt dazu, dass die entscheiden-

⁴⁶Vgl. Chen und Vann (2017), S. 1375f.

⁴⁸Vgl. Tank (2017), S. 74f.

⁴⁹Vgl. Laux, Gillenkirch und Schenk-Mathes (2014), S. 198.

⁵⁰Vgl. Kahneman und Tversky (1979), S. 263.

⁵¹Vgl. Kahneman und Tversky (1979), S. 274.

⁵²Vgl. Kahneman und Tversky (1979), S. 273f.

⁵³Vgl. Kahneman und Tversky (1979), S. 274.

de Person die erste Stufe der Lotterie bei ihrer Entscheidung nicht beachten wird. 54

Zusätzlich zu den beschriebenen Heuristiken gehen Kahneman und Tversky (1979) davon aus, dass die entscheidenden Personen komplizierte Zahlen, wie z.B. Kommazahlen runden. Des Weiteren muss angenommen werden, dass entscheidende Personen stochastisch dominante Entscheidungsalternativen erkennen und sich sofort für diese Alternative entscheiden. Hierbei wird das dazugehörige Prospect nicht editiert. Diese Annahme ist notwendig, da die Prospect-Theorie in solchen Fällen das Entscheidungsverhalten nicht korrekt vorhersagt.⁵⁵

Als Beispiel werden zwei Prospects betrachtet. Der erste Prospect ist durch zwei Ergebnisse, das positive Ergebnis $+96 \in$ mit Wahrscheinlichkeit 90% und das Ergebnis $0 \in$ mit der Wahrscheinlichkeit 10% charakterisiert. Das zweite Prospect ist durch drei Ergebnisse, das positive Ergebnis $+96 \in$ mit Wahrscheinlichkeit 80%, das positive Ergebnis $+96 \in$ - X mit Wahrscheinlichkeit 10% und das Ergebnis $0 \in$ mit der Wahrscheinlichkeit 10% und das Ergebnis $0 \in$ mit der Wahrscheinlichkeit 10% und das Ergebnis $0 \in$ mit der Wahrscheinlichkeit 10% und das Ergebnis $0 \in$ mit der Wahrscheinlichkeit 10% charakterisiert. Die Variable X kann beliebige positive Werte annehmen. Es ist erkennbar, dass das erste Prospect in jedem Fall einen höheren Erwartungswert aufweist und weniger riskant ist. Allerdings werden sich entscheidende Personen der Prospect-Theorie folgend bei kleinen X trotzdem für den zweiten Prospect entscheiden. Dies wäre ein eindeutiger Verstoß gegen das stochastische Dominanzkriterium.⁵⁶

Nachdem die Editing-Phase abgeschlossen ist, folgt die Valuation-Phase. Hierbei findet die eigentliche Bewertung eines Prospects statt. Dieser Vorgang wird mithilfe einer Nutzenfunktion modelliert. Der Nutzen eines Prospects ergibt sich als gewichteter Erwartungswert der Ergebnisse. Es werden sowohl die einzelnen Ergebnisse als auch die dazugehörigen Wahrscheinlichkeiten mithilfe einer Gewichtungsfunktion gewichtet. Aus formaler Sicht gilt für den Nutzen U eines Prospects mit zwei Ergebnissen x, y und den dazugehörigen Wahrscheinlichkeiten w_x, w_y :

$$U(x, y, w_x, w_y) = \pi(w_x) \cdot u(x) + \pi(w_x) \cdot u(y);$$

für $x \le 0 \le y, x \ge 0 \ge y$, bzw.
$$U_{gem}(x, y, w_x, w_y) = u(y) + \pi(w_x) \cdot (u(x) - u(y));$$

für $x < y < 0, x > y > 0$,
(1)

wobei π die Gewichtungsfunktion der Wahrscheinlichkeiten und *u* die Gewichtungsfunktion der Ergebnisse, die sog. Wertfunktion ist. Es muss hierbei beachtet werden, dass die passende Nutzenfunktion von der Struktur der Ergebnisse abhängt. Es werden Nutzenfunktionen mit ausschließlich positiven, bzw. negativen Ergebnissen $U(x, y, w_x, w_y)$ und Nutzenfunktionen mit gemischten Ergebnissen U_{gem} unterschieden.⁵⁷ Die Wertfunktion ordnet jedem Ergebnis einen subjektiven Nutzenwert zu. Diese Funktion hat keine eindeutige Funktionsvorschrift. Allerdings müssen drei Eigenschaften erfüllt sein. Die erste Eigenschaft ergibt sich aus der Coding-Heuristik der Editing-Phase. Diese führt dazu, dass anstelle der tatsächlichen Ergebnisse die wahrgenommenen Ergebnisse des Prospects in die Bewertung und folglich in die Wertfunktion eingehen.⁵⁸ Die zweite Eigenschaft wird Verlustaversion genannt. Hierbei wird angenommen, dass entscheidende Personen negative Ergebnisse stärker gewichten als positive. Aus formaler Sicht bedeutet dies, dass die beiden Bedingungen:

$$U(x) < -U(-x) \text{ und } \frac{\partial U}{\partial x}(x) < \frac{\partial U}{\partial x}(-x),$$
 (2)

für jedes Ergebnis x stets erfüllt sind.⁵⁹ Die letzte angenommene Eigenschaft betrifft den genauen Funktionsverlauf der Wertefunktion. Kahneman und Tversky (1979) gehen davon aus, dass die Wertfunktion im positiven Ergebnisbereich konkav und im negativen Ergebnisbereich konvex ist.⁶⁰

Die Wahrscheinlichkeitsgewichtungsfunktion $\pi(w)$ ordnet objektiven Wahrscheinlichkeiten w subjektive Wahrscheinlichkeitsgewichte zu. Die Funktion weist sechs Eigenschaften auf. Die erste angenommene Eigenschaft ist, dass die Funktion streng monoton wachsend ist. Die zweite Eigenschaft besagt, dass die Funktion auf Wahrscheinlichkeitswerte zwischen null und eins normiert. Der Wahrscheinlichkeit 0% wird per Definition ein Wahrscheinlichkeitsgewicht von 0% zugeordnet, der Wahrscheinlichkeit 100% wird per Definition ein Wahrscheinlichkeitsgewicht von 100% zugeordnet.⁶¹ Die dritte Eigenschaft betrifft kleine Wahrscheinlichkeiten. In diesem Wertebereich ist die Gewichtungsfunktion eine subadditive Funktion. Aus formaler Sicht gilt folgender Zusammenhang:

$$\pi(rw) > r \cdot \pi(w) \text{ für } 0 < r < 1.$$
(3)

Als vierte Eigenschaft wird angenommen, dass kleine Wahrscheinlichkeiten stets überbewertet werden. Deshalb gilt in diesem Wertebereich zusätzlich: $\pi(w) > w$.⁶²

Als fünfte Eigenschaft wird Subsicherheit angenommen. Dies führt dazu, dass die Summe über alle Wahrscheinlichkeitsgewichte, im Gegensatz zur Summe über alle Wahrscheinlichkeiten, per Definition immer kleiner als eins angenommen wird. Die sechste Eigenschaft wird als Subproportionalität bezeichnet und ist für den gesamten Wertebereich gültig. Subproportionalität besagt, dass die Überbewertung kleiner Wahrscheinlichkeiten mit zunehmender Wahrscheinlichkeit abnimmt. Aus formaler Sicht muss folgender Zusammenhang gelten:

$$\frac{\pi(w_2)}{\pi(w_1)} \le \frac{\pi(r \cdot w_2)}{\pi(r \cdot w_1)} \text{ mit } 0 < r < 1, w_1 > w_2.^{63}$$
(4)

⁵⁴Vgl. Kahneman und Tversky (1979), S. 271; Kahneman und Tversky (1979), S. 274.

⁵⁵Vgl. Laux et al. (2014), S. 200.

⁵⁶Vgl. Laux et al. (2014), S. 209.

⁵⁷Vgl. Kahneman und Tversky (1979), S. 275f.

⁵⁸Vgl. Kahneman und Tversky (1979), S. 277f.

⁵⁹Vgl. Laux et al. (2014), S. 203.

⁶⁰Vgl. Laux et al. (2014), S. 203.

 ⁶¹Vgl. Kahneman und Tversky (1979), S. 280.
 ⁶²Vgl. Tank (2017), S. 81.

Nachdem der konkrete Nutzen aller Prospects bestimmt ist, wird sich die entscheidende Person für den Prospect mit dem höchsten Nutzen entscheiden.⁶⁴

3.2. Die zugrundeliegende Entscheidungssituation

Die Anwendung der Prospect-Theorie zur Beschreibung des Investitionsverhaltens erfordert eine zugrundeliegende Entscheidungssituation, welche durch mögliche Ergebnisse und dazugehörige Eintrittswahrscheinlichkeiten gekennzeichnet ist. Hierfür sind einige Annahmen erforderlich. So wird die Entscheidungssituation modellhaft auf einen einzelnen Entscheidungszeitpunkt reduziert. Dieser Zeitpunkt t liegt in der Gegenwart und bekommt deshalb den Wert t = 0 zugeordnet. Der Entscheidungszeitpunkt ist durch I zur Wahl stehende Investitionsalternativen gekennzeichnet. Da sich die Investitionsalternativen gegenseitig ausschließen, kann per Definition immer nur eine Investitionsalternative durchgeführt werden. Der Manager hat die Aufgabe eine Investitionsalternative A_i aus der Menge an Investitionsalternativen auszuwählen.⁶⁵ Es ergibt sich das Entscheidungsfeld Ω

$$\Omega = \{A_1; \dots; A_i; \dots; A_l\}.$$
(5)

Es muss beachtet werden, dass einer Investitionsalternative mehrere Investitionsmöglichkeiten zugeordnet werden können. Beispielhaft werden drei Investitionsmöglichkeiten a_1 , a_2 und a_3 betrachtet. Die Investitionsmöglichkeiten a_1 und a_2 schließen sich gegenseitig aus, a_3 kann mit den beiden anderen Investitionsmöglichkeiten kombiniert werden. Es ergeben sich fünf sich ausschließende Investitionsalternativen. So ist es möglich jeweils nur a_1 , a_2 oder a_3 getrennt durchzuführen. Außerdem kann entweder das Investitionsbündel a_1 und a_3 , oder das Investitionsbündel a_2 und a_3 durchgeführt werden.⁶⁶

Im Folgenden werden Investitionsalternativen zahlungsorientiert definiert. In dieser Sichtweise wird jede Investition in eine Summe von Zahlungsströmen z_t unterteilt, welche zu verschiedenen Zeitpunkten t anfallen. Der erste Zahlungsstrom der Summe z_0 ist per Definition immer eine Auszahlung und fällt zum Zeitpunkt der Entscheidung t = 0 an.⁶⁷ In der Regel ist nur diese anfängliche Auszahlung sicher bekannt. Alle anderen Zahlungsströme fallen in der Zukunft an, sind deshalb unsicher und haben den Charakter von Zufallsvariablen.⁶⁸

Im folgenden Modell werden zwei Vereinfachungen vorgenommen. So wird davon ausgegangen, dass die Investitionsdauer T einer Investition zum Entscheidungszeitpunkt

⁶³Vgl. Laux et al. (2014), S. 205.

bereits festgelegt wurde. Folglich sind seitens des Managers keine Entscheidungen zur Investitionsdauer möglich. Zusätzlich werden alle Zahlungsströme zu einem kumulierten Zahlungsstrom Z_T am Ende der Investitionsdauer zusammengefasst. Diese Vereinfachungen führen dazu, dass eine Investitionsalternative modellhaft nur aus einem Zahlungsstrom am Ende der Investitionsdauer besteht. Es gilt:

$$Z_T = \sum_{t=0}^T z_t.$$
 (6)

Es wird davon ausgegangen, dass der kumulierte Zahlungsstrom einer diskreten Zufallsverteilung folgt. Es werden *J* zukünftige Umweltzustände eingeführt, wobei ein Umweltzustand *j* in der Zukunft sicher eintritt. Die Höhe des zukünftigen Teils des kumulierten Zahlungsstroms einer Investition hängt vom eingetretenen Umweltzustand ab. Zum Entscheidungszeitpunkt ist jedoch unklar, welcher Umweltzustand in der Zukunft eintritt. Zu diesem Zeitpunkt kann jedem Umweltzustand *j* nur eine Eintrittswahrscheinlichkeit w_j zugeordnet werden.⁶⁹ Abbildung 2 zeigt die Zusammensetzung des kumulierten Zahlungsstroms. Es wird von einer Investitionsalternative mit einer Investitionsdauer von drei Perioden und drei zukünftigen Umweltzuständen ausgegangen.

3.3. Das Investitionsverhalten ohne Clawback-Klauseln

3.3.1. Die Entscheidungssituation aus Sicht des Managers

In der vorgestellten Entscheidungssituation werden Investitionsalternativen axiomatisch als Reihe von Zahlungsströmen eingeführt. Allerdings wird im Verlauf der Arbeit davon ausgegangen, dass der Manager die Investitionsalternativen anders wahrnimmt. Es muss hierbei beachtet werden, dass die Bewertung einer Investitionsalternative von den verfolgten Zielen abhängt. Der Manager könnte in der Investitionsentscheidung z.B. die Möglichkeit sehen, die Produktionskapazitäten des Unternehmens zu erhöhen. In diesem Fall wird der Manager die Investitionsalternativen hinsichtlich der zusätzlichen erwarteten Produktionskapazität bewerten und nicht hinsichtlich der erwarteten Zahlungsströme.⁷⁰

Abhängig vom Manager sind viele, zum Teil konkurrierende Ziele denkbar.⁷¹ Zur Vereinfachung wird deshalb im Folgenden auf eine verbreitete Modellvorstellung aus der Mikroökonomik zurückgegriffen. Es wird angenommen, dass der Manager bei der Arbeit nur ein Ziel verfolgt, die Maximierung seiner Vergütung. Dies impliziert, dass die Arbeit an sich für den Manager keinen Nutzen stiftet. Der Manager arbeitet ausschließlich wegen der Vergütung, welche ihm seinen zukünftigen Konsum ermöglicht.⁷² Folglich wird der Manager die Investitionsalternativen hinsichtlich der erwarteten Vergütung und nicht hinsichtlich der erwarteten Zahlungsströme bewerten.

⁶⁴Vgl. Kahneman und Tversky (1979), S. 274.

⁶⁵Die beschriebene Entscheidungssituation entspricht aus finanzwirtschaftlicher Sicht einer Einzelentscheidung mit Auswahlproblem, vgl. Schäfer (2005), S. 23.

⁶⁶Vgl. Schäfer (2005), S. 13–15.

⁶⁷Vgl. Kruschwitz und Lorenz (2019), S. 3.

⁶⁸Vgl. Schäfer (2005), S. 9–13.

⁶⁹Vgl. Schäfer (2005), S. 236–240.

⁷⁰Vgl. Laux et al. (2014), S. 7.

⁷¹Vgl. Kruschwitz und Lorenz (2019), S. 9f.

⁷²Vgl. Woeckener (2020), S. 49.



Abbildung 2: Die beispielhafte Zusammensetzung des kumulierten Zahlungsstroms

Die Vergütung des Managers v_{ges} setzt sich üblicherweise aus den fixen und variablen Bestandteilen v_{fix} , bzw. v_{var} zusammen, es gilt:

$$v_{ges} = v_{fix} + v_{var}.$$
(7)

Die Höhe der fixen Vergütung ist vertraglich festgelegt und wird unabhängig von den persönlichen Leistungen und Entscheidungen des Managers immer in voller Höhe ausgezahlt. Im Gegensatz dazu hängt die Höhe der variablen Vergütung von den persönlichen Leistungen und Entscheidungen des Managers ab. Es sind verschiedenste Bemessungsgrundlagen denkbar. Sowohl individuelle Zielvereinbarungen als auch finanzielle Kennzahlen, wie z.B. der Gewinn, und nicht-finanzielle Kennzahlen, wie z.B. die Einschätzung des Vorgesetzten, können genutzt werden.⁷³

Im Folgenden werden vereinfachend nur Bonuszahlungen betrachtet. Bonuszahlungen erfolgen einmal jährlich und werden auf Basis betriebswirtschaftlicher Erfolgskennzahlen, wie z.B. dem Gewinn, ermittelt.⁷⁴ Mit Bonuszahlungen sollen Manager dazu motiviert werden, im Sinne des Unternehmens zu handeln.⁷⁵ Für die Bonuszahlung *b* wird im Modell folgender Zusammenhang angenommen:

$$b = v_{\text{var}} = \max(\alpha \cdot g; 0), \text{ mit } 0 < \alpha < 1.$$
(8)

Die Variable g steht hierbei für den jährlichen Gewinn des Unternehmens, die Variable α ist ein Proportionalitätsfaktor.

Die Maximumsfunktion schließt bei einem Jahresverlust eine Maluszahlung seitens des Managers aus. Hiermit wird der Prämiencharakter der Bonuszahlung hervorgehoben.

Im folgenden Modell werden, analog zum kumulierten Zahlungsstrom, zwei Vereinfachungen vorgenommen. So werden die gleichen Zeitpunkte genutzt, wie bei der zahlungsorientierten Sichtweise. Dies muss in der Realität nicht zwingend erfüllt sein. Außerdem werden alle Vergütungszahlungen zu einer kumulierten Vergütungszahlung $V_{ges,T}$ am Ende der Investitionsdauer T zusammengefasst. Es gilt:

$$V_{ges,T} = \sum_{t=0}^{T} \left(v_{fix} + \max(\alpha \cdot g_t; 0) \right)$$

= $(T+1) \cdot v_{fix} + \sum_{t=0}^{\tau} \max(\alpha \cdot g_t; 0).$ (9)

Diese Vereinfachungen führen dazu, dass eine Investitionsalternative modellhaft nur durch eine Vergütungszahlung am Ende der Investitionsdauer beschrieben wird.

3.3.2. Der Zusammenhang zwischen Vergütung und Investitionsalternative

Die Vergütung des Managers ist dann als Bewertungskriterium einer Investitionsalternativen geeignet, wenn ein Zusammenhang zur Investitionsalternative besteht. Ist diese Bedingung nicht erfüllt, bekommt der Manager unabhängig von seiner Entscheidung immer Vergütung in gleicher Höhe ausbezahlt. Er wäre indifferent zwischen allen zur Wahl stehenden Investitionsalternativen und könnte sich nicht für eine Investitionsalternative entscheiden. Nachfolgend wird gezeigt, dass ein solcher Zusammenhang mit den Bonuszahlungen des Managers besteht. Die fixe Vergütung ist bekanntlich

⁷³Vgl. Stock-Homburg (2013), S. 305–309.

⁷⁴Vgl. Breisig (2003), S. 199–201.

⁷⁵Vgl. Von Hülsen (2019), S. 12.

per Definition unabhängig von den Entscheidungen des Managers.

Ausgangpunkt der folgenden Überlegungen bilden deshalb die Bonuszahlungen, welche aus dem Gewinn des Unternehmens bestimmt werden. Der Gewinn des Unternehmens ergibt sich, wenn vom gesamten Zahlungsüberschuss des Unternehmens die Abschreibungen des Unternehmens abgezogen werden. Der Zahlungsüberschuss setzt sich wiederum aus den erwirtschafteten Zahlungsströmen aller Unternehmensinvestitionen zusammen. Diese Zahlungsströme enthalten nicht die Auszahlungen zu Beginn einer Investition. Diese Auszahlungen werden auf die geplanten Abschreibungsjahre aufgeteilt und abgeschrieben.⁷⁶

Je nach gewählter Investitionsalternative entstehen während der Investitionsdauer unterschiedliche zusätzliche Zahlungsströme, welche zum restlichen Zahlungsüberschuss, bzw. zu den restlichen Abschreibungen des Unternehmens addiert werden. Dies führt dazu, dass der Gewinn des Unternehmens und folglich die persönlichen Bonuszahlungen des Managers von der gewählten Investitionsalternative abhängen.

Des Weiteren ist zu beachten, dass die zukünftigen Zahlungsströme einer Investitionsalternative im Modell vom eingetretenen Umweltzustand abhängen. Folglich hängen auch die zukünftigen Bonuszahlungen des Mangers vom eingetretenen Umweltzustand ab. Hierbei muss berücksichtigt werden, dass die zum Entscheidungszeitpunkt ausbezahlte Bonuszahlung nicht von der gewählten Investitionsalternative abhängt. So fällt zwar per Definition eine Auszahlung bereits zum Entscheidungszeitpunkt an, diese ist allerdings nicht erfolgswirksam. Die erste Abschreibung erfolgt erst zum nächsten Zeitpunkt.

3.3.3. Das Investitionsverhalten des Managers

Im nächsten Schritt wird das Investitionsverhalten des Managers mithilfe der Prospect-Theorie modelliert. Zur Anwendung der Theorie werden sowohl die Editing-Phase als auch die Valuation-Phase in das bisherige Modell überführt. Aufgrund der zeitlichen Abfolge im Modell wird mit der Editing-Phase begonnen.⁷⁷ Es wird vereinfachend davon ausgegangen, dass nur ein Effekt während der Editing-Phase auftritt. Es wird angenommen, dass es zu einer Cancellation kommt.

Aufgrund der beschriebenen Überlegungen im vorherigen Unterkapitel, wird unterstellt, dass die kumulierte fixe Vergütung und die Bonuszahlung zum Entscheidungszeitpunkt unabhängig von der Investitionsentscheidung sind. Folglich sollten diese Bestandteile der Vergütung in der Editing-Phase aus dem Entscheidungsproblem eliminiert werden.⁷⁸ Abbildung 3 zeigt den entscheidungsrelevanten Teil der kumulierten Vergütung und wie dieser sich zusammensetzt. Im gewählten Beispiel fallen Vergütungszahlungen zum Entscheidungszeitpunkt und zu Zeitpunkt 1, Zeitpunkt 2, bzw. Zeitpunkt 3 an. Somit bleibt nur die kumulierte zukünftige Bonuszahlung B_T als entscheidungsrelevantes Ergebnis übrig. Es gilt:

$$B_T = \sum_{t=1}^T \max(\alpha \cdot g_t; 0).$$
(10)

Nach der Editing-Phase folgt die Valuation-Phase. In dieser wird mittels einer Nutzenfunktion der Nutzen einer Investitionsalternative bestimmt. Der Prospect-Theorie folgend, sind zwei verschiedene Arten von Nutzenfunktionen denkbar. Es werden Nutzenfunktionen mit ausschließlich positiven, bzw. negativen Ergebnissen und Nutzenfunktionen mit gemischten Ergebnissen unterschieden.⁷⁹

Im Folgenden wird eine Nutzenfunktion mit gemischten Ergebnissen genutzt. Dies wird damit erklärt, dass über Gleichung (3.8) Umweltzustände erlaubt sind, bei welchen kein Bonus ausgezahlt wird. Nachfolgend wird angenommen, dass ein solcher Umweltzustand bei jeder Investitionsalternative existiert. In diesem Fall ist die Bedingung ausschließlich positiver oder negativer Ergebnisse verletzt. Für die Nutzenfunktion $U_{i,gem}$ einer Investitionsalternative i wird folgender Zusammenhang angenommen:

$$U_{i,gem}(B_{T,j}, w_j) = \sum_{j=1}^{J} \pi(w_j) \cdot u(B_{T,j}).$$
(11)

Zur Vereinfachung der Notation von Gleichung (3.11) gilt nachfolgend: $U_{i,gem} = U_i$. Für den Manager ergibt sich bei *I* Investitionsalternativen das folgende Entscheidungsfeld Ω :

$$\Omega = \{U_1; \dots; U_i; \dots; U_i\}.$$
(12)

Gemäß der Prospect-Theorie wird der Manager aus dieser Menge die Investitionsalternative i mit dem größten Nutzen auswählen.

3.4. Das Investitionsverhalten bei Clawback-Klauseln

3.4.1. Die Modellierung der Merkmale einer Clawback-Klausel

Im nachfolgenden Unterkapitel werden Clawback-Klauseln in das Modell integriert. Nach Erkens et al. (2018) ist eine Clawback-Klausel durch fünf Merkmale gekennzeichnet:

- (1) die betroffene Vergütungsart,
- (2) die betroffene Mitarbeitergruppe,
- (3) den betroffenen Vergütungsanteil der Vergütungsart,
- (4) die zeitliche Wirksamkeit,
- (5) das Trigger-Event.⁸⁰

⁷⁶Vgl. Küpper, Friedl, Hofmann, Hofmann und Pedell (2013), S. 321.

⁷⁷Vgl. Kapitel 3.1.

⁷⁸Vgl. Kapitel 3.1.

⁷⁹Vgl. Kapitel 3.1.

⁸⁰Vgl. Erkens et al. (2018), S. 292.



Abbildung 3: Die Zusammensetzung der kumulierten Vergütung

Die genannten Merkmale dienen als Basis für die nachfolgende Modellierung. Der Fokus des Modells liegt nicht auf einer Gruppe von Menschen, sondern auf einer einzelnen Person. Es wird ein Manager betrachtet, welcher per Definition von einer Clawback-Klausel betroffen ist. Die vier anderen Merkmale werden im Folgenden modelliert. Für die Modellierung muss die von der Clawback-Klausel betroffene Vergütungsart eingegrenzt werden. Es wird hierbei angenommen, dass die modellierte Clawback-Klausel nur die Bonuszahlungen betrifft. Diese Annahme ergibt sich aus der Unternehmenspraxis. Es zeigt sich, dass Clawback-Klauseln überwiegend auf das variable Einkommen beschränkt sind.⁸¹

Im nächsten Schritt werden die Trigger-Events der Clawback-Klausel betrachtet. Es ergibt sich eine zeitliche Bedingung. Es muss beachtet werden, dass die Aktivierung einer Clawback-Klausel dann sinnvoll ist, wenn bereits mindestens eine Bonuszahlung erfolgt ist. Ist dies nicht der Fall, kann vom Manager nichts zurückgefordert werden. Die Bonuszahlungen im Modell fallen per Definition immer am Ende der Investitionsdauer einer Investitionsalternative an. Folglich kann davon ausgegangen werden, dass die modellierte Clawback-Klausel erst zu einem Zeitpunkt nach dem Ende der Investitionsdauer aktiviert wird.

Abhängig von der Art der Clawback-Klausel, sind verschiedene Trigger-Events denkbar. So werden z.B. SOX-Clawbacks aktiviert, wenn ein Restatement des Jahresabschlusses notwendig wird. Im Gegensatz dazu werden z.B. IGV-Clawbacks aktiviert, wenn dem betroffenen Manager gravierende Fehlentscheidungen nachgewiesen werden können.⁸² Aufgrund dieser Vielfältigkeit wird im Modell kein genaues Trigger-Event festgelegt. Es wird stattdessen die Trigger-Wahrscheinlichkeit p_j der Clawback-Klauseln eingeführt. Diese Kenngröße beschreibt die Wahrscheinlichkeit, dass ein Trigger-Event auftritt und die Clawback-Klausel ausgelöst wird. Die Wahrscheinlichkeit ist abhängig vom eingetretenen Umweltzustand.

Beispielhaft wird eine Clawback-Klausel betrachtet, welche bei einer Fehlentscheidung des Managers aktiviert wird. Zum Entscheidungszeitpunkt ist in vielen Fällen nicht klar, ob die Entscheidung eine Fehlentscheidung ist. Entscheidet sich der Manager z.B. die Entwicklung eines neuen Produktes zu starten, dann hängt die Bewertung der Entscheidung stark vom eingetretenen Umweltzustand ab. Ist das neue Produkt am Markt erfolgreich, wird die Entscheidung des Managers im Nachhinein wahrscheinlich nicht als Fehlentscheidung interpretiert. In diesem Umweltzustand ist die Trigger-Wahrscheinlichkeit der Clawback-Klausel gering. Ist das Produkt jedoch am Markt nicht erfolgreich, dann ist es durchaus denkbar, dass die Entscheidung des Managers im Nachhinein als Fehlentscheidung interpretiert wird. In diesem Umweltzustand ist die Trigger-Wahrscheinlichkeit der Clawback-Klausel deutlich größer.

Im nächsten Schritt wird festgelegt, welcher Anteil der bereits ausgezahlten Bonuszahlungen nach der Aktivierung der Clawback-Klausel zurückgefordert werden kann. Dieser Anteil ist durch den Wirkungszeitraum der Clawback-Klausel und den betroffenen Umfang der Bonuszahlungen begrenzt. Der Wirkungszeitrum ist eine zeitliche Begrenzung, bis zu welchem Zeitpunkt in der Vergangenheit Bonuszahlungen zurückgefordert werden können. Der Wirkungszeitraum hängt von der Art der Clawback-Klausel ab. Clawback-Klauseln, wie z.B. SOX-Klauseln, sind auf einen festen Zeitraum, z.B. die letzten zwölf Monate, beschränkt. Andere Clawback-Klauseln, wie z.B. IGV-Clawbacks, sind auf keinen festen Zeitraum beschränkt. Die zeitliche Begrenzung einer solchen Klausel hängt von der Art und Schwere der Fehlentscheidung (oder sonstigem Trigger Event) ab.⁸³ Der Wirkungszeitraum ist im Modell hingegen klar begrenzt. Da im Modell die kumulierte Bonuszahlung anfällt, muss sich der Wirkungszeitraum der Clawback-Klausel auf diese Zahlung beziehen.

⁸¹Vgl. Kapitel 2.1 und Kapitel 2.2.

⁸²Vgl. Kapitel 2.1.

⁸³Vgl. Kapitel 2.1.

Der betroffene Umfang ist eine inhaltliche Begrenzung der Clawback-Klausel, welcher den Anteil einer vergangenen Bonuszahlung vorgibt, der zurückgefordert werden kann. Hierbei gibt es abhängig von der Art der Clawback-Klausel große Unterschiede. Einerseits schreiben Regelungen, wie z.B. die Investitionsgüterverordnung in Deutschland vor, dass nach der Aktivierung solcher Klauseln die gesamte variable ausgezahlte Vergütung zurückgefordert werden muss. Andererseits wird in den USA der Dodd-Frank-Act diskutiert, welcher es den Unternehmen ermöglicht, bereits ausgezahlte Bonuszahlungen nur teilweise wieder zurückzufordern.⁸⁴ Die inhaltliche Begrenzung der Clawback-Klausel wird im Modell über den Vergütungsanteil β abgebildet. Wird der Parameter auf eins gesetzt, ermöglicht die Clawback-Klausel die Rückforderung der gesamten Bonuszahlungen und es können z.B. IGV-Clawbacks abgebildet werden. Wird der Parameter auf Werte kleiner eins gesetzt, können DFA-Clawbacks abgebildet werden.

3.4.2. Das veränderte Investitionsverhalten des Managers

Bevor die Nutzenfunktion des Managers bei Clawback-Klauseln bestimmt wird, müssen zwei Vorüberlegungen erfolgen. Die erste Vorüberlegung betrifft die Anzahl der Umweltzustände. Die eingeführte Trigger-Wahrscheinlichkeit führt dazu, dass je Umweltzustand zwei Fälle unterschieden werden müssen. In einem Fall wird die Clawback-Klausel ausgelöst und im anderen Fall wird die Clawback-Klausel nicht ausgelöst. Folglich existieren aus der Sicht des Managers nicht *J* Umweltzustände, sondern $2 \cdot J$ Umweltzustände.

Die beiden beschriebenen Fälle werden im Folgenden als Clawback-Zustände *c* bezeichnet. Per Definition gibt es je Umweltzustand *j* zwei Clawback-Zustände. Es wird festgelegt, dass im Clawback-Zustand *c* = 1 die Clawback-Klausel aktiviert wird, bzw. dass im Clawback-Zustand *c* = 2 die Clawback-Klausel nicht aktiviert wird. Die Wahrscheinlichkeit, dass der Clawback-Zustand eins in einem Umweltzustand eintritt, beträgt z.B. $w_j \cdot_{j,1}$, bzw. $w_j \cdot (1 - p_{(j,2)})$. Zum besseren Verständnis der weiteren Überlegungen wird die Wahrscheinlichkeit $p_{j,c}$ nachfolgend als Clawback-Wahrscheinlichkeit bezeichnet. Abbildung 4 verdeutlicht den Zusammenhang für zwei Umweltzustände. Außerdem gilt für die Wahrscheinlichkeit w_i :

$$w_{j} = w_{j} \cdot p_{j,1} + w_{j} \cdot p_{j,2} \tag{13}$$

Die zweite Vorüberlegung betrifft den von der Clawback-Klausel betroffenen Vergütungsanteil. Aus zeitlicher Sicht ist dieser auf die kumulierte Bonuszahlung B_T beschränkt. Der inhaltliche Vergütungsanteil β hängt hingegen vom eingetretenen Clawback-Zustand ab. Dies führt dazu, dass beim Clawback-Zustand c = 2 die Clawback-Klausel nicht aktiviert wird. Folglich muss der Vergütungsanteil in diesem Clawback-Zustand definitorisch null betragen. Die Vergütung, welche von der Clawback-Klausel betroffen ist, ergibt sich für jeden Clawback-Zustand c über den Term: $\beta_{j,c} \cdot B_{T,j}$. Es muss hierbei beachtet werden, dass die kumulierte Bonuszahlung am Entscheidungszeitpunkt noch nicht ausgezahlt wurde. Folglich sollte der Manager nicht am zurückgeforderten Anteil der Bonuszahlung interessiert sein, sondern am Anteil der Bonuszahlung, welchen er langfristig behalten darf. Für diesen Anteil B_{res} gilt für jeden Clawback-Zustand c der folgende Zusammenhang:

$$B_{\text{res. }jc} = \left(1 - \beta_{j,c}\right) \cdot B_{T,j} \tag{14}$$

Über Gleichung 4.9 und Gleichung 4.10 ergibt sich die Nutzenfunktion $U_{cl,i}$ des Managers bei Clawback-Klauseln für eine Investitionsalternative *i*. Es gilt:

$$U_{cl,i} = \sum_{j=1}^{J} \sum_{c=1}^{2} \pi \left(w_{j} \cdot p_{j,c} \right) \cdot u \left(\left(1 - \beta_{j,c} \right) \cdot B_{T,j} \right).$$
(15)

Aus der Nutzenfunktion ergibt sich das Investitionsverhalten des Managers. Für den Manager ergibt sich bei I Investitionsalternativen das folgende Entscheidungsfeld Ω :

$$\Omega = \left\{ U_{ci,1}; \dots; U_{cL,i}; \dots; U_{cl,i} \right\}.$$
 (16)

Gemäß Prospect-Theorie wird der Manager aus dieser Menge die Investitionsalternative *i* mit dem größten Nutzen auswählen.

4. Herleitung der Forschungshypothesen

Aufbauend auf Kapitel 3, werden im folgenden Kapitel mögliche Effekte von Clawback-Klauseln auf das Investitionsverhalten abgeleitet und als Forschungshypothesen formuliert. Hierbei wird im ersten Schritt aufgezeigt, dass Clawback-Klauseln das Investitionsverhalten nur bei Gültigkeit einer bestimmten Bedingung verändern können (4.1). Im zweiten Schritt werden Entscheidungssituationen mit entscheidungsunabhängigen Clawback-Wahrscheinlichkeiten untersucht. Es zeigt sich, dass in dieser Gruppe von Entscheidungssituationen eine weitere Bedingung erfüllt sein muss, bevor es zu einer Veränderung des Investitionsverhaltens kommt (4.2). Abschließend werden die hergeleiteten Forschungshypothesen nochmals zusammengefasst (4.3).

4.1. Die Bedingung für eine Veränderung des Investitionsverhaltens

4.1.1. Die Herleitung über Nutzendifferenzen

Im Folgenden wird untersucht, unter welchen Bedingungen Clawback-Klauseln das Investitionsverhalten verändern werden. Hierbei werden die Investitionsalternativen A_1 und A_2 einer Entscheidungssituation mit beliebig vielen Investitionsalternativen betrachtet. Es wird angenommen, dass sich der Manager ohne Clawback-Klausel für die Investitionsalternative A_1 entscheiden würde. Folglich muss folgender Zusammenhang gelten:

$$U(A_2) < U(A_1).$$
 (17)

⁸⁴Vgl. Kapitel 2.1.



Abbildung 4: Der Zusammenhang zwischen Umweltzustand und Clawback-Zustand

Der Manager verändert sein Investitionsverhalten, wenn er sich bei Clawback-Klauseln für Investitionsalternative A_2 entscheidet, oder wenn er zwischen den beiden Investitionsalternativen indifferent ist. Folglich muss in diesem Fall folgender Zusammenhang gelten:

$$U_{cl}(A_2) \ge U_{cl}(A_1).$$
 (18)

Für den Nutzen einer Investitionsalternative A_i bei Clawback-Klauseln gilt prinzipiell:

$$U_{cl}(A_i) = U(A_i) - (U(A_i) - U_{cl}(A_i)).$$
(19)

Die Nutzendifferenz $U(A_i) - U_{cl}(A_i)$ beschreibt die Veränderung des Nutzens einer Investitionsalternative, wenn Clawback-Klauseln in die Entscheidungssituation eingeführt werden. Die Nutzendifferenz wird im Folgenden als D_i bezeichnet. Gleichung (4.3) vereinfacht sich so zu:

$$U_{cl}(A_i) = U(A_i) - D_t$$
⁽²⁰⁾

Durch Einsetzten von Gleichung (4.4) in Gleichung (4.2), resultiert:

$$U(A_2) - D_2 \ge U(A_1) - D_1$$
, bzw. $D_2 \le D_1 - (U(A_1) - U(A_2))$.
(21)

Aus dem hergeleiteten Zusammenhang ergeben sich Aussagen über eine mögliche Veränderung des Investitionsverhaltens. Es zeigt sich, dass sich das Investitionsverhalten nur verändert, wenn die Nutzendifferenz von Investitionsalternative A_2 kleiner ist als die Nutzendifferenz von Investitionsalternative A_1 . Diese Bedingung reicht allein nicht aus. Es muss zusätzlich bedacht werden, dass im Fall ohne Clawback-Klauseln bereits ein initialer Nutzenunterschied $U(A_1) - U(A_2)$ zwischen den beiden Investitionsalternativen besteht. Der initiale Nutzenunterschied ist, wie aus Gleichung (4.1) erkennbar ist, stets positiv. Folglich muss die Nutzendifferenz von Investitionsalternative A_2 kleiner oder gleich der Nutzendifferenz von Investitionsalternative A_1 sein, abzüglich dieses initialen Nutzenunterschieds.

Das folgende Beispiel verdeutlicht den Zusammenhang. Es wird davon ausgegangen, dass $U(A_1) = 11$, bzw. $U_{cl}(A_1) = 6$ und $U(A_2) = 9$, bzw. $U_{cl}(A_2) = 5$ ist. Folglich ist $D_1 = 5$ und $D_2 = 4$ und die Nutzendifferenz von Investitionsalternative A_2 ist kleiner als die Nutzendifferenz von Investitionsalternative A_1 . Allerdings ist der Nutzen von Investitionsalternative A_1 auch bei Clawback-Klauseln immer noch größer. Dieser Fall entsteht, da die zweite hergeleitete Bedingung verletzt wird. Die Nutzendifferenz von Investitionsalternative A_2 ist mit $D_2 = 4$ größer und nicht kleiner als die Nutzendifferenz D_1 von Investitionsalternative A_1 abzüglich des initialen Nutzenunterschieds. Es gilt: 4 > 5 - (11 - 9), bzw. 4 > 3.

4.1.2. Die Analyse der Nutzendifferenzen

Zum besseren Verständnis der hergeleiteten Bedingung ist es sinnvoll, die eingeführten Nutzendifferenzen näher zu betrachten. Zur Analyse der Nutzendifferenzen wird die Gleichung (4.4) nach D_i aufgelöst und es wird für die beiden Nutzenwerte $U(A_i)$ und $U_{cl}(A_i)$ jeweils der funktionale Zusammenhang eingesetzt:

$$D_{i} = U_{i} - U_{cli} = \sum_{j=1}^{J} \pi(w_{j}) \cdot u(B_{\tau,j})$$

$$- \sum_{j=1}^{J} \sum_{c=1}^{2} \pi(w_{j} \cdot p_{j,c}) \cdot u((1 - \beta_{j,c}) \cdot B_{\tau,j})$$

$$= \sum_{j=1}^{J} (\pi(w_{j}) - \pi(w_{j} \cdot p_{j,2})) \cdot u(B_{T,j})$$

$$- \pi(w_{j} \cdot p_{j,1}) \cdot u((1 - \beta_{j,1}) \cdot B_{T,j})$$
(22)

Es resultiert eine komplexe Gleichung, welche stark von den Eintrittswahrscheinlichkeiten der Umweltzustände w_j , den Bonuszahlungen $B_{T,j}$, den Wahrscheinlichkeiten $p_{j,c}$ und den jeweiligen Vergütungsanteilen $\beta_{j,c}$ abhängt. Im Folgenden wird deshalb eine vereinfachende Annahme getroffen. Der Vergütungsanteil $\beta_{j,c}$ wird für jeden Umweltzustand per Definition auf eins gesetzt. Es muss beachtet werden, dass nun keine DFA-Clawbacks mehr abgebildet werden können. Es resultiert die vereinfachte Nutzendifferenz D_i^* :

$$D_{i}^{*} = \sum_{j=1}^{J} \left(\pi \left(w_{j} \right) - \pi \left(w_{j} \cdot \left(1 - p_{j,1} \right) \right) \right) \cdot u \left(B_{T,j} \right).$$
(23)

Hierbei muss beachtet werden, dass die Wahrscheinlichkeit $p_{j,2}$, durch den Term $1 - p_{j,1}$ ersetzt wurde. Dies vereinfacht die nachfolgenden Überlegungen. Die Clawback-Wahrscheinlichkeit $p_{j,1}$ ist deutlich verständlicher als die Wahrscheinlichkeit $p_{j,c}$, welche die Wahrscheinlichkeit beschreibt, dass die Clawback-Klausel nicht aktiviert wird. Die Eintrittswahrscheinlichkeiten w_j und die Bonuszahlungen $B_{T,j}$ sind unabhängig von der Existenz einer Clawback-Klausel und von der Entscheidungssituation fest vorgegeben. Folglich zeigt sich der Einfluss von der modellierten Clawback-Klausel auf die Nutzendifferenz D_i^* nur über die Wahrscheinlichkeit $1 - p_{j,1}$.

Aus formaler Sicht ergibt sich eine minimale und eine maximale Nutzendifferenz. Wenn die Clawback-Wahrscheinlichkeit in jedem Umweltzustand eins beträgt, die Clawback-Klausel also in jedem Umweltzustand sicher aktiviert wird, dann ist die Wahrscheinlichkeit $1 - p_{j,1}$ gleich null und die Nutzendifferenz maximal. In diesem Fall entspricht die Nutzendifferenz dem Nutzenbetrag der jeweiligen Investitionsalternative ohne Clawback-Klausel und die Investitionsalternative stiftet keinen Nutzen. Im Gegensatz dazu wird die minimale Nutzendifferenz erreicht, wenn die Clawback-Wahrscheinlichkeit in jedem Umweltzustand null beträgt. In diesem Fall ist die Wahrscheinlichkeit $1 - p_{i,1}$ gleich null und es gibt keine Nutzendifferenz. Der Nutzenbetrag der jeweiligen Investitionsalternative ohne Clawback-Klausel entspricht dem Nutzenbetrag der jeweiligen Investitionsalternative mit Clawback-Klausel.

Als Konsequenz ist die Nutzendifferenz auf einen positiven Wertebereich beschränkt und kann niemals kleiner als null werden. Diese Beobachtung lässt zwei interessante Schlussfolgerungen zu. Eine Nutzendifferenz, welche nie negativ wird, bedeutet, dass der Nutzen einer Investitionsalternative bei Clawback-Klauseln nie größer ist als der Nutzen einer Investitionsalternative ohne Clawback-Klauseln. Ist eine Wahrscheinlichkeit p_2 in einem Umweltzustand kleiner als eins, dann ist der Nutzen einer Investitionsalternative bei Clawback-Klauseln sogar immer geringer als der Nutzen einer Investitionsalternative ohne Clawback-Klauseln.

Zusätzlich ergeben sich klare Aussagen über die Veränderung der Nutzendifferenz in Abhängigkeit von der Wahrscheinlichkeit $1 - p_{j,1}$. Hierbei muss Gleichung (4.7) erneut betrachtet werden. Es muss berücksichtigt werden, dass die Gewichtungsfunktion π in der Prospect-Theorie streng monoton wachsend ist. Wird nun auf Basis der vorhergegangenen Ausführungen davon ausgegangen, dass w_i in jedem Umweltzustand größer als $w_j \cdot (1-p_{j,1})$ ist, dann ist die Differenz der Gewichtungsfunktionen $\pi(w_j) - \pi(w_j \cdot (1-p_{j,1}))$ in jedem Umweltzustand positiv und folglich auch die Nutzendifferenz D_i^* umso größer, je kleiner die entsprechende Wahrscheinlichkeit $1-p_{j,1}$ ist.

Die beschriebenen Eigenschaften der Nutzendifferenz führen dazu, dass die über Gleichung (4.5) hergeleitete Bedingung für eine Veränderung des Investitionsverhaltens besser interpretiert werden kann. Eine kleine Nutzendifferenz bei Investitionsalternative A_2 wird erreicht, wenn die Clawback-Wahrscheinlichkeit klein und folglich die Wahrscheinlichkeit $1 - p_{j,1}$ bei Investitionsalternative A_2 in allen Umweltzuständen groß ist. Somit ist es sehr wahrscheinlich, dass die Clawback-Klausel bei einer Entscheidung für Investitionsalternative A_2 nicht ausgelöst wird.

Eine größere Nutzendifferenz bei Investitionsalternative A_1 entsteht unter anderem, wenn die Clawback-Wahrscheinlichkeit, bzw. die Wahrscheinlichkeit $1 - p_{j,1}$, bei Investitionsalternative A_1 in allen Umweltzuständen tendenziell größer, bzw. kleiner, ist als bei Investitionsalternative A_2 . Folglich muss es bei einer Entscheidung für Investitionsalternative A_1 wahrscheinlicher sein, dass die Clawback-Klausel aktiviert wird. Die genaue erforderliche Nutzendifferenz für eine Veränderung des Investitionsverhaltens hängt vom initialen Nutzenunterschied zwischen den Investitionsalternativen und somit von der jeweiligen Entscheidungssituation ab. Als Konsequenz ist es schwierig die erforderliche Nutzendifferenz für eine Veränderung des Investitionsverhaltens ohne konkrete Entscheidungssituation zu bestimmen.

Jedoch zeigt sich, dass bei einer ausreichend großen Clawback-Wahrscheinlichkeit bei Investitionsalternative A_1 , diese erforderliche Nutzendifferenz in jeder zulässigen Entscheidungssituation existiert. Dies wird erkennbar, wenn die maximale Nutzendifferenz von Investitionsalternative A_1 in Gleichung (4.5) eingesetzt wird. Die maximale Nutzendifferenz wird erreicht, wenn die Clawback-Wahrscheinlichkeit in jedem Umweltzustand eins beträgt, bzw. die Wahrscheinlichkeit $p_{j,2}$ in jedem Umweltzustand null beträgt. Aus formaler Sicht gilt dann $D_1 = UA_1$ und der Zusammenhang vereinfacht sich zu:

$$D_2 \le U(A_2). \tag{24}$$

Es ist ersichtlich, dass die vereinfachte Bedingung stets erfüllt ist. Die Differenz D_2 kann per Definition nur Werte zwischen null und $U(A_2)$ annehmen. Somit ist der initiale Nutzenunterschied zumindest im Grenzfall immer irrelevant.

Zusammenfassend ergibt sich folgende Forschungshypothese:

> H1: Eine ausreichend große und von der Investitionsentscheidung abhängige Clawback-Wahrscheinlichkeit bei einer vormals dominanten Investitionsalternative verändert das Investitionsverhalten.

4.2. Der Spezialfall unabhängiger Clawback-Wahrscheinlichkeiten

Die bisherigen Überlegungen erwecken den Eindruck, dass sich das Investitionsverhalten insbesondere dann ändert, wenn die Clawback-Wahrscheinlichkeit und folglich Wahrscheinlichkeit $1-p_{j,1}$ in allen Umweltzuständen von Investitionsalternative A_2 tendenziell größer ist als bei Investitionsalternative A_1 . Es gibt jedoch Entscheidungssituationen, bei welchen die Wahrscheinlichkeit $1-p_{j,1}$ bei jeder Investitionsalternative und in jedem Umweltzustand identisch ist und trotzdem eine Veränderung des Investitionsverhaltens beobachtet wird.

Ein Beispiel für eine solche Entscheidungssituation sind die Probleme drei und vier von Kahneman und Tversky (1979). In den beiden Experimenten waren Probanden jeweils aufgefordert sich für eine von zwei zur Wahl stehenden Investitionsalternativen zu entscheiden. In Problem drei stand eine sichere Investitionsalternative mit 3.000\$ und eine riskante Investitionsalternative, welche mit einer Wahrscheinlichkeit von 80% 4.000\$ liefert und mit einer Wahrscheinlichkeit von 20% 0\$ liefert, zur Wahl. In diesem Experiment haben sich 80% der Probanden für die erste Investitionsalternative und 20% der Probanden für die zweite Investitionsalternative entschieden.⁸⁵

Problem vier war durch eine ähnliche Entscheidungssituation gekennzeichnet. Allerdings wurden die Eintrittswahrscheinlichkeiten der Ergebnisse der beiden Investitionsalternativen um 75% reduziert. Somit standen eine Investitionsalternative, welche mit einer Wahrscheinlichkeit von 25% 3.000\$ liefert und mit einer Wahrscheinlichkeit von 75% 0\$ liefert und eine Investitionsalternative, welche mit einer Wahrscheinlichkeit von 20% 4.000\$ liefert und mit einer Wahrscheinlichkeit von 80% 0\$ liefert, zur Wahl. In diesem Experiment haben sich, im Gegensatz zu Problem 3, 35% der Probanden für die erste Investitionsalternative und 65% der Probanden für die zweite Investitionsalternative entschieden.⁸⁶

Diese Reduktion der Eintrittswahrscheinlichkeiten entspricht aus formaler Sicht einer Clawback-Klausel, welche unabhängig von der gewählten Investitionsalternative in 75% der Fälle ausgelöst wird. Folglich beträgt die Wahrscheinlichkeit $1 - p_{j,1}$, also die Wahrscheinlichkeit, dass die Clawback-Klausel nicht ausgelöst wird, bei beiden Investitionsalternativen und in jedem Umweltzustand 25%. Es ist klar erkennbar, dass die im letzten Unterkapitel formulierte Bedingung für eine Veränderung des Investitionsverhaltens nicht erfüllt ist. Die Wahrscheinlichkeit $1 - p_{j,1}$ ist bei der zweiten Investitionsalternative nicht größer als bei der ersten Investitionsalternative. Ungeachtet dessen kommt es zu einer Veränderung des Investitionsverhaltens.⁸⁷

Hierbei muss beachtet werden, dass die Entscheidungssituation in Problem vier so formuliert war, dass die Eintrittswahrscheinlichkeiten der Ergebnisse einer Investitionsalternative jedem Probanden bekannt waren. Ist dies nicht der Fall, verändert sich das Verhalten der Probanden. Kahneman und Tversky (1979) zeigen dies mithilfe von Problem zehn. Hierbei war erneut die Entscheidungssituation aus Problem drei beschrieben. Allerdings wurde die Entscheidungssituation um eine Bedingung erweitert. Es war zusätzlich angegeben, dass die Probanden nur mit einer Wahrscheinlichkeit von 25% überhaupt an der Entscheidungssituation teilnehmen dürfen. Aus formaler Sicht entspricht Problem vier dem bereits dargelegten Problem vier. In diesem Experiment haben sich jedoch, im Gegensatz zu Problem vier und in Übereinstimmung mit Problem drei, 22% der Probanden für die erste Investitionsalternative und 78% für die zweite Investitionsalternative entschieden.

Es zeigt sich der bereits in Kapitel 3.1 beschriebene Isolation Effekt. Da die zusätzlich angegebene Wahrscheinlichkeit bei beiden Investitionsalternativen identisch ist, berücksichtigen die Probanden diese Wahrscheinlichkeit bei ihrer Entscheidung nicht. Diese Beobachtung muss bei der Übertragung von Problem vier auf eine Investitionsentscheidung bei Clawback-Klauseln beachtet werden. Wie an Problem vier und Problem zehn erkennbar ist, wird sich die Investitionsentscheidung eines Managers bei gleichen Clawback-Wahrscheinlichkeiten nur verändern, wenn die tatsächliche Eintrittswahrscheinlichkeit einer Bonuszahlung angegeben ist. Diese Wahrscheinlichkeit entspricht formal dem Produkt $w_j \cdot (1 - p_{j,1})$. Ist dies nicht erfüllt, kommt es aufgrund des Isolation-Effekts zu keiner Veränderung des Investitionsverhaltens.

Aus den dargelegten Überlegungen ergibt sich eine weitere Forschungshypothese:

> H2: Eine ausreichend große, aber von der Investitionsentscheidung unabhängige Clawback-Wahrscheinlichkeit verändert das Investitionsverhalten nur, wenn die tatsächliche Eintrittswahrscheinlichkeit der Bonuszahlung dem Entscheider bekannt ist.

4.3. Zusammenfassung der Forschungshypothesen

In den vorherigen Unterkapiteln wurden zwei Forschungshypothesen abgeleitet. Diese werden im Folgenden nochmals zusammengefasst.

H1: Eine ausreichend große und von der Investitionsentscheidung abhängige Clawback-Wahrscheinlichkeit bei einer vormals dominanten Investitionsalternative verändert das Investitionsverhalten.

H2: Eine ausreichend große, aber von der Investitionsentscheidung unabhängige Clawback-Wahrscheinlichkeit verändert das Investitionsverhalten nur, wenn die tatsächliche Eintrittswahrscheinlichkeit der Bonuszahlung dem Entscheider bekannt ist.

⁸⁵Kahneman und Tversky (1979), S. 266.

⁸⁶Kahneman und Tversky (1979), S. 266.

⁸⁷Vgl. Kahneman und Tversky (1979), S. 271.

Die Clawback-Wahrscheinlichkeit ist hierbei jeweils die unabhängige Variable und die Investitionsentscheidung, bzw. das Investitionsverhalten, ist hierbei jeweils die abhängige Variable.

5. Charakterisierung der empirischen Datenerhebung

Im folgenden Kapitel werden zwei Experimente entwickelt, mit welchen die im vierten Kapitel hergeleiteten Forschungshypothesen getestet werden können. Zu Beginn wird die Wahl von Experimenten als Untersuchungsart erläutert (5.1). Hierbei wird auch beschrieben, wie die Daten erhoben werden (5.2). Anschließend wird auf das experimentelle Design (5.3) und die Darstellung der Entscheidungssituation (5.4) näher eingegangen. Abschließend werden weitere Fragen, welche an die Probanden gestellt werden, erklärt (5.5).

5.1. Die verwendete Untersuchungsart

Es stellt sich die Frage, mit welcher Untersuchungsart die hergeleiteten Forschungshypothesen am besten getestet werden können. Prinzipiell werden explorative, populationsbeschreibende und hypothesenprüfende Untersuchungen unterschieden. Mit explorativen Untersuchungen werden grundlegende Zusammenhänge in neuen Forschungsgebieten untersucht. Hierbei wird meistens das Ziel verfolgt, neue oder genauere Forschungshypothesen zu formulieren. Populationsbeschreibende Untersuchungen ermöglichen es hingegen, Merkmale bestimmter Gruppen genauer zu beschreiben. Hypothesenprüfende Untersuchungen werden hingegen genutzt, wenn ausformulierte Forschungshypothesen bereits vorliegen und diese Hypothesen getestet werden sollen.⁸⁸ Es wird deutlich, dass eine hypothesenprüfende Untersuchung anzuwenden ist.

Insgesamt werden zwei verschiedene hypothesenprüfende Untersuchungsarten, Korrelationsstudien und Experimente, unterschieden. Während bei Korrelationsstudien nach Zusammenhängen in bereits erhobenen Daten gesucht wird, sind Experimente dadurch gekennzeichnet, dass selbst Daten erhoben werden.⁸⁹ Korrelationsstudien haben einen gravierenden Nachteil bei der Untersuchung von kausalen Zusammenhängen. So kann ein ermittelter Zusammenhang zwischen zwei Forschungsobjekten immer mit verschiedenen Ansätzen erklärt werden. Wird z.B. ein Zusammenhang zwischen A und B nachgewiesen, dann bleibt unklar, ob A auf B wirkt, oder ob B auf A wirkt. Des Weiteren könnte auch eine unbekannte Variable C sowohl auf A und B wirken.⁹⁰

Bei Experimenten tritt kein solcher Nachteil bei der Untersuchung von kausalen Zusammenhängen auf. Jedes Experiment basiert auf dem gleichen Prinzip. Es wird stets eine experimentelle Manipulation durchgeführt, bei welcher eine oder mehrere unabhängige Variablen der Untersuchung verändert werden. Anschließend werden Effekte auf vermutete abhängige Variablen gemessen. Werden während des Experiments alle sonstigen Variablen konstant gehalten, ergeben sich eindeutige kausale Schlussfolgerungen. Falls eine Veränderung der abhängigen Variablen beobachtet wird, kann diese Veränderung eindeutig auf die Veränderung der unabhängigen Variablen zurückgeführt werden.⁹¹ Aus diesem Grund werden Experimente zur Untersuchung des Zusammenhangs zwischen Clawback-Klauseln und Investitionsverhalten gewählt.

Die erforderlichen Eigenschaften des Experiments hängen vom verfolgten Ziel ab. Nachfolgend wird die erforderliche Validität der Ergebnisse als Entscheidungskriterium genutzt. Eine hohe interne Validität bedeutet, dass die Untersuchung einen eindeutigen Zusammenhang misst, welcher durch wenige alternative Erklärungsansätze erklärt werden kann. Im Gegensatz dazu bedeutet eine hohe externe Validität, dass die Ergebnisse der Untersuchung verallgemeinerbar und in der Unternehmenspraxis beobachtbar sind. Die beiden Arten von Validität schließen sich in der Regel aus. So steigt z.B. die externe Validität, wenn die Untersuchung realitätsnäher ist. Allerdings ist die Untersuchung dann durch mehr Variablen und Störfaktoren gekennzeichnet. Dies führt dazu, dass oft mehrere Erklärungsansätze für einen untersuchten Zusammenhang existieren. Folglich ist die interne Validität gering.92

Im Folgenden wird eine hohe interne Validität als wichtiger angesehen als eine hohe externe Validität. Diese Annahme hat einen wesentlichen Grund. Da das Modell noch nie praktisch getestet wurde, ist es erforderlich, zuerst den Zusammenhang zwischen Clawback-Klauseln und Investitionsverhalten an sich nachzuweisen. Deshalb muss sichergestellt werden, dass auch tatsächlich der Einfluss von Clawback-Klauseln auf das Investitionsverhalten im Experiment gemessen wird. Nur so kann die Gültigkeit des hergeleiteten Modells überhaupt überprüft werden. Ist der Nachweis des Zusammenhangs erbracht, können zukünftige Arbeiten das Model aufgreifen und die Realitätsnähe des Modells untersuchen.

Eine hohe interne Validität wird erreicht, wenn das Experiment in einer kontrollierten Umgebung, in z.B. einem Labor durchgeführt wird. Dies hat den Vorteil, dass untersuchungsbedingte Störvariablen weitestgehend eliminiert werden können. Des Weiteren muss ein klassisches experimentelles Design und kein quasiexperimentelles Design gewählt werden. Folglich müssen die Probanden den einzelnen Experimentalgruppen zufällig zugeteilt werden. Diese Eigenschaft wird als Randomisierung bezeichnet. Die zufällige Zuteilung hilft bei der Elimination von personenbezogenen Störvariablen. In diesem Fall kann bei einer ausreichend großen Gruppengröße davon ausgegangen werden, dass die Verteilung der Störvariablen in allen Gruppen annähernd gleich ist. Als Konsequenz können Untersuchungsergebnisse nicht mehr über personenbezogene Störvariablen erklärt

⁸⁸Vgl. Bortz und Döring (2006), S. 49–53.

⁸⁹Vgl. Smith (2005), S. 100; Smith (2005), S. 142.

⁹⁰Vgl. Bortz und Döring (2006), S. 490f.

⁹¹Vgl. Schulz (1999), S. 31.

⁹²Vgl. Bortz und Döring (2006), S. 53.

werden.⁹³ In den nachfolgenden Unterkapiteln wird die Umsetzung des Experiments näher beschrieben.

5.2. Die Datenerhebung über Amazon MTurk

Das Experiment wird über die Plattform Amazon Mechanical Turk (Amazon MTurk) durchgeführt. Amazon MTurk ist ein Online-Marktplatz, über welchen virtuelle Arbeit, z.B. die Teilnahme an einer Untersuchung, gegen Bezahlung angeboten werden kann.⁹⁴ Die Online-Plattform wird bereits seit einigen Jahren für wissenschaftliche Forschung, wie z.B. für die Durchführung von Befragungen und Experimenten, genutzt.⁹⁵

Es werden sowohl Vor- als auch Nachteile im Vergleich zu klassischen Laborexperimenten mit Studenten oder Experten beobachtet. Auf diese Vor- und Nachteile wird nachfolgend näher eingegangen. So kann die Randomisierung der Experimentalgruppen in einem solchen Online-Experiment leicht durchgeführt werden. Plattformen, wie z.B. UNIPARK, ermöglichen es, Online-Studien zu erstellen, bei welchen der Online-Link direkt auf Amazon MTurk hochgeladen werden kann. In UNIPARK wird sichergestellt, dass die Zuteilung der Probanden in die einzelnen Experimentalgruppen komplett zufällig und vollständig automatisiert erfolgt.⁹⁶

Des Weiteren kann über Amazon MTurk mit nur wenig Aufwand eine große Anzahl an Probanden erreicht werden. Es wird kein Marketing, wie Flyer oder Nachrichten in Social Media, zur Anwerbung von Probanden benötigt. Außerdem kann der große Pool an Probanden jederzeit genutzt werden. Es muss z.B. nicht auf Semesterferien Rücksicht genommen werden. In dieser Zeit sind viele Studenten nicht an der Universität, was die Anwerbung von Probanden für Laborexperimente erschwert.⁹⁷

Des Weiteren zeigt sich, dass Experimente, welche über Amazon MTurk durchgeführt werden, kosteneffizienter als Laborexperimente sind. Kees, Berry, Burton und Sheehan (2017) und Goodman, Cryder und Cheema (2013) zeigen, dass Studien, welche sowohl im Labor als auch über Amazon MTurk durchgeführt werden, ähnliche und vergleichbare Ergebnisse liefern können.⁹⁸ Allerdings sind online durchgeführten Experimente meistens deutlich günstiger als entsprechende Laborexperimente. Da Probanden über Amazon MTurk direkt bezahlt werden können, entfallen zusätzliche Gebühren an Dritte, wie z.B. Gebühren an PayPal.⁹⁹

Die tatsächliche Qualität der Ergebnisse von Online-Studien über Amazon MTurk ist jedoch umstritten. Goodman/Cryder/Cheema (2013) beobachten, dass Probanden in Amazon MTurk Studien im Vergleich zu Probanden in Laborexperimenten weniger aufmerksam sind. So wird z.B. das Informationsmaterial der Studie häufig nur oberflächlich gelesen.¹⁰⁰ Außerdem zeigen einige Studien generell große Abweichungen bei den Ergebnissen von Amazon MTurk Experimenten im Vergleich zu herkömmlichen Laborexperimenten.¹⁰¹ Dies könnte mit der Intelligenz oder dem Fachwissen der Probanden zusammenhängen. Buchheit et al. (2019) beobachten, dass Experimente über Amazon MTurk ähnliche Ergebnisse wie Experimente mit Bachelor-Studenten liefern. Experimente mit Master-Studenten liefern jedoch andere Ergebnisse.¹⁰²

5.3. Das experimentelle Design der Untersuchung

5.3.1. Die Beschreibung des gewählten Ansatzes

Es stellt sich die Frage, wie die vermuteten Effekte von Clawback-Klauseln auf das Investitionsverhalten in einem Experiment gemessen werden können. Hierbei muss das bereits eingeführte experimentelle Prinzip genauer charakterisiert werden. In der Verhaltensforschung sind verschiedene Umsetzungen des klassischen experimentellen Prinzips denkbar. Eine solche Umsetzung wird als experimentelles Design bezeichnet. Nachfolgend werden die verschiedenen experimentellen Designs näher erläutert.¹⁰³

Experimentelle Designs sind durch zwei Unterscheidungsmerkmale gekennzeichnet. So muss die experimentelle Manipulation an sich näher charakterisiert werden. Bei within-subjects Designs wird das Verhalten von Probanden vor und nach der experimentellen Manipulation gemessen. Durch einen Vergleich des Verhaltens der Probanden nach der Manipulation mit dem Verhalten der Probanden vor der Manipulation, zeigen sich die Effekte der Manipulation. Im Gegensatz dazu stehen between-subjects Designs. Hierbei wird das Verhalten von Probanden nach der Manipulation in mehreren Experimentalgruppen gemessen. Die verschiedenen Gruppen unterscheiden sich in der Stärke der experimentellen Manipulation. In diesem Fall zeigen sich durch einen Vergleich des Verhaltens der Probanden in den einzelnen Experimentalgruppen, die Effekte der Manipulation.¹⁰⁴

Für das vorliegende Experiment wird ein betweensubjects Design gewählt. Dieses Design hat gegenüber dem within-subjects Design den Vorteil, dass die Probanden seltener die Zielsetzung des Experiments erkennen. Ist diese Eigenschaft nicht erfüllt, können die Probanden in ihrem Verhalten beeinflusst werden. So wird z.B. beobachtet, dass Probanden, welche die Zielsetzung eines Experiments kennen, sich eher übereinstimmend zu den Forschungshypothesen verhalten, als Probanden, die die Zielsetzung eines Experiments nicht kennen.¹⁰⁵

⁹³Vgl. Bortz und Döring (2006), S. 54–57.

⁹⁴Vgl. Amazon MTurk (2020), S. 1.

⁹⁵Für nähere Informationen zu UNIPARK, vgl. Unipark (2020), S. 1.

⁹⁶Für nähere Informationen zu UNIPARK, vgl. Unipark (2020), S. 1.
⁹⁷Vgl. Mason und Suri (2012), S. 2f.

⁹⁸Vgl. Goodman et al. (2013), S. 222; Kees et al. (2017), S. 151f.

⁹⁹Vgl. Mason und Suri (2012), S. 3.

¹⁰⁰Vgl. Goodman et al. (2013), S. 221.

¹⁰¹Vgl. Teschner und Gimpel (2018), S. 211, Buchheit, Dalton, Pollard und Stinson (2019), S. 101f.

¹⁰²Vgl. Buchheit et al. (2019), S. 101f.

¹⁰³Vgl. Smith (2005), S. 104f.

¹⁰⁴Vgl. Charness, Gneezy und Kuhn (2012), S. 1.

¹⁰⁵Vgl. Charness et al. (2012), S. 2.

Des Weiteren wird das experimentelle Design durch die Anzahl der manipulierten Variablen charakterisiert. Wird bei einem Experiment während der experimentellen Manipulation nur eine Variable verändert, dann ist das experimentelle Design einfaktoriell. Allerdings werden in vielen Experimenten zwei oder mehr Variablen variiert. Ein solches Design ist oft dadurch gekennzeichnet, dass sowohl die einzelnen Einflüsse der unabhängigen Variablen auf die abhängigen Variablen als auch mögliche Interaktionseffekte zwischen den Variablen gemessen werden. Die Anzahl der benötigten Experimentalgruppen hängt von den getesteten Ausprägungen der unabhängigen Variablen ab. Zum Beispiel müssen bei einem vollständigen Experiment mit zwei unabhängigen Variablen mit je zwei getesteten Ausprägungen vier Experimentalgruppen gebildet werden.¹⁰⁶

Beim faktoriellen Design des vorliegenden Experiments sind verschiedene Ansätze denkbar. So ist es naheliegend, die Clawback-Wahrscheinlichkeit als eine unabhängige Variable mit drei Ausprägungen zu interpretieren. In der ersten Ausprägung würde keine Clawback-Klausel existieren, bzw. die Clawback-Wahrscheinlichkeit würde null Prozent betragen. Die zweite Ausprägung würde der ersten Forschungshypothese entsprechen. Des Weiteren würde die dritte Ausprägung der zweiten Forschungshypothese entsprechen.

Diese Interpretation der Clawback-Klausel ist für den Test der zweiten Forschungshypothese problematisch. Wird bei der dritten Ausprägung eine Veränderung des Investitionsverhaltens beobachtet, dann kann diese Veränderung unterschiedlich interpretiert werden. Es wäre nicht eindeutig bestimmbar, ob die beobachtete Veränderung durch die tatsächlich bekannte Eintrittswahrscheinlichkeit der Bonuszahlung, oder nur durch die eingeführte Clawback-Wahrscheinlichkeit ausgelöst wird. Im Folgenden wird deshalb ein anderer Ansatz gewählt.

Statt einem Experiment mit unabhängigen Variablen mit drei Ausprägungen, werden zwei Experimente mit jeweils einer unabhängigen Variablen mit zwei Ausprägungen durchgeführt. Im ersten Experiment wird die erste Forschungshypothese überprüft. Es wird eine Experimentalgruppe ohne Clawback-Klausel, bzw. mit einer Clawback-Wahrscheinlichkeit von null Prozent und ein Experimentalgruppe, welche der ersten Forschungshypothese entspricht, unterschieden. Im zweiten Experiment wird die zweite Forschungshypothese getestet. Hierbei werden erneut zwei Experimentalgruppen gebildet. Beide Experimentalgruppen sind durch eine ausreichend große und von der Investitionsentscheidung unabhängige Clawback-Wahrscheinlichkeit gekennzeichnet. Allerdings wird nur in der zweiten Experimentalgruppe die tatsächliche Eintrittswahrscheinlichkeit der Bonuszahlung erklärt. In Tabelle 1 ist das experimentelle Design der beiden Experimente nochmals zusammengefasst.

5.3.2. Die Operationalisierung des theoretischen Modells

Um die beschriebenen Experimente durchführen zu können, ist es notwendig das hergeleitete Modell in eine konkrete Entscheidungssituation zu überführen. Diese Entscheidungssituation muss so gewählt werden, dass in beiden Experimenten eine Veränderung des Investitionsverhaltens erwartet wird. Für die erste Experimentalgruppe des ersten Experiments bedeutet dies, dass eine Entscheidungssituation mit mehreren Investitionsalternativen, einer dominanten Investitionsalternative und einer Clawback-Wahrscheinlichkeit aufgebaut werden muss. Dies kann auf Basis der hergeleiteten Gleichungen geschehen.

Bei diesem Vorgehen muss jedoch bedacht werden, dass die Gewichtungsfunktion π keinen eindeutigen Funktionsverlauf hat. Wenn keine Annahmen zum Funktionsverlauf erfolgen, ist bei einer Entscheidungssituation mit mehreren Investitionsalternativen nicht bestimmbar, welche Investitionsalternative die anderen dominiert und ausgewählt wird. Im Folgenden wird deshalb das bereits in Kapitel 4.2 erläuterte Problem drei von Kahneman und Tversky (1979) als Ausgangsbasis genutzt.

Die Entscheidungssituation besteht folglich aus zwei Investitionsalternativen. Die sichere Investitionsalternative erwirtschaftet immer einen Bonus von 3.000\$. Die riskante Investitionsalternative erwirtschaftet mit einer Wahrscheinlichkeit von 80% einen Bonus von 4.000\$ und mit einer Wahrscheinlichkeit von 20% einen Bonus von 0\$. Hierbei wird aufgrund der Ergebnisse von Kahneman und Tversky (1979) erwartet, dass sich die Probanden signifikant öfter für die sichere Investitionsalternative entscheiden.

In der zweiten Experimentalgruppe des ersten Experiments wird zusätzlich eine Clawback-Klausel in die bereits beschriebene Entscheidungssituation aufgenommen. Per Definition werden sich die Probanden bei einer ausreichend großen Clawback-Wahrscheinlichkeit bei der sicheren Investitionsalternative für die riskante Investitionsalternative entscheiden. Eine ausreichend große Clawback-Wahrscheinlichkeit ist über Gleichung (4.2) bestimmbar. Aus formaler Sicht gilt:

$$\sum_{j=1}^{J} \pi(w_{j}) \cdot u(B_{\tau,j}) \ge \sum_{j=1}^{J} \pi(w_{j} \cdot (1-p_{j,1})) \cdot u(B_{\tau,j}).$$
(25)

Im nächsten Schritt muss die Entscheidungssituation in den Zusammenhang eingesetzt werden:

$$\pi(80\%) \cdot u(4.000) \ge \pi \left(100\% \cdot \left(1 - p_{j,1} \right) \right) \cdot u(3.000).$$
 (26)

Es zeigt sich, dass Gleichung (5.2) z.B. für eine Clawback-Wahrscheinlichkeit $p_{j,1}$ von zwanzig Prozent sicher erfüllt ist. Es gilt dann:

$$\pi(80\%) \cdot (u(4.000) - u(3.000)) \ge 0. \tag{27}$$

Hierbei muss beachtet werden, dass die Wertfunktion streng monoton wachsend ist und folglich die Differenz u(4.000) - u(3.000) immer größer als null ist. Außerdem ist die Gewichtungsfunktion π per Definition immer größer

¹⁰⁶Vgl. Collins, Dziak und Li (2009), S. 202.

Tabelle 1: Das experimentelle Design der Untersuchung

Experiment	Experimentalgruppe 1	Experimentalgruppe 2		
1	Clawback-Wahrscheinlichkeit Ausreichend große und von der Investitionsentscheidung			
	von null Prozent	abhängige Clawback-Wahrscheinlichkeit		
2	Ausreichend große und von der Investitionsentscheidung			
	unabhängige Clawback-Wahrscheinlichkeit			
2	Tatsächliche Eintrittswahrscheinlich-	Tatsächliche Eintrittswahrscheinlichkeit der Bonuszahlung		
	keit der Bonuszahlung nicht bekannt	bekannt		

als null. Aufgrund des unsicheren Funktionsverlaufs der Gewichtungsfunktion π wird nachfolgend eine deutlich größere Clawback-Wahrscheinlichkeit als 20% angenommen. Es wird davon ausgegangen, dass die Clawback-Klausel bei Wahl der sicheren Investitionsalternative mit einer Wahrscheinlichkeit von 80% aktiviert wird. Somit wird im zweiten Fall des ersten Experiments erwartet, dass sich die Probanden signifikant öfter für die riskante Investitionsalternative entscheiden.

Im zweiten Experiment werden die Probleme vier und zehn von Kahneman und Tversky (1979) als Ausgangsbasis für die konkrete Entscheidungssituation genutzt. Dies ist naheliegend, da die zweite Forschungshypothese aus diesen beiden Problemen entwickelt wurde.¹⁰⁷ Die erste Experimentalgruppe des zweiten Experiments basiert auf Problem zehn. Hierbei müssen sich die Probanden erneut zwischen der sicheren und der riskanten Investitionsalternative entscheiden. Allerdings existiert eine von der Investitionsentscheidung unabhängige Clawback-Wahrscheinlichkeit, die Clawback-Klausel wird in 75% der Fälle aktiviert. Die resultierende tatsächliche Eintrittswahrscheinlichkeit der Bonuszahlung wird jedoch nicht angegeben. Hierbei wird erwartet, dass sich die Probanden signifikant öfter für die sichere Investitionsalternative entscheiden.

Die zweite Experimentalgruppe des zweiten Experiments entspricht Problem vier von Kahneman und Tversky (1979) und ist formal gesehen identisch zur ersten Experimentalgruppe. Allerdings wird die angegebene Eintrittswahrscheinlichkeit der Ergebnisse mit der Clawback-Wahrscheinlichkeit multipliziert. Die erste Investitionsalternative wird den Probanden als Investition, welche mit einer Wahrscheinlichkeit von 25% einen Bonus von 3.000\$ und mit einer Wahrscheinlichkeit von 75% einen Bonus von 0\$ erwirtschaftet, beschrieben. Analog dazu wird die zweite Investitionsalternative als Investition, welche mit einer Wahrscheinlichkeit von 20% einen Bonus von 4.000\$ und mit einer Wahrscheinlichkeit von 80% einen Bonus von 0\$ erwirtschaftet, beschrieben. Hierbei wird erwartet, dass sich die Probanden signifikant öfter für die riskante Investitionsalternative entscheiden. Tabelle 1 fasst das operationalisierte experimentelle Design der Untersuchung zusammen.

5.4. Die Darstellung der Entscheidungssituation

5.4.1. Die Wahl einer kontextreichen Entscheidungssituation

Es muss festgelegt werden, wie die Entscheidungssituation für die Probanden dargestellt wird. Die Entscheidungssituation kann in abstrakter Form, wie z.B. in Tabelle 2 oder im konkreten Unternehmenskontext beschrieben werden.¹⁰⁸ Im Folgenden wird für beide Experimente eine kontextreiche Form der Darstellung gewählt. Diese Form der Darstellung ist eine deutliche Abweichung von Kahneman und Tversky (1979) und wird aufgrund der dargelegten Nachteile der Datenerhebung über Amazon MTurk gewählt. Wird auf Basis vorheriger Überlegungen angenommen, dass von Amazon MTurk kommende Probanden weniger gebildet, weniger intelligent und weniger aufmerksam sind, dann ist es fraglich, ob die Probanden die aufgebaute Entscheidungssituation ohne Kontext verstehen können.¹⁰⁹

Dieses Verständnis der Entscheidungssituation ist jedoch wichtig, da das Verhalten der Probanden sonst signifikant vom erwarteten Verhalten abweichen kann. So finden z.B. Kirchler/Huber/Stöckl (2012) Hinweise, dass die unerwartete Bildung von Finanzblasen im Finanzmarktexperiment von Smith/Suchanek/Williams (1988) durch verwirrte Teilnehmer, welche das Experiment nicht verstanden haben, ausgelöst wird. Wird den Probanden statt der originalen Darstellung des Experiments eine kontextreiche Darstellung präsentiert, dann wird die Blasenbildung deutlich unwahrscheinlicher.¹¹⁰

Es wird gezeigt, dass dieses Verständnis bei weniger gebildeten Probanden durch eine kontextreichere Darstellung der Entscheidungssituation verbessert werden kann. Chou et al. (2009) beobachten, dass Probanden von einem Community College eine Entscheidungssituation deutlich besser verstehen, wenn eine kontextreiche Darstellung anstatt einer abstrakten Darstellung gewählt wird. Eine wichtige Voraussetzung ist hierbei, dass die Entscheidungssituation in einem den Probanden bekannten Kontext präsentiert wird. Allerdings kann nicht ausgeschlossen werden, dass es trotz kontextreicher Darstellung zu falschen Entscheidungen auf Seiten der Probanden kommt.¹¹¹

¹⁰⁷Vgl. Kapitel 4.2.

¹⁰⁸Vgl. Alekseev, Charness und Gneezy (2017), S. 48f.

¹⁰⁹Vgl. Kapitel 5.2.

¹¹⁰Vgl. Kirchler und Stöckl (2012), S. 878–880.

¹¹¹Vgl. Chou, McConnell, Nagel und Plott (2009), S. 171–174.

Experiment	Experimentalgruppe 1	Experimentalgruppe 2	
	3.000 \$ (100%)	3.000 \$ (100%),	
		aber Clawback (80%)	
1	oder	oder	
1	4 000 (2004)		
	4.000(80%)	4.000\$ (80%)	
		und 0\$ (20%)	
	3.000 \$ (100%)		
	oder	3.000 \$ (25%)	
2	4.000\$ (80%)	oder	
	und 00 (2070)	4.000\$ (20%)	
	unabhängig davon:	und 0\$ (80%)	
	Clawback (75%)		

Tabelle 2: Das operationalisierte experimentelle Design der Untersuchung

5.4.2. Die beschriebene Entscheidungssituation

Der Kontext der Entscheidungssituation der beiden Experimente wird nachfolgend näher spezifiziert. Da im hergeleiteten Modell von einem Manager im Unternehmenskontext ausgegangen wird und Clawback-Klauseln im Unternehmenskontext auftreten, wird auch den Probanden die Entscheidungssituation im Unternehmenskontext beschrieben. Die Probanden sollen im Experiment die Rolle eines Managers in einer Bierbrauerei annehmen. Die Wahl der Bierbranche hat zwei Vorteile. So sollte das Produkt Bier jedem Probanden bekannt sein. Das Produkt Bier ist das meistverkaufte alkoholische Getränk weltweit und wird in den meisten Ländern der Welt konsumiert.¹¹²

Des Weiteren ist es unwahrscheinlich, dass Probanden bereits Erfahrungen bei Investitionsentscheidungen für die Bierherstellung sammeln konnten. Es arbeitet nur ein geringer Teil der Beschäftigten in der Brauwirtschaft. Im Jahr 2015 waren z.B. in Deutschland ca. 43 Millionen Personen erwerbstätig.¹¹³ Hiervon waren nur etwa 27.000 Personen in der Bierherstellung beschäftigt.¹¹⁴ Dies entspricht einem Anteil von etwa 0,06%. Es ist deshalb schwer vorstellbar, dass der Entscheidungsprozess der Probanden bei der Investitionsentscheidung durch etwaige Erfahrungswerte beeinflusst wird.

Zu Beginn der Experimente wird den Probanden ihre Rolle als Manager der "Bavaria SE", einer großen Brauerei in Deutschland beschrieben. Im nächsten Schritt werden die Probanden darauf hingewiesen, dass ihre jährliche Bonuszahlung vom Jahresgewinn der Brauerei abhängt. Dies wird damit begründet, dass der Aufsichtsrat sicherstellen will, dass die Manager der Brauerei stets im Sinne des Unternehmens handeln. Zur Berechnung der jährlichen Bonuszahlung wird ein einfacher Zusammenhang gewählt. Den Probanden wird erklärt, dass sie zehn Prozent des jährlichen Gewinns als persönlichen Gewinn ausbezahlt bekommen.

In der zweiten Experimentalgruppe des ersten Experiments und in beiden Experimentalgruppen des zweiten Experiments wird zusätzlich eine Clawback-Klausel beschrieben, welche die Bonuszahlungen des Managers betrifft. Die Clawback-Klausel bei der zweiten Experimentalgruppe des ersten Experiments wird aktiviert, wenn sich im Nachhinein herausstellt, dass der Proband, bzw. die Probandin eine für die Brauerei nachteilige Entscheidung getroffen hat. Im Gegensatz dazu ist die Aktivierung der im zweiten Experiment beschriebenen Clawback-Klausel unabhängig von den Entscheidungen der Probanden. Die Aktivierung erfolgt in diesem Fall, wenn im Nachhinein ein Fehler im Jahresabschluss der Brauerei entdeckt wird und dieser korrigiert werden muss. In allen drei Experimentalgruppen wird den Probanden erklärt, dass bei Aktivierung der Clawback-Klausel die gesamte Bonuszahlung an die Brauerei zurückgezahlt werden muss.

In der eigentlichen Entscheidungssituation haben die Probanden die Aufgabe eine neue Würzepfanne, nachfolgend vereinfachend Braukessel genannt, für die Brauerei auszuwählen.¹¹⁵ Dies wird damit begründet, dass der alte Braukessel starke Abnutzungsspuren zeigt und deshalb ersetzt werden muss. Hierbei wird den Probanden erklärt, dass die Kapazität des gewählten Braukessels die maximale Kapazität an Bier vorgibt, welche im nächsten Geschäftsjahr gebraut werden kann. Des Weiteren werden den Probanden zwei mögliche Szenarien für die während des nächsten Geschäftsjahres absetzbare Menge an Bier präsentiert. Mit einer Wahr-

¹¹²Vgl. Statista (2020), S. 1.

¹¹³Vgl. Statistisches Bundesamt (2016), S. 1.

¹¹⁴Vgl. Stracke und Homann (2017), S. 90.

¹¹⁵Für eine Erklärung des Brauprozesses, vgl. Deutscher Bundestag (2019), S. 1.

scheinlichkeit von 80% kann im nächsten Geschäftsjahr Bier im Wert von 1.000.000\$ verkauft werden, mit einer Wahrscheinlichkeit von 20% kann jedoch nur Bier im Wert von 600.000\$ verkauft werden.

Den Probanden werden zwei Braukessel, ein Braukessel mit großer Kapazität und ein Braukessel mit kleiner Kapazität, zur Wahl gestellt. Mit dem großen Braukessel kann maximal Bier im Wert von 1.000.000\$ gebraut werden. Der Braukessel verursacht jährliche Kosten in Höhe von 600.000\$. Mit dem kleinen Braukessel kann nur maximal Bier im Wert von 600.000\$ gebraut werden. Allerdings verursacht dieser Braukessel auch nur jährliche Kosten in Höhe von 300.000\$. Zur Vereinfachung der Entscheidungssituation wird hierbei nicht näher auf die Zahlungsströme der beiden Investitionsalternativen eingegangen. Allerdings wird darauf hingewiesen, dass aus der Investition folgende Abschreibungen bereits in den jährlichen Kosten berücksichtigt sind.

Im letzten Schritt wird die gesamte Entscheidungssituation für die Probanden mithilfe einer Tabelle zusammengefasst. Hierbei wird der resultierende jährliche Gewinn jeder Investitionsalternative in Abhängigkeit vom eingetretenen Umweltzustand gezeigt und die Berechnung dieses Wertes erläutert. Des Weiteren wird die jeweils resultierende Bonuszahlung für die Probanden angegeben und die Berechnung des angegebenen Wertes gezeigt. In der zweiten Experimentalgruppe des ersten und zweiten Experiments wird zusätzlich die Auswirkung der Clawback-Klausel auf den langfristigen persönlichen Bonus dargestellt. Abbildung 5 zeigt bespielhaft die Tabelle, welche der zweiten Experimentalgruppe des ersten Experimentes präsentiert wird. Die ausformulierte Darstellung der Entscheidungssituation für alle vier Experimentalgruppen findet sich in Anhang c).

5.4.3. Der Einfluss der angepassten Bonuszahlungen

Es muss beachtet werden, dass in der kontextreichen Entscheidungssituation zehnmal größere Bonuszahlungen beschrieben werden als in Kapitel 5.3.2. Diese Entscheidung wurde getroffen, um die Entscheidungssituation an den beschriebenen Kontext anzupassen. Es wird beobachtet, dass Bonuszahlungen an das Topmanagement durchschnittlich in dieser Größenordnung liegen. So verdienten z.B. Topmanager in Deutschland im Jahr 2018 im Schnitt mehrere 100.000€. Die durchschnittliche variable Vergütung betrug hierbei 20-30% vom Gesamtgehalt.¹¹⁶

Die veränderten Bonuszahlungen beeinflussen den erwarteten Nutzen der beiden Investitionsalternativen. Die verwendete Wertfunktion ist per Definition streng monoton wachsend. Als Folge wird den jeweiligen Bonuszahlungen ein höherer Nutzenwert zugeordnet, was wiederum den Gesamtnutzen der beiden Investitionsalternativen vergrößert. Des Weiteren wird der Funktionsverlauf der Wertfunktion als konkav angenommen. Dies führt dazu, dass den verzehnfachten Bonuszahlungen ein weniger als verzehnfachter Nutzenwert zugeordnet wird.¹¹⁷ Es stellt sich die Frage, ob die beiden beschriebenen Effekte die erwarteten Investitionsentscheidungen der Probanden in den einzelnen Experimentalgruppen beeinflussen.

Hierbei ist es sinnvoll das erwartete Verhalten der Probanden in den einzelnen Experimentalgruppen mithilfe einer Ungleichung auszudrücken. Für die erste Experimentalgruppe des ersten und des zweiten Experiments gilt folgender Zusammenhang:

$$\pi(0,8) \cdot u(4.000) < 1 \cdot u(3.000), \text{ bzw. } \pi(0,8) < \frac{u(3,000)}{u(4,000)}.$$
(28)

Analog gilt für die zweite Experimentalgruppe des ersten und zweiten Experiments:

$$\frac{\pi(0,8)}{\pi(0,2)} > \frac{u(3.000)}{u(4.000)'}, \text{ bZW. } \frac{\pi(0,2)}{\pi(0,3)} > \frac{u(3.000)}{u(4.000)}.$$
(29)

Bei einer Verzehnfachung der Bonuszahlung muss der Quotient u(3.000)/u(4.000) in allen vier Experimentalgruppen durch den Quotienten u(30.000)/u(40.000) ersetzt werden. Es ist allerdings fraglich ob in diesem Fall die Ungleichungen noch erfüllt sind. Nur bei Kenntnis der genauen Funktionsvorschrift der Wertfunktion u ergibt sich eine eindeutige Aussage.

Tversky und Kahneman (1992) entwickeln in ihrer Arbeit zur Kumulativen Prospect-Theorie eine entsprechende Funktionsvorschrift für die Wertfunktion. Für die Wertfunktion $u(x, \alpha, \beta, \lambda)$ gilt:

$$u(x) = \begin{cases} x^{\alpha} & \text{wenn } x \ge 0\\ -\lambda \cdot (-x)^{\beta} & \text{wenn } x < 0 \end{cases}$$
(30)

Hierbei wird über die Parameter α und β der konkave, bzw. konvexe Funktionsverlauf abgebildet. Der Parameter λ ist immer größer als eins und bildet die Verlustaversion ab.¹¹⁸ Da in allen vier Experimentalgruppen keine negativen Bonuszahlungen getestet werden, ist für die folgende Überlegung nur die obere der beiden Funktionsvorschriften relevant. Es zeigt sich, dass der Quotient u(30.000)/u(40.000) unter Annahme der beschriebenen Funktionsvorschrift dem Quotienten u(3.000)/u(4.000) entspricht:

$$\frac{u(30.000)}{u(40.000)} = \frac{30.000^{\alpha}}{40.000^{\alpha}} = \frac{10^{\alpha}}{10^{\alpha}} \cdot \frac{3.000^{\alpha}}{4.000^{\alpha}} = \frac{3.000^{\alpha}}{4.000^{\alpha}} = \frac{u(3.000)}{u(4.000)}$$
(31)

Es ist klar ersichtlich, dass die Verzehnfachung der Bonuszahlung aus theoretischer Sicht keinen Einfluss auf die Investitionsentscheidung der Probanden hat.

5.5. Sonstige Fragen an die Probanden

Es muss beachtet werden, dass es für die Untersuchung der Forschungshypothesen nicht ausreicht, wenn nur die Investitionsentscheidung der Probanden experimentell gemessen wird. Zwar sind die Experimente so gestaltet, dass der

¹¹⁶Vgl. Von Hülsen (2019), S. 10f.

¹¹⁷Vgl. Kapitel 3.1.

¹¹⁸Vgl. Al-Nowaihi, Bradley und Dhami (2008), S. 338f.

	Big kettle	Small kettle
Maximum capacity per year	\$ 1,000,000 worth of beer	\$ 600,000 worth of beer
Operating costs per year (inc. depreciation)	\$ 600,000	\$ 300,000
Possible profit per year	<u>When scenario 1 occurs (80%);</u> \$ 1,000,000 - \$ 600,000 = \$ 400,000 <u>When scenario 2 occurs (20%);</u> \$ 600,000 - \$ 600,000 = \$ 0	<u>In both scenarios:</u> \$ 600,000 - \$ 300,000 = \$ 300,000
Your possible bonus (10% of the profit per year)	When scenario 1 occurs (80%); \$ 40,000 When scenario 2 occurs (20%); \$ 0	When scenario 1 occurs (80%); \$ 0* When scenario 2 occurs (20%); \$ 30,000

* Given scenario 1 occurs and you chose the small kettle. In this case the big kettle would have been more profitable. Hence, the recoupment of your bonus will be triggered.

Abbildung 5: Die Darstellung der Tabelle für die zweite Experimentalgruppe des ersten Experiments

Einfluss möglicher Störvariablen aus theoretischer Sicht minimiert und der Erfolg der experimentellen Manipulation sichergestellt wird. Allerdings ist unklar, ob die getroffenen Maßnahmen auch tatsächlich wirken. So ist z.B. denkbar, dass einige Probanden die Entscheidungssituation trotz kontextreicher Darstellung nicht verstehen und sich zufällig für eine der beiden Investitionsalternativen, bzw. Braukessel entscheiden.

Aus diesem Grund müssen die getroffenen Maßnahmen auf ihre Wirksamkeit überprüft werden. Hierbei kann auf etablierte Ansätze aus der experimentellen Forschung zurückgegriffen werden. Die Randomisierung des Experiments wird nachgewiesen, wenn die personenbezogenen Störvariablen in allen Experimentalgruppen gleich verteilt, bzw. normalverteilt sind.¹¹⁹ In diesem Fall wird durch einen Vergleich der Mittelwerte der potenziellen Störvariablen in den einzelnen Experimentalgruppen auf mögliche ungeplante Unterschiede zwischen den Experimentalgruppen geschlossen.¹²⁰

Hierfür müssen die potenziellen Störvariablen im Experiment gemessen werden. Dies wird erreicht, indem die Probanden am Beginn des jeweiligen Experiments zu verschiedenen potenziellen Störvariablen befragt werden.¹²¹ In den dargestellten Experimenten sind die Probanden aufgefordert Angaben zu ihrem Geschlecht, ihrem Geburtsjahr, ihrer Nationalität, ihrer aktuellen Beschäftigungssituation und ihrem Einkommen zu machen. Des Weiteren wird der Ort, an welchem die Studie ausgefüllt wird und das Wissen der Probanden über Statistik abgefragt.

In den beiden Experimenten werden, neben den bereits genannten eher demographischen Störvariablen, auch zwei thematisch relevante Störvariablen auf Randomisierung überprüft. Die erste dieser Variablen ist die generelle Risikoneigung der Probanden. Diese Frage ist notwendig, da ein Einfluss der Risikoneigung auf das Investitionsverhalten bestehen könnte. So zeigen z.B. Experimente wie Sitkin (1995), dass ein signifikanter Zusammenhang zwischen der generellen Risikoneigung und dem wahrgenommenen Risiko der Probanden und ein signifikanter Zusammenhang zwischen dem wahrgenommenen Risiko und dem Entscheidungsverhalten der Probanden besteht.¹²² Die Risikoneigung der Probanden wird mithilfe der Risk Propensity Scale von Meertens und Lion (2008) gemessen.¹²³

Die zweite betrachtete inhaltliche Störvariable ist die Einstellung der Probanden zum Produkt Bier. Auch hierbei ist ein Effekt auf das Investitionsverhalten denkbar. So zeigen z.B. Bamberg, Kühnel und Schmidt (1999), dass die Entscheidung einer Person für ein Verkehrsmittel von der generellen Einstellung der Person zum Thema Verkehr beeinflusst wird.¹²⁴ Analog ist denkbar, dass die Entscheidung einer Person für einen Braukessel von der generellen Einstellung der Person zum Thema Bier beeinflusst wird. Zur Messung der Variable wird eine eigene Skala genutzt. Hierbei werden verschiedene Aspekte zu Bier, z.B. die Präferenz für Bier im Vergleich zu anderen alkoholischen Getränken, abgefragt.

Der Erfolg der experimentellen Manipulation wird mithilfe verschiedener Kontrollfragen getestet. Die Aufmerksamkeit der Probanden wird mithilfe von Instructional Manipulation Checks überprüft. Die Idee ist hierbei, dass Probanden häufig den Fragetext nicht lesen und deshalb zufällig antworten. Deshalb werden einfache Kontrollfragen gestellt, welche jedoch nur beantwortet werden können, wenn der Fra-

¹¹⁹Vgl. Bortz und Döring (2006), S. 526f.

¹²⁰Vgl. Sibbertsen und Lehne (2015), S. 397–399.

¹²¹Vgl. Bortz und Döring (2006), S. 526f.

¹²²Vgl. Sitkin (1995), S. 1586.

¹²³Vgl. Meertens und Lion (2008), S. 1520.

¹²⁴Vgl. Bamberg et al. (1999), S. 21f.

getext gelesen wurde.¹²⁵ Dieser Ansatz wird in zwei Kontrollfragen verwendet. So sollen die Probanden z.B. die richtige Lösung der Rechenoperation 2+3 aus drei Antwortmöglichkeiten auswählen.

Des Weiteren wird das Verständnis der Probanden der Entscheidungssituation mithilfe einer Kontrollfrage getestet. In der ersten Kontrollfrage werden die Probanden dazu aufgefordert ihre Einschätzung zur zukünftigen verkauften Menge an Bier abzugeben. Es stehen die monetär bewerteten Biermengen aus den beiden Zukunftsszenarien, 1.000.000\$ und 600.000\$, zur Wahl. Unabhängig von der Experimentalgruppe gibt es zwei Kombinationen aus gewählter Investitionsalternative und erwarteter Verkaufsmenge an Bier, welche darauf hindeuten, dass die Probanden die Entscheidungssituation nicht verstanden haben.

Diese Kombinationen sind die Wahl des großen Braukessels, wenn eine verkaufte Biermenge von 600.000\$ erwartet wird und die Wahl des kleinen Braukessels, wenn eine verkaufte Biermenge von 1.000.000\$ erwartet wird. In beiden Kombinationen würde bewusst auf einen Teil des maximal möglichen Unternehmensgewinns, bzw. persönliche Bonus verzichtet werden. Wird z.B. ein Umsatz in Höhe von 600.000\$ erwartet, dann würde durch die Wahl des großen Braukessels ein Gewinn von 0\$ und ein Bonus von \$0 realisiert werden. Wird stattdessen der kleine Braukessel gewählt, würde ein Gewinn von 300.000\$ und ein Bonus von 30.000\$ realisiert werden.

Der Erfolg der experimentellen Manipulation wird zusätzlich mit einer Kontrollfrage zur Risikowahrnehmung der Probanden getestet. Bei dieser Frage sollen die Probanden angeben, welcher der beiden Investitionsalternativen für sie persönlich als riskanter erscheint. Mithilfe der Frage wird überprüft, ob die Probanden die angegebenen Wahrscheinlichkeiten wie angenommen gewichten. Auf Basis der hergeleiteten Entscheidungssituation sind signifikante Unterschiede zwischen den Experimentalgruppen in beiden Experimenten zu erwarten. So wird z.B. erwartet, dass im ersten Experiment der große Braukessel in der ersten Experimentalgruppe und der kleine Braukessel in der zweiten Experimentalgruppe als riskanter wahrgenommen wird.

Zusätzlich werden die Probanden in einer offenen Frage gebeten ihre Einschätzung über das Ziel des Experiments anzugeben. Die Frage ermöglicht es zu prüfen, ob die Probanden die Zielsetzung des Experiments erkennen. Das vollständige Experiment ist in Anhang c) dargestellt.

6. Ergebnisse der Untersuchung

Im folgenden Kapitel werden die Ergebnisse der beiden durgeführten Experimente dargestellt. Zu Beginn werden die erhobenen Daten genauer beschrieben (6.1). Danach wird der Chi-Quadrat-Unabhängigkeitstest als statistischen Testverfahren vorgestellt, welches zur Untersuchung der Stichprobe benötigt wird (6.2). Anschließend werden die Ergebnisse der Tests der Randomisierung der Störvariablen dargestellt. (6.3). Des Weiteren werden die abgeleiteten Forschungshypothesen näher untersucht und getestet (6.4).

6.1. Die Beschreibung der Stichprobe

Die Daten beider Experimente wurden vom 27.03.2020 bis zum 29.03.2020 erhoben. Den MTurk Workern wurde jeweils ein Dollar für die Teilnahme angeboten. Insgesamt wurden 205 Probanden rekrutiert, welche zufällig und gleichmäßig auf die Experimentalgruppen verteilt wurden. Diese große Zahl an Probanden hat den Vorteil, dass aufgrund des zentralen Grenzwertsatzes der Statistik von einer Normalverteilung der geprüften Störvariablen in den einzelnen Experimentalgruppen ausgegangen werden kann.¹²⁶

Im Folgenden wird auf die überprüften demographischen Variablen näher eingegangen. Das mittlere Geburtsjahr der Probanden ist 1982. Das älteste angegebene Geburtsjahr ist 1947 und das jüngste angegebene Geburtsjahr ist 1999. Abbildung 6 zeigt sie Verteilung der angegebenen Geburtsjahre. Bei der Frage zur Nationalität wurden zwei Länder häufig genannt. 156 Probanden haben die USA als Nationalität angegeben und 36 Probanden haben Indien als Nationalität angegeben. Aus Geschlechtersicht ist die Studie klar durch Männer dominiert. 131 Probanden haben ihr Geschlecht als männlich angegeben, 72 Probanden haben ihr Geschlecht als weiblich angegeben und zwei Probanden haben kein Geschlecht angegeben. Bei der Frage zur Beschäftigungssituation der Probanden werden zwei Antworten häufig genannt. 153 Probanden haben angeben, dass Sie angestellt sind und 32 Probanden haben angegeben, dass Sie selbstständig sind.

Beim monatlichen Einkommen der Probanden werden drei Einkommensgruppen von den Probanden häufig genannt. 44 Probanden geben an zwischen 1.000\$ und 2.000\$ pro Monat zu verdienen, 37 Probanden geben an zwischen 2.000\$ und 3.000\$ monatlich zu verdienen und 35 Probanden geben an zwischen 5.000\$ und 6.000\$ monatlich zu verdienen. Abbildung 7 zeigt die gesamte Einkommensverteilung.

Bei der Frage zum Ort, an welchem das Experiment bearbeitet wird, ist eine Antwortmöglichkeit sehr dominant. 155 Probanden haben das Experiment zuhause bearbeitet. Die Probanden schätzen ihr statistisches Wissen im Mittel mit der Note 3,65 und folglich als befriedigend bis ausreichend ein. Hierbei muss beachtet werden, dass die der Frage zugrundeliegende Scala das aus sechs Noten bestehende deutsche Notensystem ist. Insgesamt haben 10 Probanden die Fragen zum Test der Aufmerksamkeit falsch beantwortet. Da bei diesen Probanden unklar ist, ob die Probanden die restlichen Fragen überhaupt gelesen haben, werden diese Probanden für die weiteren Analysen aussortiert.

6.2. Das verwendete statistische Testverfahren

Es stellt sich die Frage, wie die Forschungshypothesen und wie die Randomisierung der Störvariablen geprüft

¹²⁵Vgl. Oppenheimer, Meyvis und Davidenko (2009), S. 867f.

¹²⁶Vgl. Sibbertsen und Lehne (2015), S. 399.


Abbildung 6: Die beobachtete Verteilung der angegebenen Geburtsjahre



Abbildung 7: Die beobachtete Einkommensverteilung

werden können. Hierbei muss beachtet werden, dass das Investitionsverhalten der Probanden mithilfe einer nichtmetrischen Skala erhoben wird. Deshalb ist bei fast allen durchgeführten Tests der erhobenen Daten ein Chi-Quadrat-Unabhängigkeitstest erforderlich. Mithilfe des Tests wird untersucht, ob die Ausprägungen der überprüften Variable mit der Experimentalgruppe zusammenhängen. Hierbei müssen die Experimentalgruppen als eigene Variable E mit jeweils zwei Ausprägungen je Experiment definiert werden. Bei einer getesteten Variable A ergeben sich zwei statistische Hypothesen:

$$H_0: A$$
 und E sind unabhängig, bzw.
 $H_1: A$ und E sind abhängig.¹²⁷ (32)

Die Teststatistik des Chi-Quadrat-Unabhängigkeitstest erfordert einige Umformungen in den erhobenen Daten. So muss im ersten Schritt eine Kreuztabelle gebildet werden. In dieser Tabelle wird gezählt, wie oft eine Ausprägung der überprüften Variable in den betrachteten Experimentalgruppen genannt wird. Im nächsten Schritt muss der mittlere Häufigkeitswert aller Ausprägungen der Variable in allen Experimentalgruppen bestimmt werden.¹²⁸

Die Idee des Chi-Quadrat-Unabhängigkeitstest ist zu testen, ob die in den Experimenten beobachteten Häufigkeiten bei den einzelnen Ausprägungen der überprüften Variable signifikant von den mittleren Häufigkeiten verschieden sind.¹²⁹ Aus dieser Idee ergibt sich die Chi-QuadratTeststatistik χ^2 :

$$\chi^{2} = \sum_{k=1}^{K} \sum_{l=1}^{L} \frac{\left(n_{k,l} - \bar{n}_{k,i}\right)^{2}}{\bar{n}_{k_{n}l}}.$$
(33)

Hierbei beschreibt der Parameter *L* die Anzahl an Ausprägungen der überprüften Variable und der Parameter *K* die Anzahl an Experimentalgruppen. Des Weiteren steht der Parameter $n_{k,l}$ für die beobachtete Häufigkeit der Ausprägungen einer Variable in einer Experimentalgruppe und der Parameter $\bar{n}_{k,l}$ für jede mittlere Häufigkeit der Ausprägungen einer Variable in einer Experimentalgruppe.¹³⁰ Die Nullhypothese kann abgelehnt werden, wenn der Zusammenhang:

$$\chi^2 < \chi^2_{df,1-\alpha} \tag{34}$$

gilt. Der Parameter $\chi^2_{df,1-a}$ ist der Wert der Chi-Quadrat-Verteilung, welcher erwartet wird, wenn die Variablen unabhängig sind und folglich die Nullhypothese nicht verworfen werden kann. Der Parameter α beschreibt die maximal akzeptierte Irrtumswahrscheinlichkeit und der Parameter dfbeschreibt die notwendigen Freiheitsgrade der Verteilung. Die Freiheitsgrade df ergeben sich aus dem Produkt der bereits eingeführten Parameter L und K. Es gilt:

$$df = (L-1) \cdot (K-1).^{131}$$
(35)

6.3. Die Überprüfung der Randomisierung

Insgesamt wurden die Variablen Geschlecht, Geburtsjahr, Nationalität, Beschäftigung, Einkommen, Ort der Probanden, Statistikwissen, Risikoneigung und Einstellung zu Bier

¹²⁷Vgl. Sibbertsen und Lehne (2015), S. 434.

¹²⁸Vgl. Backhaus, Erichson, Plinke und Weiber (2018), S. 342.

¹²⁹Vgl. Backhaus et al. (2018), S. 347f.

¹³⁰Vgl. Sibbertsen und Lehne (2015), S. 434.

¹³¹Vgl. Sibbertsen und Lehne (2015), S. 435.

in beiden Experimentgruppen auf Randomisierung getestet.¹³² Die Variablen Geburtsjahr, Einkommen, Statistikwissen Risikoneigung und Einstellung zu Bier sind metrische Variablen. Deshalb wurde beim Test der Variablen jeweils ein Zweistichproben-T-Test eingesetzt. Hierbei kann bei nahezu allen Variablen jeweils in beiden Experimenten Randomisierung nachgewiesen werden. Jedoch wird beim ersten Experiment bei der Variable Geburtsjahr ein signifikanter Unterschied beim Mittelwert festgestellt. Tabelle 3 zeigt die zugrundeliegende Statistik.¹³³

Es zeigt sich, dass die Probanden in der ersten Experimentalgruppe im Durschnitt 5,5 Jahre älter sind als die Probanden in der zweiten Experimentalgruppe. Der Unterschied ist signifikant zur Irrtumswahrscheinlichkeit $\alpha = 2\%$. Somit ist es möglich, dass das Alter der Probanden die Ergebnisse des ersten Experiments beeinflusst.

Die Variablen Geschlecht, Nationalität, Beschäftigung und Ort der Probanden sind nicht-metrische Variablen. Aus diesem Grund wird die Randomisierung dieser Variablen den beiden Experimenten eine Serie von Chi-Quadrat-Unabhängigkeitstests getestet. Bei den Tests zeigt sich, dass die erforderliche Randomisierung für die Variablen Geschlecht, Nationalität und Beschäftigung erfüllt ist. Beim ersten Experiment wird ein signifikanter Unterschied beim Ort der Probanden beobachtet. Die dazugehörige Statistik ist in Tabelle 4 dargestellt.

Es ist erkennbar, dass die Probanden der zweiten Experimentalgruppe das Experiment häufiger zuhause und weniger häufig außerhalb bearbeitet haben als die Probanden der ersten Experimentalgruppe. Der Effekt ist zur Irrtumswahrscheinlichkeit 4,6 Prozent signifikant. Folglich könnte der Ort der Probanden deren Investitionsentscheidung beeinflussen. Zusammenfassend zeigen die durchgeführten Tests der Randomisierung, dass die Randomisierung im ersten Experiment bei zwei Variablen nicht erfüllt ist.

6.4. Die Überprüfung der Forschungshypothesen

6.4.1. Das beobachtete Investitionsverhalten im gesamten Datensatz

Abbildung 8 zeigt wie oft die beiden Braukessel in den jeweiligen Experimentalgruppen der beiden Experimente gewählt wurden. Zur besseren Vergleichbarkeit der Experimentalgruppen werden die relativen Häufigkeiten gezeigt. Beim ersten Experiment haben sich in der ersten Experimentalgruppe 66,7% der Probanden für den großen Braukessel entschieden und 33,3% der Probanden für den kleinen Braukessel. In der zweiten Experimentalgruppe haben sich 72,9% der Probanden für den großen Braukessel und 27,1% der Probanden für den kleinen Braukessel entschieden. Beim zweiten Experiment wird ein ähnliches Investitionsverhalten beobachtet. Hierbei haben sich in der ersten Experimentalgruppe 65,3% der Probanden für den großen Braukessel und 34,7% der Probanden für den kleinen Braukessel entschieden. In der zweiten Experimentalgruppe haben sich 56,0% der Probanden für den großen Braukessel und 44,0% der Probanden für den kleinen Braukessel entschieden.

Im ersten Experiment wurde auf Basis der ersten Forschungshypothese erwartet, dass die Aufnahme von einer Clawback-Klausel in die Vergütung der Probanden dazu führt, dass signifikant mehr Probanden den großen Braukessel wählen. Folglich müsste ein deutlicher Unterschied beim Investitionsverhalten der beiden Experimentalgruppen erkennbar sein. Jedoch zeigt sich nur ein sehr geringer Unterschied von ca. 6%.

Beim zweiten Experiment wurde auf Basis der zweiten Forschungshypothese erwartet, dass die Erklärung der von der Investitionsentscheidung unabhängigen Clawback-Klausel dazu führt, dass signifikant mehr Probanden den großen Braukessel wählen. Folglich müsste auch hier ein deutlicher Unterschied beim Investitionsverhalten der Experimentalgruppen erkennbar sein. Es zeigt sich allerdings auch nur ein geringer Unterschied von ca. 9%. Des Weiteren ist der Effekt entgegengesetzt zum erwarteten Effekt. Die Erklärung der von der Investitionsentscheidung unabhängigen Clawback-Klausel führt dazu, dass etwas mehr Probanden den kleinen Braukessel wählen.

Da die Investitionsentscheidung als nicht-monetäre Variable gemessen wird, muss ein Chi-Quadrat-Unabhängigkeitstest zum statistischen Test der Forschungshypothesen gewählt werden. Die Ergebnisse der beiden Tests sind in Tabelle 5 dargestellt. Wie aus Tabelle 5 erkennbar ist, sind die beobachteten Effekte bei beiden Experimenten zu klein, um einen Zusammenhang zwischen dem beobachteten Investitionsverhalten und der Experimentalgruppe, zu belegen.

Bei beiden Experimenten zeigt sich, dass die Annahme einer Abhängigkeit des Investitionsverhaltens von der Experimentalgruppe unwahrscheinlich ist. Im ersten Experiment beträgt die Irrtumswahrscheinlichkeit 65,7% und im zweiten Experiment 34,3%. Deshalb kann die Nullhypothese bei beiden Experimenten nicht verworfen werden. Somit kann die Gültigkeit beider Forschungshypothesen empirisch nicht belegt werden.

6.4.2. Die Einschränkung des Datensatzes

Bei der Interpretation der erhobenen Daten sind die erhobenen Daten zur Risikowahrnehmung der Probanden interessant. Auch bei dieser Variable weichen die Ergebnisse von den erwarteten Ergebnissen ab. In beiden Experimenten wird, unabhängig von der Experimentalgruppe, der große Braukessel als riskanter wahrgenommen. Die Ergebnisse deuten darauf hin, dass die experimentelle Manipulation nicht erfolgreich war.¹³⁴ Diese These wird durch die Betrachtung einer weiteren Kontrollvariablen unterstützt.

¹³²In diesem Zusammenhang wurden auch die Antworten der Probanden zur Zielsetzung des Experiments ausgewertet. Kein Proband, bzw. keine Probandin, hat die Zielsetzung des Experiments erkannt.

¹³³Für die kompletten Testergebnisse vgl. Anhang d).

¹³⁴Vgl. Anhang e).

Tabelle 3: Der signifikante Unterschied beim A	Alter der Probanden in	ersten Experiment
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Deskriptive Statistik							Zweist	tichproben-	T-Test
	Experimental-	N	Mittelwert	Std	Standardfehler des		т	df	Sig (2-seitig)
	gruppe		Witterwert	Abweichung	Mittelwertes		•	u.	olg. (2 oolig)
Age	1	48	1978,69	14,415	2,081		0.060	04.000	0.020
	2	48	1984,29	7,901	1,140		-2,302	94,000	0,020

Tabelle 4: Der signifikante Unterschied beim Ort der Probanden im ersten Experiment

		Kreuz		Chi-Quadra	at-Test			
Emeriment			Ort der P	robanden		Chi-Quadrat-	-16	Asymptotische
Experimer	imentalgruppe at the at my at home Gesamt University workplace		Gesamt	Wert	ar	Signifikanz (zweiseitig)		
	Anzahl	6	14	28	48	6,174	2	0,046
1	Erwartete Anzahl	3,5	11,5	33,0	48,0			
	Anzahl	1	9	38	48			
2	Erwartete Anzahl	3,5	11,5	33,0	48,0			
01	Anzahl	7	23	66	96			
Gesamt	Erwartete Anzahl	7,0	23,0	66,0	96,0			



Abbildung 8: Das beobachtete Investitionsverhalten in den beiden Experimenten

Tabelle 5: Die Chi-Quadrat-Unabhängigkeitstests zur Untersuchung der Forschungshypothesen

Chi-Quadrat-Test Experiment 1				Chi-Q	uadrat-Test	Experiment 2
Chi-Quadrat- Wert	df	Asymptotische Signifikanz (zweiseitig)		Chi-Quadrat- Wert	df	Asymptotische Signifikanz (zweiseitig)
0,445	1	0,505		0,898	1	0,343

So zeigen die erhobenen Daten einige Auffälligkeiten bei der Frage zum inhaltlichen Verständnis der Entscheidungssituation. In jeder der Experimentalgruppen gibt es Probanden deren Antwort darauf hindeutet, dass sie die Entscheidungssituation nicht verstanden haben. So haben in der ersten Experimentalgruppe des ersten Experiments vier Probanden den kleinen Braukessel gewählt, obwohl sie davon ausgehen, dass zukünftig Bier im Wert von 1.000.000\$ verkauft wird. Des Weiteren haben fünf Probanden den großen Braukessel gewählt, obwohl sie davon ausgehen, dass zukünftig Bier im Wert von 600.000\$ verkauft wird.

Ein ähnlicher Effekt ergibt sich auch bei der zweiten Ex-

perimentalgruppe. In dieser Gruppe haben sechs Probanden den kleinen Braukessel gewählt, obwohl sie davon ausgehen, dass zukünftig Bier im Wert von 1.000.000\$ verkauft wird. Außerdem haben fünf Probanden den großen Braukessel gewählt, obwohl sie davon ausgehen, dass zukünftig Bier im Wert von 600.000\$ verkauft wird. Da bei den ermittelten Probanden sehr wahrscheinlich ist, dass diese die Entscheidungssituation nicht verstanden haben, werden diese bei den folgenden Analysen nicht mehr betrachtet.

Es muss beachtet werden, dass bei den restlichen Probanden im Datensatz nicht sicher davon ausgegangen werden kann, dass diese die Entscheidungssituation verstanden haben. Es ist denkbar, dass Probanden zufällige Antworten gegeben haben. So kann ein Proband z.B. zufällig den großen Braukessel auswählen und angeben, dass er eine Verkaufsmenge im Wert von 1.000.000\$ erwartet. Solche Probanden würden bei den folgenden Analysen weiterhin berücksichtigt werden. Aus diesem Grund wird nachfolgend ein weiteres Kriterium entwickelt, um das Verständnis der Entscheidungssituation zu überprüfen.

Hierbei muss die tatsächliche Zeit, in welcher die Probanden mit der Entscheidungssituation beschäftigt waren, näher betrachtet werden. Diese Zeit beginnt sobald den Probanden die Entscheidungssituation gezeigt wird und endet, wenn ein Proband, bzw. eine Probandin, eine Investitionsentscheidung trifft. Im ersten Experiment waren die Probanden der experimentellen Manipulation durchschnittlich 179,5 Sekunden ausgesetzt, im zweiten Experiment beträgt dieser Wert 240 Sekunden. Da sich ein Proband im zweiten Experiment 4.620 Sekunden mit der Entscheidungssituation beschäftigt hat, entsteht eine Differenz von 1 Minute zwischen den Mittelwerten. Wird der Mittelwert des zweiten Experiments um diesen Ausreißer bereinigt, sinkt dieser auf 184,5 Sekunden und ist somit in derselben Größenordnung wie der Mittelwert des ersten Experiments.

Aufgrund des Umfangs und der Komplexität der Entscheidungssituation wird im Folgenden davon ausgegangen, dass die Probanden sich eine gewisse Zeit mit der Entscheidungssituation beschäftigen müssen, bis diese die Entscheidungssituation verstehen und eine durchdachte Investitionsentscheidung treffen können. Dies bedeutet, dass eine zeitliche Grenze gewählt werden muss, ab welcher davon ausgegangen wird, dass die meisten Probanden die Entscheidungssituation verstanden haben.

Die Bestimmung dieser Grenze ist schwierig. Da die Entscheidungssituation für diese Arbeit entwickelt wurde und noch nie in anderen Untersuchungen eingesetzt wurde, gibt es keine Erfahrungswerte für eine solche zeitliche Grenze. Um etwaige Fehler durch eine subjektive Wahl zu vermeiden, wird die zeitliche Grenze im Folgenden als sehr klein angenommen. Es wird davon ausgegangen, dass die Probanden mindestens 60 Sekunden der experimentellen Manipulation ausgesetzt sein müssen, um die Entscheidungssituation zu verstehen. Diese Zeit wird nach Meinung vieler Tester der beiden Experimente mindestens benötigt, um die Entscheidungssituation überhaupt zu lesen.

Da die Beschreibung des experimentellen Settings in den durchgeführten Experimenten über vier Seiten verteilt ist, wird zusätzlich eine zeitliche Grenze pro Seite angenommen. Hierbei wird bei den ersten drei Seiten jeweils von einer zeitlichen Grenze von zehn Sekunden ausgegangen. Bei der Seite existiert, aufgrund des wenigen Fließtextes, keine zeitliche Grenze. In den folgenden Analysen werden nur Probanden betrachtet, welche sowohl das hergeleitete inhaltliche Kriterium als auch die hergeleiteten zeitlichen Kriterien zum Verständnis der Entscheidungssituation erfüllen.

6.4.3. Das beobachtete Investitionsverhalten im eingeschränkten Datensatz

Abbildung 9 zeigt das beobachtete Investitionsverhalten im eingeschränkten Datensatz. Es ergeben sich große Abweichungen zum beobachteten Investitionsverhalten im gesamten Datensatz. So wählen in der ersten Experimentalgruppe des ersten Experiments 59,3% der Probanden den großen Braukessel und 40,7% Probanden den kleinen Braukessel. Im Gegensatz dazu wählen in der zweiten Experimentalgruppe 81,5% der Probanden den großen Braukessel und 18,5% der Probanden den kleinen Braukessel. Beim zweiten Experiment zeigt sich ein umgekehrter und nicht erwarteter Effekt. Hierbei wählen in der ersten Experimentalgruppe 73,9% der Probanden den großen Braukessel und 26,1% der Probanden den kleinen Braukessel. In der zweiten Experimentalgruppe wählen 53,6% Probanden den großen Braukessel und 46,4% der Probanden den kleinen Braukessel.

Des Weiteren liefern die jeweiligen Chi-Quadrat-Unabhängigkeitstests, im Vergleich zum gesamten Datensatz, abweichende Ergebnisse. Die Ergebnisse sind in Tabelle 6 dargestellt. Beim ersten Experiment wird die vorhergesagte Abhängigkeit des Investitionsverhaltens von der Experimentalgruppe beobachtet. Der Chi-Quadrat-Unabhängigkeitstest zeigt einen Zusammenhang der beiden Variablen, allerdings bei einer hohen Irrtumswahrscheinlichkeit von 7,4%. Es ist erkennbar, dass die erste Forschungshypothese im eingeschränkten Datensatz gilt.

Beim zweiten Experiment wird ein ähnlicher Effekt beobachtet. Hierbei ist die Irrtumswahrscheinlichkeit mit 13,5% jedoch so hoch, dass weiterhin von keinem Zusammenhang von Investitionsentscheidung und Experimentalgruppe ausgegangen werden kann. Folglich kann die zweite Forschungshypothese auch durch eine Einschränkung des Datensatzes nicht belegt werden.

Die Einschränkung des Datensatzes führt zu einer Veränderung bei der Risikowahrnehmung der Probanden im ersten Experiment. Prinzipiell zeigt sich der erwartete signifikante Unterschied zwischen den Experimentalgruppen. Es muss hierbei eine Irrtumswahrscheinlichkeit von 2,4% akzeptiert werden. Jedoch ist der Effekt nicht so stark ausgeprägt wie angenommen. Während in der ersten Experimentalgruppe weiterhin mehrheitlich der große Braukessel als riskanter wahrgenommen wird, sind die Probanden in der zweiten Experimentalgruppe indifferent welcher Braukessel riskanter ist. Beim zweiten Experiment zeigt sich keine Veränderung zum Test mit dem gesamten Datensatz.¹³⁵

7. Zusätzliche Analysen und Überlegungen

Im folgenden Kapitel werden die ermittelten Zusammenhänge diskutiert. Die Analysen beziehen sich stets auf den eingeschränkten Datensatz. Im ersten Unterkapitel (7.1) werden die nicht-randomisierten Variablen des ersten Experiments näher untersucht. Im zweiten Unterkapitel (7.2)

¹³⁵Vgl. Anhang e).



Abbildung 9: Das beobachtete Investitionsverhalten im eingeschränkten Datensatz

Tabelle 6: Die jeweiligen Chi-Quadrattests im eingeschränkten Datensatz

Chi-Q	uadrat-Test	Experiment 1		Chi-Q	uadrat-Test	Experiment 2
Chi-Quadrat- Wert	df	Asymptotische Signifikanz (zweiseitig)		Chi-Quadrat- Wert	df	Asymptotische Signifikanz (zweiseitig)
3,197	1	0,074		2,235	1	0,135

werden die unterschiedlichen Ergebnisse im Vergleich zu Kahneman und Tversky (1979) beschrieben. Außerdem wird ein möglicher Erklärungsansatz für das abweichende Investitionsverhalten hergeleitet.

7.1. Die Analyse der nicht-randomisierten Variablen

7.1.1. Der Effekt des Orts der Probanden

Die Ergebnisse des ersten Experiments sind, aufgrund der fehlenden Randomisierung der Variablen Geburtsjahr und Ort der Probanden, unsicher. Aus theoretischer Sicht ist nicht belegbar, dass das beobachtete Investitionsverhalten durch die beschriebene Clawback-Klausel und nicht durch die unterschiedlichen Ausprägungen der Störvariablen in den beiden Experimentalgruppen entsteht. So kann es z.B. sein, dass nicht die Clawback-Klausel, sondern der unterschiedliche Ort der Probanden zum unterschiedlichen Investitionsverhalten in den beiden Experimentalgruppen führt. Im Folgenden werden deshalb die beiden nicht-randomisierten Störvariablen näher untersucht.

Die Vermutung, dass das Investitionsverhalten im ersten Experiment vom Ort der Probanden abhängt, wird mit einem weiteren Chi-Quadrat-Unabhängigkeitstest getestet. Hierbei wird angenommen, dass ein Zusammenhang zwischen dem Ort der Probanden und der Investitionsentscheidung der Probanden besteht. Tabelle 7 zeigt die Ergebnisse des durchgeführten Tests. Es ist klar erkennbar, dass nur von einer Abhängigkeit der beiden Variablen ausgegangen werden darf, wenn eine hohe Irrtumswahrscheinlichkeit von 69% akzeptiert wird. Diese Beobachtung wird im Folgenden so interpretiert, dass die Investitionsentscheidung der Probanden nicht mit dem Ort der Probanden zusammenhängt.

7.1.2. Der Effekt des Alters der Probanden

Zur Überprüfung des Zusammenhangs zwischen dem Alter der Probanden und dem Investitionsverhalten der Probanden werden drei Altersgruppen gebildet. Es wird nach Geburtsjahr 1990 oder später, nach Geburtsjahr zwischen 1960 und 1989 und nach Geburtsjahr vor 1960 getrennt. Folglich kann erneut ein Chi-Quadrat-Unabhängigkeitstest zum Test des Zusammenhangs eingesetzt werden. Tabelle 8 zeigt die Testergebnisse. Auch bei diesem Test zeigt sich, dass nur von einer Abhängigkeit der beiden Variablen ausgegangen werden darf, wenn eine hohe Irrtumswahrscheinlichkeit von 69,7% akzeptiert wird.

Allerdings sind die erhobenen Daten durch eine Auffälligkeit gekennzeichnet. Alle sechs Probanden der Altersgruppe 1949-1959 sind in der ersten Experimentalgruppe. Der älteste Proband in der zweiten Experimentalgruppe hat angegeben 1962 geboren zu sein. Werden diese sechs Probanden aus der Stichprobe entfernt, nähern sich die Mittelwerte der beiden Experimentalgruppen stark an. In der ersten Experimentalgruppe liegt der Mittelwert bei einem Geburtsjahr von 1983,19 und in der zweiten Experimentalgruppe liegt der Mittelwert bei einem Geburtsjahr von 1982,48. Wird weiterhin angenommen, dass die Mittelwerte in den beiden Experimentalgruppen verschieden sind, müsste eine Irrtumswahrscheinlichkeit von 33,6% akzeptiert werden.

Diese weitere einschränkende Maßnahme verändert die beobachteten Häufigkeiten beim Investitionsverhalten des ersten Experiments. Tabelle 9 zeigt die veränderten Häufigkeiten und den dazugehörigen Chi-Quadrat-Unabhängigkeitstest. In der ersten Experimentalgruppe wählen elf Probanden statt sechzehn Probanden den großen Braukessel und zehn statt elf Probanden den kleinen Braukessel. Diese Verschiebung führt dazu, dass der Zusammen-

	Ko	ntingenztab	belle		C	hi-Qua	drat-Test
Ort dor P	robandon	In	vestitionsverha	lten	Chi-Quadrat-	df	Asymptotische
	Iobanden	big kettle	small kettle	Gesamt	Wert	u	Signifikanz (zweiseitig
at the	Anzahl	1	1	2	0,743	2	0,690
University	Erwartete Anzahl	1,4	0,6	2,0			
at my	Anzahl	3	2	5			
workplace	Erwartete Anzahl	3,5	1,5	5,0			
	Anzahl	34	13	47			
at home	Erwartete Anzahl	33,1	13,9	47,0			
	Anzahl	38	16	54			
Gesamt	Erwartete Anzahl	38,0	16,0	54,0			

Tabelle 7: Der Chi-Quadrat Unabhängigkeitstest für die Variable Ort und die Variable Investitionsentscheidung

Tabelle 8: Der Chi-Quadrat Unabhängigkeitstest für die Variable Geburtsjahr und die Variable Investitionsentscheidung

	Kontingenztabelle						Chi-Quad	rat-Test
Alter der E	Probanden	Inv	vestitionsverhal	ten		Chi-Quadrat-	df	Asymptotische
Aller der Probanden		big kettle	small kettle	Gesamt		Wert	u	Signifikanz (zweiseitig)
4040 4050	Anzahl	5	1	6		0,723	2	0,697
1949-1959	Erwartete Anzahl	4,2	1,8	6,0				
4000 4000	Anzahl	26	11	37				
1960-1989	Erwartete Anzahl	26,0	11,0	37,0				
1990-	Anzahl	7	4	11				
Present	Erwartete Anzahl	7,7	3,3	11,0				
Garant	Anzahl	38	16	54				
Gesamt	Erwartete Anzahl	38,0	16,0	54,0				

hang von Investitionsentscheidung und Experimentalgruppe signifikanter wird. Es muss nur noch eine Irrtumswahrscheinlichkeit von 3,1% akzeptiert werden.

Diese Beobachtung könnte auf eine Moderation des Zusammenhangs zwischen der Variable Investitionsentscheidung und der Variable Experimentalgruppe durch die Variable Geburtsjahr hindeuten. So könnte z.B. angenommen werden, dass der erwartete Zusammenhang bei jüngeren Probanden stärker ausgeprägt ist. Die Hypothese kann jedoch mit den erhobenen Daten nicht getestet werden. Die Gruppengröße der jungen und der alten Altersgruppe ist zu klein, um jeweils sinnvolle Aussagen zum genauen Investitionsverhalten treffen zu können.

Zur Verdeutlichung ist es sinnvoll nochmals Tabelle 8 zu betrachten. Basierend auf dem gesamten eingeschränkten Datensatz, wird bei der Altersgruppe 1949-1959 erwartet, dass sich 70% der Probanden, bzw. 4,2 Probanden, für den großen Braukessel und 30% der Probanden, bzw. 1,8 Probanden, für den kleinen Braukessel entscheiden. Da sich jeder Proband für eine Investitionsalternative entscheiden muss, sind solche Kommazahlen nicht in der Realität beobachtbar. Stattdessen muss erwartet werden, dass entweder vier oder fünf Probanden, bzw. entweder ein oder zwei Probanden, den großen, bzw. kleinen, Braukessel wählen. Folglich könnte das beobachtete Investitionsverhalten der Altersgruppe auch rein statistischer Natur sein.

7.2. Eine mögliche Erklärung des Unterschieds zu Kahneman und Tversky (1979)

Beim Vergleich der Ergebnisse der beiden Experimente mit den jeweiligen Ergebnissen von Kahneman und Tversky (1979) fallen zwei Unterschiede auf. Auf Basis dieser Arbeit war angenommen worden, dass die Probanden in den ersten Experimentalgruppen der beiden Experimente eine starke Präferenz für den kleinen Braukessel, bzw. die sichere Investitionsalternative zeigen werden. Des Weiteren wurde davon ausgegangen, dass die Probanden in der zweiten Experimentalgruppe des zweiten Experiments eine starke Präferenz für den großen Braukessel, bzw. die riskante Investitionsal-

	Kontingenztabelle					hi-Quad	Irat-Test	
Experime	ntalarunna	In	vestitionsverhalt	en	Chi-Quadrat-	df	Asymptotische	
Expenine	ntaigruppe	big kettle small kettle Gesamt		Gesamt	Wert	u	Signifikanz (zweiseitig	
	Anzahl	11	10	21	4,656	1	0,031	
1	Erwartete Anzahl	14,4	6,6	21,0				
_	Anzahl	22	5	27				
2	Erwartete Anzahl	18,6	8,4	27,0				
	Anzahl	33	15	48				
Gesamt	Erwartete Anzahl	33,0	15,0	48,0				

Tabelle 9: Das beobachtete Investitionsverhalten im weiter eingeschränkten	Datensatz
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ternative zeigen werden. Beide Annahmen können mit den erhobenen Daten nicht belegt werden.

Es stellt sich die Frage, wie dieser Unterschied erklärt werden kann. Zur Erklärung wird im Folgenden das hergeleitete Modell genutzt. Das veränderte Investitionsverhalten deutet darauf hin, dass die Probanden den Investitionsalternativen andere Nutzenwerte zuweisen, als bei Kahneman und Tversky (1979). Hierbei muss daran erinnert werden, dass ein Einfluss der Wertfunktion aufgrund der verzehnfachten Ergebnisse der Investitionsalternativen unwahrscheinlich ist.¹³⁶ Folglich müssen in den beiden durchgeführten Experimenten die Eintrittswahrscheinlichkeiten der finanziellen Ergebnisse anders gewichtet werden.

Es ist denkbar, dass dieser Effekt durch ein verändertes Framing der Entscheidungssituation entsteht. Bei Kahneman und Tversky (1979) wird den Probanden eine Lotterie beschrieben, in welcher diese ihr persönliches Vermögen vergrößern können.¹³⁷ Im Gegensatz dazu wird in den beiden durchgeführten Experimenten den Probanden eine Investitionsentscheidung eines Unternehmens beschrieben und ein Bezug zum persönlichen Vermögen hergestellt. Hierbei wird angenommen, dass die Probanden diesem Bezug folgen und ihre Entscheidung basierend auf dem persönlichen Vermögen treffen. Diese Annahme wurde axiomatisch eingeführt und muss deshalb nicht zwingend zutreffen.

Wenn zumindest ein Teil der Probanden die Entscheidungssituation aus Unternehmenssicht und nicht aus persönlicher Sicht wahrnimmt, dann ist nicht klar, ob die Wahrscheinlichkeitsgewichte aus Kahneman und Tversky (1979) auch für diese Probanden gelten. Dieser andere Kontext könnte dazu führen, dass die Probanden die Entscheidungssituation rationaler betrachten und deshalb die Eintrittswahrscheinlichkeiten der Ergebnisse weniger stark gewichten. So zeigen z.B. Tenbrunsel und Messick (1999), dass Entscheidungen von Personen erheblich von der eingenommenen Sichtweise auf die Entscheidungssituation abhängen.¹³⁸ Es ist beispielsweise denkbar, dass das Wahrscheinlichkeitsgewicht $\pi(0,8)$ aufgrund der beschriebenen Entscheidungssituation so groß ist, dass die Ungleichung Gleichung (5.4) verletzt wird.

Solche Hypothesen können mit den erhobenen Daten nicht überprüft werden. Zwar wurde die Wahrscheinlichkeitsgewichtung der Probanden bei der Durchführung der Experimente gemessen. Allerdings sind die erhobenen Daten zu ungenau für eine weitere Analyse. Da die Probanden angeben sollten, welche Investitionsalternative riskanter erscheint, können nur Aussagen zum Verhältnis der Wahrscheinlichkeitsgewichte und keine Aussagen zu den absoluten Wahrscheinlichkeitsgewichten getroffen werden. So wird z.B. in der ersten Experimentalgruppe des ersten Experiments beobachtet, dass die Probanden den großen Braukessel als riskanter wahrnehmen. Es ist jedoch nicht ermittelbar, ob die Probanden diese Investitionsalternative als riskanter, bzw. als weniger riskant als die entsprechenden Probanden bei Kahneman und Tversky (1979) wahrnehmen.

8. Schlussbetrachtung

In der vorliegenden Arbeit werden Effekte von Clawback-Klauseln auf das Investitionsverhalten untersucht. Es ergeben sich sowohl theoretische als auch empirische Ergebnisse. Zu Beginn der Arbeit wird ein Modell vorgestellt, welches das Investitionsverhalten von Managern mit und ohne Clawback-Klauseln beschreibt. Hierbei wird die Abhängigkeit der eigenen Bonuszahlung von der gewählten Investitionsalternative aufgezeigt. Darauf aufbauend wird angenommen, dass der modellierte Manager bei der Investitionsentscheidung nur seine eigene Bonuszahlung maximiert. Diese Annahme ermöglicht es, das Investitionsverhalten des Managers mithilfe der Prospect-Theorie von Kahneman und Tversky (1979) zu beschreiben. Es wird jeweils eine Nutzenfunktion mit und ohne Clawback-Klauseln hergeleitet.

Aus dem hergeleiteten Modell lassen sich eindeutige Aussagen zu Effekten von Clawback-Klauseln auf das Investitionsverhalten ableiten. Es zeigt sich, dass das Investitionsverhalten nur verändert werden kann, wenn die Einführung einer Clawback-Klausel dazu führt, dass eine ausreichend

¹³⁶Vgl. Kapitel 5.4.3.

¹³⁷Vgl. z.B. Kahneman und Tversky (1979), S. 271.

¹³⁸Vgl. Tenbrunsel und Messick (1999), S. 704.

große Clawback-Wahrscheinlichkeit bei einer vormals dominanten Investitionsalternative auftritt. Des Weiteren wird von einem Isolation-Effekt bei von der Entscheidungssituation unabhängigen Clawback-Wahrscheinlichkeiten ausgegangen.

Es ergeben sich zwei Forschungshypothesen, welche mithilfe zweier Experimente überprüft werden. Hierfür wird eine Datenerhebung über Amazon MTurk durchgeführt. Die Experimente weisen zwei Charakteristika auf. So wird, um die Entscheidungssituation verständlicher zu machen, ein kontextreiches Setting im Rahmen einer Bierbrauerei gewählt. Des Weiteren werden viele zusätzliche Fragen in die Experimente aufgenommen. Diese Fragen dienen zur Kontrolle der Randomisierung potenzieller Störvariablen und zur Kontrolle der Aufmerksamkeit und des inhaltlichen Verständnisses der Probanden.

Die Untersuchung der erhobenen Daten liefert unterschiedliche Ergebnisse. So kann ein signifikanter Effekt von entscheidungsabhängigen Clawback-Klauseln auf das Investitionsverhalten nachgewiesen werden. Dies gelingt allerdings erst, wenn der erhobene Datensatz nach verschiedenen Kriterien eingeschränkt wird. Der vermutete Effekt von entscheidungsunabhängigen Clawback-Klauseln wird nicht beobachtet. Außerdem wird ein schwacher Effekt des Alters der Probanden auf den untersuchten Zusammenhang beobachtet. Des Weiteren weichen die Ergebnisse zum Teil deutlich von den Ergebnissen von Kahneman und Tversky (1979) ab.

Die Arbeit weist einige Limitationen auf. So wird zum Beweis des Modells nur das Investitionsverhalten der Probanden gemessen. Diese Messung allein reicht jedoch nicht aus, um die Gültigkeit und Aussagekraft des Modells zu untersuchen. Es bleibt z.B. unklar, ob die Probanden ihre Investitionsentscheidung tatsächlich nur auf Basis der persönlichen Bonuszahlung treffen. Hierfür sind weitere Untersuchungen nötig, welche die einzelnen Bestandteile des Modells genauer untersuchen.

Außerdem ist denkbar, dass die Verwendung einer kontextreichen Entscheidungssituation zum Auftreten von einem oder mehreren Framing-Effekten geführt hat. Diese ungeplanten Effekte könnten die erhobenen Daten und insbesondere das beobachtete Investitionsverhalten systematisch verzerren. Zukünftige Untersuchungen könnten an diesem Punkt ansetzten und die beiden beschriebenen Experimente ohne Kontext und in starker Anlehnung an Kahneman und Tversky (1979) durchführen. Der Vergleich zu den bereits erhobenen Daten verspricht interessante Erkenntnisse.

Des Weiteren wird eine leichte Abhängigkeit des Investitionsverhaltens vom Alter der Probanden beobachtet. Dieser Effekt kann mithilfe des hergeleiteten Modells nicht erklärt werden. Hierbei ist denkbar, dass das Alter der Probanden die Stärke des Zusammenhangs zwischen einer Clawback-Klausel und dem beobachteten Investitionsverhalten moderiert. Zukünftige Untersuchungen könnten diese Beobachtung aufgreifen und den Zusammenhang zwischen Clawback-Klauseln und Investitionsverhalten unter Berücksichtigung des Alters untersuchen. Die vorliegende Arbeit erweitert das betriebswirtschaftliche Verständnis von Clawback-Klauseln. Es wird ein einfaches Modell zum Zusammenhang zwischen Clawback-Klauseln und Investitionsverhalten hergeleitet, welches alle bekannten Formen von Clawback-Klauseln beinhaltet. Aus diesem Modell ergeben sich klare Effekte von Clawback-Klauseln auf das Investitionsverhalten. Diese Effekte können in Teilen im Experiment belegt werden. Aus Sicht der Praxis ist interessant, dass Clawback-Klauseln das Investitionsverhalten tatsächlich verändern können und somit als Instrument zur Steuerung des Investitionsverhaltens eingesetzt werden können.

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Multi-Period Optimization of the Refuelling Infrastructure for Alternative Fuel Vehicles

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Abstract

Alternative fuel vehicles (AFV) are gaining increasing attention as a mean to reduce greenhouse gas (GHG) emissions. One of the most critical barriers to the widespread adoption of AFVs is the lack of sufficient refuelling infrastructure. Although it is expected, that an adequate number of alternative fuel stations (AFS) will eventually be constructed, due to the high resource intensity of infrastructure development, an optimal step-by-step construction plan is needed. For such a plan to be actionable, it is necessary, that the underlying model considers realistic station sizes and budgetary limitations.

This bachelor thesis addresses this issue by introducing a new formulation of the flow-refuelling location model, that combines multi-periodicity and node capacity restrictions (MP-NC FRLM). For this purpose, the models of Capar and Kluschke have been extended, and the pre-generation process of sets and variables has been improved. The thesis furthermore adapts and applies the two evaluation concepts Value of the Multi-Period Solution (VMPS) and Value of Multi-Period Planning (VMPP) to assess the model's relative additional benefit over static counterparts. Besides, several hypotheses about potential drivers of the two evaluation concepts VMPS and VMPP have been made within the scope of a numerical experiment, to help central planners identify situations, where the additional complexity of a dynamic model would be worthwhile.

While the MP-NC FRLM has proven to provide additional benefit over static counterparts, it comes at the cost of a higher solving time. The main contributor to the higher solving is hereby the incorporation of a time module.

Keywords: Alternative fuel vehicle; refuelling infrastructure; optimal location; multi-period; fuel station.

1. Introduction and Problem Formulation

Over the last decade, the awareness of environmental problems and climate change has grown significantly. Via the internet and social media, it is now easier than ever for nongovernmental organizations (NGO), scientists and activists to reach millions of people with their message: Climate Change is real, and if humanity in its entirety does not act with all necessary vehemence, the effects of global warming will be devastating. Even if the goals of the Paris Climate Agreement are accomplished, and global warming is held below 2°C compared to pre-industrial times, the consequences will still be grave. Risks to livelihoods, food security, water supply and impacts on biodiversity and ecosystems, including species loss and extinction, are the most commonly mentioned consequences. Nonetheless, global greenhouse gas (GHG) emissions continue to rise and path the way to a significant climate crisis. In contrast to the increasing production of greenhouse gases, GHG emissions in 2030 need to be approximately 25% respectively 55% lower than in 2017 to put the world on a pathway to limiting global warming to 2°C respectively 1,5°C (UN Environment (2018)).

Alongside the rising awareness for climate change and its consequences, alternative fuel vehicles (AFV) are gaining increasing attention. According to the IPCC, the transportation sector accounts for 14% of global greenhouse gas emissions, Edenhofer et al. (2014), in Europe for even 20% and rising (Rosca, Costescu, Rusca, and Burciu (2014)) (see figure 1). The step-wise replacement of combustion engines with, for example, battery-electric (BEV) or fuel cell electric vehicles (FCEV) is, hence, seen as an essential cornerstone for reducing greenhouse gases and other emissions. To become more popular, AFVs have to overcome several barriers. The most commonly discussed barriers are hereby the limited range of BEVs ,Capar and Kuby (2012); Lim and Kuby (2010), and the high cost for FCEVs (James, Huya-Kouadio, Houchins, and Desantis (2017)). While each AFV type has its respective barriers, one common problem is the lack of alternative refuelling infrastructure (Zhang, Kang, and Kwon (2017)).



Figure 1: Global GHG Emissions by Economic Sector: With a share of 14% transportation contributes significantly to global emissions. (Edenhofer et al. (2014))

Although the popularity of AFVs is rising, many potential customers hesitate to buy BEVs and FCEVs, because the current level of refuelling infrastructure is not as mature as that of conventional gas stations and is not widely distributed (Zhang et al. (2017)). To facilitate the use of alternative drive technologies, it is, therefore, essential to plan and establish a refuelling infrastructure that is in line with the rising demands (Melendez (2006)). The decision where AFS should be placed is serious, because it has an influence on the allocation of further gas stations and might be decisive for the market success of alternative drive technologies. It becomes more important, as establishing a refuelling infrastructure is expensive, and decisions for a location are most probably final due to the high costs of changing the location. Hence, optimal allocation seems to be inevitable (Jochem, Brendel, Reuter-Oppermann, Fichtner, and Nickel (2016)).

In consequence numerous efforts have been made to determine the optimal siting of AFS alongside a road network by the means of mathematical optimization (Kuby and Lim (2005); MirHassani and Ebrazi (2013); Capar, Kuby, Leon, and Tsai (2013)). The road network in these optimization problems is represented as a Graph. Potential fuel station locations like cities, route intersections, road service areas are represented as the nodes. The roads are described as edges, that link the nodes. Traffic is depicted as flow that passes nodes and edges on a trip from an origin node to a destination node. The main goal of the optimization models is, to determine the optimal siting of a pre-specified number of *p* fuel stations so that the amount of refuelled origindestination (OD) trips respectively the amount of refuelled traffic is maximal. Figure 2 shows how the trip from Cologne to Karlsruhe via Frankfurt could be modelled as a graph. Applied to this OD trip, the AFS siting models would determine which of the nodes would be the optimal location for a fuel station so that traffic on the way from Cologne to Karlsruhe is refuelled.

Over the last couple of years, models have become increasingly sophisticated, and scientists have begun to consider important real-world restrictions for fuel station siting in their optimization. Some of the more recent models, for example, consider that the possible storage amount of fuel at gas stations is not infinite. Restraining factors are, for example, limitations of the building land or laws that constrain the maximum amount of fuel stored at a single location. Hence, several authors included capacity restrictions in their model (Hosseini and MirHassani (2017);Kluschke et al. (2020)).

Alternative fuel stations are not only capacitated, the construction of such stations is also resource-intensive. Therefore it is unrealistic to assume the construction of a larger number of fuel stations within a short amount of time due to, for example, limitations of budget or labour. Hence, besides determining the optimal AFS placement, it is essential to provide an efficient step-by-step construction plan for the refuelling infrastructure. Thus, some authors have started to extend models by a temporal dimension. Time is hereby discretized into several planning respectively construction periods of equal length.

In consequence, these multi-period models have the objective of providing an optimal period-by-period construction plan, that respects periodic budget limitations (Chung and Kwon (2015); Zhang et al. (2017)).

Although there exist some multi-period AFS location models, a multi-period model that also respects budgetary constraints and capacity restrictions of the building sites have yet to be developed.

The main objective of this thesis is to address this issue by providing an optimization model that delivers an efficient construction plan for building up an alternative fuel station network based on empirical flow data. Therefore the node-capacitated flow-refuelling location model (NC-FRLM)



Figure 2: Possible transformation of a real-world road trip from Cologne to Karlsruhe into a graph.

by Kluschke et al. (2020) was extended by adding a period module alongside a periodic budget to more realistically represent changing demands and construction capacity. The thesis aims at answering the following research questions:

- How can the node-capacitated FRLM be extended to provide a multi-period construction plan for an alternative fuel station network while respecting changing demands and construction capacity?
- Does a multi-period model provide benefits compared to static modelling approaches and how can this benefit be quantified?

The thesis is structured as follows: First, a short overview of the existing literature for flow-refuelling location models (FRLM) is given in section 2.1. Section 2.2 introduces the basic FRLM, as well as the node-capacitated FRLM extension by Kluschke et al. (2020), which are explained before the new multi-period node-capacitated FRLM modelling approach is presented in section 2.3. To examine the benefits and the computational complexity of the model, a numerical experiment is conducted in section 2.4, before completing the thesis with a conclusion and suggestions for further research in section 3.

2. Literature Review

The following Literature Review is subdivided into two parts. The General Literature Review gives the reader a comprehensive overview of the current literature and thematizes mainly the flow-refuelling location model and its expansions. Apart from the basic FRLM and its origin, various approaches towards capacitated and multi-period extensions will also be discussed. The last subsection introduces the reader to the current state of the art FRLM modelling. More specifically, the two models on which the new FRLM extension is based, namely the arc-cover path-cover FRLM by Capar et al. (2013) and the node-capacitated FRLM by Kluschke et al. (2020), are described in detail.

2.1. General Literature Review

Of all facility location problems, the FRLM is the most commonly used model in AFV infrastructure planning. It is based on the idea by Hodgson (1990) to model traffic as flow, that is passing nodes along an origin-destination trip on a graph. The nodes of the network are considered candidate locations for fuel stations, that serve the refuelling demand. The FRLM can either be formulated as a set covering or a maximal covering problem. While the set covering formulation determines the minimal amount of fuel stations necessary to cover all OD trips, the maximal covering formulation maximizes the path/flow coverage with a given amount of p fuel stations. Current FRLM extensions include the consideration of station and node capacity limits and the inclusion of multiple construction periods. The two most common concepts for evaluating multi-period models are the Value of the Multi-Period Solution and the Value of Multi-Period Planning. Both concepts quantify the relative value difference between a multi-period model and pre-specified counterparts.

2.1.1. The Flow-Refueling Location Model

Capar et al. (2013) identify seven different models for solving a facility location problem: p-median problem, set covering problem, maximal covering location problem, flow interception location problem, flow-refuelling location problem, network interdiction problem and network sensor problem. In the context of infrastructure planning for alternative drive technologies, the flow-refuelling location model (FRLM) is the most commonly used (Kluschke et al. (2020)). Figure 3 classifies the new MP-NC FRLM within the different research streams for facility location models.



Figure 3: Overview over facility location models and classification of the MP-NC FRLM

The FRLMs and their expansions are based on the idea of Hodgson (1990) to not express demand as a stationary node attribute but to model it as a flow, that is passing nodes along an origin-destination (OD) trip on a graph. Within the application of alternative fuel station placement, the demand flow represents the vehicle traffic with its need for refuelling on the way from origin to destination.

The nodes of the network are candidate locations for the construction of gas stations to capture the flow and serve the demand. On a highway network, for example, nodes refer to highway entries, intersections or exits.

In their first formulation of the FRLM, Kuby and Lim (2005) extended Hodgson's model to consider the limited range of vehicles. Contrary to prior models, a trip was no longer refuelled, if the OD flow passes one single facility along its path. For refuelling, the entire path had to be covered, which might include more than one refuelling stop at a gas station, depending on the vehicle range, the path length and the node spacing. The possible need to refuel at several facilities required the pre-generation of valid facility combinations on each OD path, which made the model potentially difficult to solve in large networks. To address this problem, Lim and Kuby (2010) proposed heuristic algorithms to solve larger problems. Moreover, MirHassani and Ebrazi (2013) both developed FRLM formulations, that did not require the pre-generation of facility combinations and solved the model faster than the heuristics of Lim and Kuby (2010).

The arc-cover path-cover model, Capar et al. (2013) provided a new formulation of the FRLM, that was computationally more efficient than previous formulations and heuristics. The main idea of this new formulation was to refuel each OD path arc-wise. If all arcs on a path can be refuelled at one of the open facilities, the whole path is seen as refuelled and travelable.

Due to the efficiency of the formulation, Capar et al. (2013)'s model is the base for many of today's FRLM extensions like Hosseini and MirHassani (2017); Zhang et al. (2017); Kluschke et al. (2020) and will therefore be further discussed in section 2.2.

Although the FRLM initially followed a maximal coverage approach, intending to cover the maximal possible amount of flow through the allocation of p facilities, it can be reformulated into a set-covering problem. The set covering formulation aims at minimizing the number of stations necessary to cover a given share of flow respectively demand (Jochem et al. (2016)). Furthermore, Wang and Wang (2010) were the first ones to reformulate the FRLM into a set covering problem. Contrary to most FRLM formulations, their model only used origin-destination trip data as input without including information about the demand of the OD flows. Capar et al. (2013) also provide a set covering formulation of their arc-cover path-cover model, that, like their maximal covering formulation, considers the OD demand.

2.1.2. Capacitated FRLMs

Most articles on the FRLM do not consider capacity limits for facilities and assume, that all flows passing through a station can be served, regardless of its dimension. As AFS do have capacity limits and are expensive to set up, considering existing refuelling limitations is vital to improving the informative value of the models (Hosseini and MirHassani (2017)).

Upchurch, Kuby, and Lim (2009) were the first ones to address this issue with their capacitated FRLM. Their model defines the capacity of a station through the number of its interchangeable modular refuelling units, which can serve a certain amount of vehicles. In consequence, the main objective is not the optimal placement of p facilities, but p modular units on nodes of the network. As Upchurch et al. (2009) do not limit the number of modular units per node, the amount of refuelling capacity that could be built at each node is potentially infinite.

Wang and Lin (2013) provided a capacitated extension of Wang and Lin (2009)'s model that is designed explicitly for BEVs and considers multiple types of charging stations as well as a constrained facility budget. Like Upchurch et al. (2009), they model the capacity of stations through the number of vehicles, that they can serve. The capacity of each station type is calculated through the recharging efficiency of the used technology, given a pre-specified refuelling time. Contrary to Upchurch et al. (2009), the maximum number of facilities at the nodes is limited, so that node-specific restrictions, like local limitations of the power supply or the building land, can be included in the model. Therefore Wang and Lin (2013) can be considered as the first ones to apply node capacity restrictions to the FRLM.

Hosseini and MirHassani (2017) present a capacitated expansion of MirHassani and Ebrazi (2013)'s and Capar et al. (2013)'s models and solved them with a heuristic method based on Lagrangian relaxation. Hosseini and MirHassani (2017) assumed the stations to be fast-refuelling and determined the degree of capacity utilization through the actual amount refuelled. This approach differs from previous ones by Upchurch et al. (2009) and Wang and Lin (2013), who base facility capacity on the number of refuelable vehicles and not on the total amount of refuelling, the station can provide that. Following up on their article, the authors have published two further expansions of their capacitated FRLM.

Hosseini and MirHassani (2015) developed a stochastic version of their capacitated FRLM formulation, to consider the uncertainty of the traffic flow, based on a finite number of scenarios. As the solution time drastically increased with the network size and the number of considered scenarios, a solution heuristic for the stochastic model was presented and successfully tested on an intercity network for Arizona.¹

The second expansion by Hosseini, MirHassani, and Hooshmand (2017) adds the drivers' willingness to deviate from their pre-defined shortest path to visit an AFS to the model. To be able to obtain a solution in a reasonable time for larger instances of the problem, an iterative-based heuristic algorithm was presented.

Most recently Kluschke et al. (2020) present a node capacitated formulation of the arc-cover path-cover formulation by Capar et al. (2013). Like Wang and Lin (2013) they base their model on the idea, that a potentially unlimited amount of refuelling at a single node is unrealistic. Reasons for that are, for example, technical limitations (e.g. the amount of electricity provided at a single location) or legal limitations (e.g. the quantity of hydrogen stored at a single location). The capacity of a station is modelled in units of the alternative fuel (e.g. kg of hydrogen), and its use to capacity is determined by the actual amount refuelled to serve the captured flows. Kluschke et al. (2020) successfully applied their model to the siting of hydrogen refuelling infrastructure for heavy-duty vehicles on the German highway network. Furthermore, they can be considered the first ones to combine node capacity restrictions, and OD demand flows in a model. As their model serves as the base for the FRLM extension

presented in this thesis, it will be further discussed in section 2.3.

2.1.3. Multi-Period FRLMs

As pointed out by Hosseini and MirHassani (2017), AFS is not only capacitated, the construction of such stations is also resource-intensive. Therefore it might not be useful to assume the construction of a larger number of fuel stations within time due to, for example, limitations of budget or labour Chung and Kwon (2015)).

Furthermore, the development of an alternative fuel infrastructure constitutes a so-called "chicken-egg problem", Kuby and Lim (2005) and Wang and Wang (2010), that might only be solved through strategic multi-period planning controlled by a central authority (Chung and Kwon (2015)). On the one hand, companies are unlikely to invest in alternative fuel stations until there is sufficient demand for profitable operations. On the other hand, potential customers are less incentivized to buy alternative fuel vehicles unless there is an agreeable level of refuelling infrastructure (Bento (2008)).

Even though multi-periodicity seems to be an essential aspect of AFS infrastructure planning, the existing literature has rarely considered it.

Chung and Kwon (2015) first addressed the issue of multi-periodicity by extending the maximal covering FRLM formulation of MirHassani and Ebrazi (2013). They present three different methods for multi-period planning of flowrefuelling locations: a multi-period optimization method (M-opt), a forward myopic method (F-Myopic) and a backwards myopic method (B-Myopic). All three methods were applied for the siting of BEV charging stations along the Korean expressways.

The M-opt method solves a multi-period optimization model over T discrete time periods and sites n_t , $t \in T$ facilities per period to maximize the total amount of flow covered over all periods. Once a facility is sited, it must remain open until the final period. n_t depicts the total number of stations that are operational in period t of which $n_t - n_{t-1}$ are newly constructed in period t.

The F-Myopic method solves *T* single-period optimization models successively starting in period one. Like in the Mopt method, in each optimization problem (= time period) n_t-n_{t-1} facilities are allocated, given the siting of the stations in the prior period t-1. That means, for example, that all stations sited in period one are automatically allocated to the same spot in period two. Given the allocated stations from period one, n_2 facilities are sited in period two to maximize the amount of flow covered.

The B-Myopic method follows an approach similar to the F-Myopic method but begins the series of single-period optimization problems in the last period, T. The n_T nodes where facilities have been located in period T serve as candidate nodes for the siting of n_{T-1} facilities in period T - 1. The same procedure is repeated until period one.

Chung and Kwon (2015) stated that the M-Opt method produces the best result in all cases, but also requires the

¹Even though (Hosseini and MirHassani,2017) appeared in the November issue of *International Transactions in Operational Research*, it was first published in October 2015. Therefore the publishing order of the capacitated FRLM and its stochastic expansion by the authors still follows the logical timeline

most computational resources. Although the myopic methods produce significantly worse results on some demand profiles, the B-Myopic method is recommended for larger problems as the B-Myopic solutions are nearly as good as the M-Opt solutions in most cases.

Li, Huang, and Mason (2016) present a multi-period multi-path refuelling location model, that seeks to minimize the roll-out costs for refuelling infrastructure that serves all origin-destination trips. The model takes the drivers' willingness to deviate from their shortest OD path for refuelling into account. An OD pair is considered served, if at least one path, either the shortest path or a path within a reasonable deviation, is refuelled. In their model, (Li et al. (2016)) allow the costly relocation of facilities, but do not include traffic flows between OD pairs.

In a case study for the development of a fast-charging network in South Carolina, Li et al. (2016) applied both, a multi-period optimization method as well as F-Myopic and B-Myopic methods and compared the outcomes. Their findings are consistent with the results of Chung and Kwon (2015) as both of their myopic methods performed worse than the multi-period optimization approach in terms of the objective function value.

Miralinaghi, Keskin, Lou, and Roshandeh (2017)'s model takes a different approach and aims at minimizing the total system cost. The model includes facility construction costs, facility operating costs and the total travel costs experienced by the users of the network. Although Miralinaghi et al. (2017) work with OD pairs, they pre-calculate neither the shortest path nor a path with a reasonable deviation that a driver would take. They implicitly assume that drivers are willing to take any detour necessary to refuel on their trip. They applied the model to an intra-city transportation network and solved it via branch-and-bound and Lagrangian relaxation algorithms.

Zhang et al. (2017) base their multi-period capacitated FRLM on the maximal covering arc-cover path-cover formulation of Capar et al. (2013) and are the first ones to combine multi-periodicity and capacity restrictions in an FRLM formulation. They furthermore model demand as an endogenous variable that depends on demand dynamics and depicts the interaction of network users and network planners.

In their model, demand is displayed as the AFV market share of an OD flow for path q in period t. The market share per path and per period depends on several factors: the market share of the prior period, the natural growth of the market share and the path-specific flow coverage compared to the average flow coverage in the network.

Zhang et al. (2017) model the capacity restrictions of fuel stations according to Upchurch et al. (2009) as the number of vehicles that can charge at a refuelling module per period. Like Upchurch et al. (2009) the number of refuelling modules per node was not limited, which proved to be problematic when the model was applied to a case study about the siting of AFS in the Washington DC - New York - Boston area. The results suggest the construction of up to 70 refuelling modules per single node, which seems to be unrealistic

when considering technical and legal limitations to the total refuelling capacity per single node (Kluschke et al. (2020)).

2.1.4. Assessment of Multi-Period Models

For assessing the additional benefit of multi-period models, the two most frequently found concepts in the literature are the "Value of the Multi-Period Solution "(VMPS) and the "Value of Multi-Period Planning" (VMPP).

The Value of the Multi-Period Solution is a concept first introduced by Alumur, Nickel, Saldanha-da Gama, and Verter (2012), that aims at quantifying the additional benefit of a multi-period model compared to a static counterpart. The static counterpart is a model, that looks for a time-invariant solution of the multi-period problem and scales the outcome adequately to compensate for only solving the problem for one single period (Laporte, Nickel, and Saldanha da Gama (2015)).

As there are several possibilities to define the static counterpart to a multi-period problem, the Value of the Multi-Period Solution can vary along with the definition of the counterpart. Laporte et al. (2015), for example, name several possibilities on how to consider time-varying demands in a static counterpart. While it is one possibility to average all demands over the planning horizon, it is also possible to determine a reference value, e.g. the maximum value observed throughout the planning horizon, for calculating the counterpart's solution. The VMPS is finally calculated as the relative difference between the multi-period model's solution and the one of its counterpart.

The Value of Multi-Period Planning is an evaluation concept first mentioned by Ballou (1968). Although it has yet to be precisely defined, the concept aims at quantifying the additional benefit from considering multiple periods while planning, contrary to continuously solving static problems for each period, given the results of the prior calculations. Two possible comparison models are the F-Myopic and the B-Myopic solution approaches, that was, for example, utilized by Chung and Kwon (2015).

For retrieving comparable results as well as for decisionmakers to consider multi-period over step-wise optimizing models, it is essential to assume, that demand and economic data can be accurately predicted for every considered period. The Value of Multi-Period Planning is obtained by subtracting the solution value of the myopic comparison model from the value of the multi-period model and dividing it by the myopic model's value. Ballou (1968) postulate, that given the assumption of predictive accuracy the Value of Multi-Period Planning should always be positive, which goes along with Chung and Kwon (2015)'s findings.

2.1.5. Contribution of this thesis

In summary, there are only four studies that address the application of the flow-refuelling location model over multiple periods. Furthermore, of those studies, Zhang et al. (2017) are the only ones also to incorporate capacity restrictions in their model. However, the results of their conducted case study indicate that their use of station capacity limits might be of limited practicability due to existing node-specific capacity limitations. To provide a plan for the construction of an AFS network over time with realistic stations sizes on nodes, the use of node capacity restrictions is necessary.

To the author's best knowledge, this thesis is the first piece of work to design and test a multi-period and also nodecapacitated FRLM (MP-NC FRLM). In addition to proposing a general model, this thesis adopts the two assessment criteria, VMPS and VMPP, to fit the specific case of bench-marking the model's additional benefit. The thesis furthermore discusses several factors, that potentially influence the VMPS and VMPP and in this context, addresses the issue of computational complexity.

2.2. Introduction to Current State of the Art FRLM Modelling

The previous paragraph provided a general overview of the FRLM and its current extensions. The two most significant extensions are the consideration of station/node capacity restrictions and the optimization over multiple periods. In the following, the two models on which the MP-NC FRLM model extension is based, are explained in further detail.

Capar et al. (2013) take a different and more efficient way of formulating the FRLM than previous authors. Their main idea is to refuel each OD path arc-wise. If every arc on an OD round-trip can be refuelled at one of the open fuel stations, the whole path is seen as refuelled and travelable. Kluschke et al. (2020) later extend Capar et al. (2013)'s model with capacity restrictions, that limit the total amount of refueling at fuel stations. To better fit their case study of siting hydrogen fuel stations for trucks along the German highway, Kluschke et al. (2020) modify and add several model assumptions. Contrary to Capar et al. (2013), they use single OD trips instead of round-trips and make detailed presumptions about starting and ending fuel level of drivers as well as the total amount refuelled during the trip.

2.2.1. The Basic Arc-Cover Path-Cover FRLM | Capar et al. 2013

The following section describes the arc-cover path-cover FRLM (AC-PC-FRLM) of Capar et al. (2013) in further detail, starting with the model assumptions. After introducing the set covering formulation of the AC-PC FRLM, the calculation of the set $K_{j,k}^q$ and the functionality of the model are illustrated using a simple example. $K_{j,k}^q$ represents the set of facility locations, that could refuel the arc $a_{j,k}$ on path q. For concluding, the maximal covering formulation of Capar et al. (2013)'s AC-PC FRLM is given.

Capar et al. (2013)'s arc-cover path-cover FRLM (AC-PC-FRLM) can be either formulated as a set covering or as a maximal covering problem. The main objective of the set covering problem is to determine the minimal amount of alternative fuel stations and their location on a Graph G = (N,A)under the condition, that at least a pre-specified share of the total fuel demand *S* is satisfied. On the other hand, the maximal covering formulation aims at maximizing the served demand with *p* facilities. The vehicle traffic is depicted as flow, that passes from an origin *O* to a destination *D* on the graph. Traffic flow is considered refuelled or served if vehicles can travel from origin to destination and back to the origin without running out of fuel.

Model Assumptions and Mathematical Formulation

Capar et al. (2013) formulate their model under the following assumptions:

- 1. The traffic between an origin-destination pair flows on the shortest path through the network.
- 2. The traffic volume between OD pairs is known in advance.
- 3. Drivers have full knowledge about the location of the fuel stations along their path and refuel sufficiently to complete their round trips.
- 4. Only nodes of the network are considered as possible refuelling facility locations.
- 5. All vehicles are assumed to have similar driving ranges, a similar fuel tank capacity and similar fuel consumption.
- 6. The fuel consumption is directly proportional to the distance travelled.
- 7. Refuelling stations are incapacitated.

Assumptions 1-3 seem reasonable because every driver has access to a navigation system, either through car equipment or a smartphone, that can provide information about the shortest route, refuelling opportunities and traffic information. As Capar et al. (2013) specifically apply the model to private BEVs, the adoption of round trips rather than single trips is comprehensible considering the fact, that the passengers will want to return to their homes (=the origin) at some point after reaching the destination. In Assumption 4, Capar et al. (2013) limit potential station locations to the network nodes and by that prohibit the possibility of siting a station anywhere on an arc between two nodes. Restricting the siting to the nodes reduces the complexity of the model without significantly negatively impacting the results when applied to real transportation networks except in remote areas (Kuby and Lim (2007)). Assumptions 5-7 are further technical simplifications of reality.

Capar et al. (2013) define the set covering formulation of their arc-cover path-cover FRLM as follows:

$$\min\sum_{i \in N} z_i \tag{2.1}$$

s.t.
$$\sum_{i \in K_{i,k}^q} z_i \ge y_q \forall q \in Q, \ a_{j,k} \in A_q$$
(2.2)

$$\sum_{q \in Q} f_q \ y_q \ge S \forall \ i \in N \tag{2.3}$$

$$z_i, \ y_q \in \{0,1\} \forall \ q \ \in \ Q, \ i \ \in \ N$$
(2.4)

Sets	
Ν	Set of all nodes on the Graph G
Q	Set of all OD pairs
A_{a}	Set of all directional arcs on the OD path
1	$q \in Q$ from origin to destination and back
K^{q}_{ik}	Set of all potential station locations, that
J,K	can refuel the directional arc $a_{ik} \in A_a$
Variables	· · · · · · · · · · · · · · · · · · ·
z_i	Binary Variable that equals to one, if a re-
	fuelling facility is constructed at node <i>i</i>
y_a	Binary Variable that equals to one, if the
- 1	flow on path q is refuelled
Parameters	
f_a	Total vehicle flow on the OD path q
S	Proportion of the minimal amount of total
	flow refuelled

The objective function (2.1) of the model minimizes the total number of stations built on the nodes N of Graph G. Constraint (2.2) presents the core of the new arc-cover path-cover formulation by Capar et al. (2013), which allows them to formulate their FRLM without the pre-generation of all possible facility combinations for all paths. $K_{j,k}^q$ is hereby the set of all nodes, where a constructed facility could refill the arc $a_{j,k}$ on the OD-path q. (2.2) ensures, that a path is only counted as refuelled if the built stations z_i refuel all arcs on the OD-path q. Constraint (2.3) guarantees the refuelling of at least S * 100% of all OD-flows f_q of all OD trips q. (2.4) defines the two binary variables z_i and y_q . z_i equals to one if a facility is constructed at node i, whereas y_q equals to one if a path q is refuelled.

Pre-Calculation of the Set $K_{j,k}^q$

Like mentioned in the previous paragraph, the set $K_{j,k}^q$ is the core of Capar et al. (2013)'s new FRLM formulation. For each arc of each path, $K_{j,k}^q$ provides a list of candidate nodes for facilities, that could refuel the directional arc $a_{j,k}$. A path q can only be considered as covered, if every arc of this path is refuelled by a gas station from their candidate set. $K_{j,k}^q$ is calculated prior to the optimization of the model by applying the following logic, depicted in Code Listing 1:

for all $q \in Q$: for all $a_{j,k} \in A_q$: for all nodes i on the OD round trip q, that are not the destination node k of the arc $a_{j,k}$ if the distance(node i, node k) \leq vehicle_range, following the round trip, then add node i to $K_{j,k}^q$

Code Listing 1: Algorithm for determining the set $K_{j,k}^q$ in the AC-PC FRLM

To determine the set of potential facility locations $K_{j,k}^q$, every node i, that lies between the origin node and the destination node of the arc $a_{j,k}$ on path q, will be inspected, to whether it qualifies for hosting a station, that can refuel the arc a_j , k. Node I will be added as a potential location, if the destination node of the arc $a_{j,k}$ is reachable leaving node i with a full tank.

Contrary to the first FRLM formulation by Kuby and Lim (2005), vehicles here do not start from the origin with a prespecified fuel level, e.g. half of the tank. Capar et al. (2013) determine the initial tank filling based on the location of the AFS on the path, assuming that drivers only frequent the same OD trip. If there is a fuel station sited at the origin, the vehicle will start with a full tank; if there is no fuel station at the origin, the vehicle will start the trip with the remaining fuel from the last fill-up on the same OD round trip.

For better understanding, the calculation of the set $K_{j,k}^q$ and the model functionality illustrated in a simple example below.

Figure 4 shows a four-node sized network with the origindestination pair (1,2). The vehicle range is assumed to be 120 km. For satisfying the demand flow, each arc on the round trip from the origin to the destination and back has to be refuelled. Therefore, the candidate node set $K_{j,k}^q$ has to be determined before the optimization process, starting with the arc $a_{1,2}$. The origin node one is the only node on the trip from the origin to the destination node of arc two.

As z_1 lies within the vehicle range (120 km) of node z_2 coming from the origin, it counts as a potential station location for refuelling the arc $a_{j,k}$. Hence, z_1 is added to the set $K_{1,2}^{(x_1,z_4)}$. Node two that is visited during the way back from the destination to the origin is on the path $a_{2,1} + a_{1,2} = 80 \text{ km} \le 120 \text{ km}$ away from node two and counts as well a potential station location. As the distance from node 3 is $a_{3,2} + a_{2,1} + a_{1,2} = 110 \text{ km} \le 120 \text{ km}$, z_3 is added as well as a potential station location. Following the flow direction of the OD path, node 4 is 140 km away from node 2 is, therefore, no station locations. Thus, the set of potential facility sites, that could refuel the arc $a_{j,k}$ is $K_{1,2}^{(z_1,z_4)} = \{z_1, z_2, z_3\}$. The potential station locations for the other arcs on the round trip are listed in the table 1.

For refuelling the whole round trip (1,4), a facility must be built at least one of the candidate locations of each set $K_{j,k}^{(1,4)}$. Although several combinations of fuel stations could serve the vehicle flow, placing a station at node 2, with the variable $z_2 = 1$, is the only option, that serves the whole demand with the construction of just one facility and is, therefore, the optimal solution of the minimization problem.

The maximal covering formulation of the arc-cover pathcover FRLM is created by switching the objective function of the set covering approach (2.1) with constraint (2.3) and modify them accordingly.



Figure 4: Exemplary graph network for illustrating the calculation of the set $K_{i,k}^{q}$

Sets	Pot	entia	l Stat	ion L	ocations
$K_{1,2}^{(1,4)}$	z_1	z_2	z_3		
$K_{2,3}^{(1,4)}$	z_1	z_2			
$K_{3,4}^{(1,4)}$	z_1	z_2	z_3		
$K_{4,3}^{(1,4)}$		z_2	z_3	z_4	
$K_{3,2}^{(1,4)}$		z_2	z_3	z_4	
$K_{2,1}^{(1,4)}$		z_2	z_3	z_4	

Table 1: Set $K_{i,k}^q$ for the graph in Figure 4.

$$\max\sum_{q \in Q} f_q y_q \tag{2.5}$$

s.t.
$$\sum_{i \in K_{i,k}^{q}} z_{i} \ge y_{q} \forall q \in Q, a_{j,k} \in A_{q}$$
(2.6)

$$\sum_{i=N} z_i = p \tag{2.7}$$

$$z_i, \ y_q \in \{0, 1\} \forall \ q \in Q, \ i \in N$$
(2.8)

p displays the number of stations that will be allocated to maximize the total flow covered on all OD paths.

2.2.2. FRLM Extension: Node Capacity Restrictions | Kluschke et al. 2020

In the previous paragraph, the reader was familiarised with AC-PC FRLM by Capar et al. (2013), which is the base model for Kluschke et al. (2020)'s extension. The AC-PC FRLM follows the idea of seeing each path as a sequence of arcs, that have to be refuelled for the path to be covered in its entirety. Kluschke et al. (2020) adopt this principle for their node-capacitated extension of the AC-PC FRLM's set covering formulation. The following sections begin by discussing the new FRLM assumptions, that were added by Kluschke et al. (2020). After presenting the mathematical formulation, a closer look is taken at the calculation of sets and parameters in Kluschke et al. (2020)'s model. Apart from adapting the $K_{j,k}^q$ generation algorithm, Kluschke et al. (2020) introduce the new parameter r_{iq} , that as well needs to be calculated before the optimization. The parameter r_{iq} is highly important

to the model because it depicts the amount of refuelling of vehicles at the fuel station. If the total amount of refuelling of all vehicles at a station reaches Kluschke et al. (2020)'s capacity limit, it is no longer possible to fill up there.

To consider station location capacity limits, for example, local limitations of the power supply or the building land, Kluschke et al. (2020) added node capacity restrictions to the set covering formulation of Capar et al. (2013)'s arc-cover path-cover FRLM. Contrary to Capar et al. (2013), they do not apply their node-capacitated FRLM to refuelling BEV vehicles, but to fuel cell-powered heavy-duty vehicles and adjusted Capar et al. (2013)'s assumptions to fit their specific case.

Model Assumptions and Mathematical Formulation

The assumptions made by Kluschke et al. (2020) are listed below. Modified and additional assumptions are high-lighted in italics:

- 1. The traffic between an origin-destination pair flows on the shortest path through the network.
- 2. The traffic volume between OD pairs is known in advance.
- 3. Drivers have full knowledge about the location of the fuel stations along their path and refuel efficiently *to complete their one-way origin-destination trips*.
- 4. Only nodes of the network are considered as possible AFS locations.
- 5. All vehicles are assumed to be homogeneous. The maximum driving range that can be achieved in a single refuelling is similar for each vehicle.

- 6. The fuel consumption is directly proportional to the distance travelled.
- 7. Nodes and fuel stations are capacitated.
- 8. refuelling is only required on trips longer than 50 km.
- 9. Each vehicle starts and ends its trips with the same fuel level, which is sufficient for a specific range. There are no refuelling stations at the origins and destinations.

Kluschke et al. (2020) use the first six assumptions of Capar et al. (2013) with one small adjustment to better fit the model to their case study that thematizes the siting of AFS along with the German highway network. As trucks usually receive a delivery order to another location, once it reaches the destination (tramp traffic), they model the OD routes as one-way trips instead of round trips

Assumption 7 is the first general difference between the two models, as Kluschke et al. (2020) formally introduce the node capacity restrictions to their model. In Assumption 8, a lower bound for OD trip lengths is introduced to reduce the total number of considered OD trips and thus reduce the computational complexity of the model. In this context, Kluschke et al. (2020) speculate, that short trips of less than 50 km might not require public refuelling infrastructure. Although it is not clear how likely this speculation is, it shifts the model focus to refuelling mainly long haul transportation. It can easily be relaxed for an application in different contexts.

Assumption 9 simultaneously incorporates two suppositions. As Kluschke et al. (2020) want to focus on public refuelling infrastructure, they assume, that there are no private AFS. In consequence, they prohibit the siting of facilities at the origin and the destination nodes of the paths, as trucks start and end their trips at the private cargo bays of the transportation companies. Assumption 9 furthermore implies, that truck drivers refuel efficiently and by that do not make unnecessary refuelling stops. In consequence, they only refuel the exact amount needed to travel their route. As vehicles end with the same fuel level as they started with, they have to refuel at least once per trip.

Kluschke et al. (2020) extend the arc-cover path-cover FRLM as follows:

$$\min\sum_{i \in N} z_i \tag{2.9}$$

s.t.
$$\sum_{i \in K^{q}_{i}} z_{i} \ge y_{q} \forall q \in Q, a_{j,k} \in A_{q}$$
(2.10)

$$\sum_{q \in Q} f_q p r_{iq} y_q g_{iq} x_{iq} \le c z_i \forall i \in N$$
(2.11)

$$\sum_{i \in K_{i,k}^q} x_{iq} = y_q \forall q \in Q, \ a_{j,k} \in A_q$$

$$(2.12)$$

$$\sum_{i \in N} x_{iq} = y_q \ l_q \forall \ q \ \in \ Q \tag{2.13}$$

$$x_{iq} \le z_i \forall \ i \ \in \ N, \ q \ \in \ Q \tag{2.14}$$

$$z_i \in \{0, 1\} \forall \ i \in N \tag{2.15}$$

$$0 \le x_{iq} \le 1 \forall i \in N, q \in Q \tag{2.16}$$

Sets	
Ν	Set of all nodes on the Graph G
Q	Set of all OD pairs
A_q	Set of all directional arcs on the OD path
1	$q \in Q$ from origin to destination
K_{ik}^q	Set of all potential station locations, that
<i>)</i> ,,,	can refuel the directional arc $a_{i,k} \in A_q$
Variables	
z_i	Binary Variable that equals to one, if a re-
	fuelling facility is constructed at node <i>i</i>
x_{ia}	Semi-Continuous Variable that indicates
1	the proportion of vehicles on path q that
	are refuelled at node <i>i</i>
Parameters	
р	Fuel efficiency / fuel consumption per ve-
	hicle range
с	refuelling capacity per node
f_q	Total vehicle flow on the OD path q
y_q	Proportion of vehicles that are to be refu-
•	elled on path q
l_q	Number of refuelling occasions on path q
	depending on the total path distance, $l_q =$
	ceil {total trip distance / vehicle range}
8 _{iq}	Binary indicator, that is set to one, if node
-	i is a potential station location on path q
r_{iq}	refuelled driving distance at node <i>i</i> on path
	q

For the consideration of node capacity limits, Kluschke et al. (2020) added constraints (2.11) - (2.13) to the FRLM. Constraint (2.11) limits the total amount refuelled at node *i* to the maximum capacity of the station built there. The demand served at node *i* is computed as the flow of trucks (f_q) multiplied with the fuel consumption per vehicle range (p) and the amount of refuelled km (r_{iq}). Given three exemplary values, the total refuelling amount would be calculated like this: 2 * 0,5 $\frac{1}{\text{km}}$ * 100 km = 100 l

Two trucks refuel enough fuel to travel 100 km. As they consume 0,5 litres per kilometre, they in total fill up 100 l of fuel.

The total amount refuelled is further influenced by the proportion of vehicles that shall be refuelled on path $q(y_q)$, the proportion of vehicles on path q that refuel at node i(giq) and whether node i is a potential station location at all (g_{iq}) . Note, that unlike in the original AC-PC FRLM formulation by Capar et al. (2013), y_q is not a variable, but a parameter. As Kluschke et al. (2020)'s main objective is to determine the minimal amount of AFS that serve the total demand, y_q is set to 1 for all $q \in Q$.

Constraint (2.12) defines, that all vehicles on path q can refuel the arc $a_{j,k}$ at any of the possible locations given by the set $K_{j,k}^q$. Constraint (2.13) ensures that all vehicles of a flow refuel at the ensured number of refuelling occasions on path q. (2.14) states that vehicles can only refuel at node i if there is an open facility. (2.15) and (2.16) define the decision variables.

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Calculation of Sets and Parameters

The previous paragraph discussed Kluschke et al. (2020)'s model assumptions and introduced the reader to their nodecapacitated FRLM formulation. As their model is an extension of Capar et al. (2013), the core of the AC-PC FRLM, the set of fuel station candidate locations $K_{j,k}^q$, is present as well. Kluschke et al. (2020) modified $K_{j,k}^q$ due to their utilisation of single trips instead of round trips.

Hence they use a different pre-generation algorithm, which is explained in the following.

To compare the total amount refuelled at a station with its capacity limit, Kluschke et al. (2020) introduce the parameter r_{iq} that displays the amount of refuelling of each vehicle at gas stations. As r_{iq} needs to be computed before the optimization, its pre-generation process is as well illustrated in the upcoming section.

Contrary to Capar et al. (2013), Kluschke et al. (2020) use single trips instead of round trips. They furthermore assume that vehicles end their trips with the initial fuel level. Thus, they take a different approach in the pre-generation of the set $K_{i,k}^q$. The main adjustments are:

- *K*^q_{j,k} is generated while iterating node-wise and not arcwise over each path *q*.
- All vehicles start with a similar, predetermined initial fuel range (IFR). The IFR of vehicles in the AC-PC FRLM, on the other hand, is endogenously determined by the optimal location of fuel stations on each path.
- Arcs are divided into *critical* and *non-critical* arcs. An arc is considered as *critical*, if the travelability or refuelling of the path is not automatically guaranteed, e.g. through the initial fuel level.
- As vehicles start and end the trips with the same fuel level, drivers have to refuel at their last stop enough to not only reach the destination but to reach it with the initial fuel level. To respect the maximum capacity of the tank, an adjusted trip distance is used to calculate the set $K_{j,k}^q$, every time the iteration reaches a destination node. The adjusted distance formula is calculated as follows: $AD_q = TD_q + IFR DO_q$

The adjusted distance of path q (AD_q) equals the sum of total trip distance (TD_q) and initial fuel range (IFR) minus the network access distance from the origin node (DO_q). Note, that DO_q only has a value greater than zero, if the origin node does not lie within the considered network. Else wise $DO_q = 0$.

A pseudo-code for the generation of $K_{j,k}^q$ according to Kluschke et al. (2020) is given in the Code Listings 2 and 3. For better clarity, the process of identifying potential station locations was black-boxed in the code below and explained in a separate listing. A flowchart of the algorithm can be found in Appendix A for further illustration.

To generate the set $K_{j,k}^q$, the algorithm determines the set of potential facility locations, in case that reaching the end

```
for all q \in Q:
    for all nodes i on path q:
        if distance(origin, node i) \leq initial
         fuel range:
              ""if arc with destination node i
             lies within IFR, it is
             non-critical and already refuelled"""
             if node i is destination node of
             path q:
                 identify potential station
                 locations ** using the
                 adjusted distance
                    before reaching the
                 destination, vehicles need
                    refuel to end with IFR"""
                 to
             else:
                 continue with the next node in
                 the loop
         else:
             if node i is destination node of
             path q:
                 identify potential station
                 locations ** using the
                 adjusted distance
             else:
                 identify potential station
                 locations*
```

Code Listing 2: Algorithm for determining the set $K_{j,k}^q$ in the NC-FRLM

of an arc $a_{j,k}$ requires refuelling. Therefore, only arcs are considered, whose destination node either lies outside the initial fuel range from the origin or is as well the destination node of the OD trip.

Apart from the set $K_{j,k}^q$ it is also necessary to pre-calculate the values of the parameter r_{iq} in the NC-FRLM. r_{iq} displays the driveable distance, that shall be added to the current vehicle range by refuelling at node *i* on path *q*, in case a gas station is built there. Within the model, r_{iq} is used to both represent the drivers' efficient refuelling strategy and determine the total amount of refuelling at a gas station z_i . Although it is an essential part of Kluschke et al. (2020)'s model extension, the calculation of r_{iq} and its role as a parameter are only partially described. The following approaches this issue by providing a comprehensive overview of the parameter r_{iq} and its pre-generation process.

For the NC-FRLM, Kluschke et al. (2020) assume, that vehicles start and end their trips with the same fuel level and refuel efficiently on their way. That implies that drivers only take as many refuelling stops on the route as needed. Hence, Kluschke et al. (2020) define the following, underlying refuelling strategy for their model: A driver will always fill up the maximal possible amount until the last stop. There, the driver refuels the difference between the total fuel needed to complete the trip and the total fuel filled up during the previous gas station stops. In the end, the driver has refilled the exact amount of fuel that he had consumed during the trip. Hence, he ends the route with the initial fuel level in the tank.

```
1 # * if i is not the destination node of path q
 for all nodes k, that lie on the path from
      originto node i:
      if distance(origin, node i) -distance(origin,
      node k) \leq vehicle range:
           if node k is a potential station location
           (parameter g_{kq} = 1):
6
               add node k to K_{i-1,i}^q
    ** if i is the destination node of path q
9 #
  for all nodes k, that lie on the path from origin
10
  to destination node i:
11
      if adjusted distance(origin, node i) -
      distance(origin, node k) \leq vehicle range:
          if node k is a potential station location
14
           (parameter g_{kq} = 1):
               add node k to K_{i-1,i}^q
16
```

Code Listing 3: Identification of potential station locations in the K_{ik}^{q} algorithm in the NC-FRLM

Calculating the difference between the current and the maximum fuel level, to determine the amount of possible refuelling, might seem relatively easy. Especially, as fuel consumption is assumed to be directly proportional to the distance travelled. The necessary consideration of refuelling along the route, however, adds a variable component to the calculation.

The exact fuel level, and therefore the current vehicle range, depends on the following three factors:

- The initial fuel range at the origin node,
- The total distance travelled from the origin node to node *i*,
- Possible refuelling and the corresponding refuelling amounts at nodes along the way from the origin node to node *i*, which necessitates the modelling as a decision variable.

For the benefit of the model complexity, Kluschke et al. (2020) desist from precisely calculating the current fuel level and modelling the refuelling through additional decision variables and constraints. Instead, they estimate the values of the refuelling amount r_{iq} .

Kluschke et al. (2020) therefore subdivide each OD path into l_q route sections. l_q is the model parameter that indicates the number of refuelling occasions on path q. l_q is calculated as $l_q =$ ceil {total trip distance / vehicle range}. As l_q depicts the number of refuelling occasions on path q as well as the number of route sections, each vehicle refuels only once per route section. Although the refuelling capacity of the tank, the difference between the current and the maximal fuel level, varies between nodes, the values of r_{iq} are identical for each node within a route section. Following the refuelling strategy, drivers will refuel the maximal tank capacity in every route section, but the last one. Depending on the location of the fuel stations along the route, it is likely to happen, that the vehicle's tank is not empty when refuelling the maximal tank capacity. Refuelling then leads to exceeding the maximal tank capacity and therefore to overflowing.

Kluschke et al. (2020) assume, that due to their definition of the set $K_{j,k}^q$ and the model's objective of minimizing the total amount refuelling stations, facilities will be built preferably at the end of the subdivided route sections so that the minimal amount of facilities can refuel every arc of the OD path. In consequence, vehicles would fill up instead at the end of the sections and with only a small amount of rest fuel left in the tank, so that the overflowing would not be substantial. In the model, the overflowing is not considered, and the refuelled amount is added to the tank.

For the calculation of r_{iq} , Kluschke et al. (2020) differentiate between three cases:

- if l_q = 1 (one refuelling stop, one route sections) vehicles shall fill up the amount of fuel necessary to cover the total trip distance at any of the potential station locations.
- if $l_q = 2$ (two refuelling stops, two route sections) in the first section, defined by the initial fuel range, vehicles shall refuel the maximal vehicle range. In the second section, vehicles shall refuel the difference between the total trip distance and the already refuelled amount.
- if $l_q \geq 2$ (multiple refuelling stops, multiple route sections) in every route section, apart from the last one, vehicles shall refuel the maximal vehicle range. On the last stop, vehicles refuel the difference between the total trip distance and the already refuelled distance. The first $l_q 1$ route sections are defined by the vehicle range.

The pseudo-code for the algorithm, that determines the parameter r_{iq} is displayed in Code Listing 4:

According to the algorithm, vehicles will refuel the maximum tank capacity in every route section, but the last one. In the last gas station stop, they will fill up the difference between the total fuel needed to travel the OD path and the refuelled amount in the previous gas station stops.

In case the trip has only one route section, the amount of fuel needed to travel the whole distance will be refuelled in the only fill-up. As vehicles refuel once per route section, drivers refuel precisely the amount needed to travel the OD path and therefore end the trip with the initial fuel level.

For a better understanding, the parameter r_{iq} and its role in the model is illustrated in a simple example below:

Figure 5 shows a five node network with the origindestination pair (1,5). The total trip distance is 250 km. The maximal vehicle range amounts to 200 km, and the initial fuel range is 100 km. Therefore the number of necessary refuelling stops l_q is two.

The Parameter r_{iq} is calculated to constitute the driving distance a vehicle would refuel the nodes of the trip, in case there was an operating fuel station. According to the above-presented algorithm, the OD trip is subdivided into two sections, of which the first one has the length of the initial fuel



Figure 5: Exemplary calculation of the parameter r_{iq} for a five node graph network

```
all paths q \in Q:
  for
       for all nodes i on the path q:
2
3
            if the total number of refuelling stops
              = 1:
           la
               r_{iq} = total path distance
            else:
                if the total number of refuelling
                stops l_q = 2:
                     if the distance(origin, node i) \leq
q
                     initial fuel range:
10
                             = maximal vehicle range
                         r_{iq}
12
                      else:
                         r_{iq} = (total path distance -
14
                         vehicle range)
                else:
16
                     if the distance(origin, node i) \leq
                     (vehicle range * (l_q - 1)):
                            = maximal vehicle range
18
                         r_{iq}
19
                      else:
                         r_{iq} = (total path distance -
20
                         (vehicle range * (l_q - 1))
```

Code Listing 4: Algorithm for determining r_{iq} in the NC-FRLM

range. The length of the second and final section accounts for the difference between the total trip distance and the distance of the prior section. As described, the value of r_{iq} is similar for each node of the corresponding section and amounts to the vehicle range in the first one. The refuelled distance in the final section equals the difference between the total trip distance and the total amount refuelled in the prior sections. As drivers in total filled up precisely the amount needed to travel the trip distance, they end with the initial fuel level.

Given an optimal solution of the problem, z_3 , $z_4 = 1$, fuel stations are constructed at nodes three and four. When a vehicle refuels at node three according to the model, it has fuel for 10 km left in the tank and would overflow while refuelling 200 km. Kluschke et al. (2020) hereby pretend that refuelling more than the maximal refuelling capacity is possible, and the excess fuel is not wasted.

Kluschke et al. (2020)'s general idea of estimating the refuelling amount rather than precisely calculating it through decision variables to benefit the model complexity is reasonable. Although the tank level and the refuelling amount is not accurate, the share of overflowing in the total amount refuelled, and therefore the inaccuracy, is small due to the model setting. Thus, the capacity utilization of the station can still be approximated rather well. Although the extent of the inaccuracy and its possible impact on the optimal solution have not been further examined by Kluschke et al. (2020), it seems like a fair trade-off for the reduced model complexity.

As the calculation of r_{iq} , the corresponding assumptions and their motivation seem comprehensible, the multi-period node-capacitated FRLM applies the same logic with minor corrections to the r_{iq} generation algorithm.

3. New FRLM Extension: The Multi-Period Node-Capacitated FRLM

The previous chapter provided the reader with a comprehensive overview of the current FRLM literature in the first part and subsequently introduced the reader to the current state of the art FRLM modelling. Most importantly, profound knowledge about the MP-NC FRLM predecessor models, the AC-PC FRLM by Capar et al. (2013) and the NC-FRLM by Kluschke et al. (2020), was conveyed.

Capar et al. (2013)'s model refuels the OD trips arc-wise. If every arc on a trip can be refuelled at one of the operating fuel stations, the whole path is considered refuelled and travelable. Kluschke et al. (2020) extend Capar et al. (2013)'s AC-PC FRLM with capacity restrictions, that limit the total amount of refueling at fuel stations.

The multi-period node-capacitated FRLM is formulated as a maximal covering problem and seeks to maximize the number of refuelled OD trips given fuel station construction costs and a periodic budget. The model considers the possible value change of parameters over time and in turn provides a period-by-period plan for the step-wise development of an AFS refuelling infrastructure.

In the following sections, the model assumptions, the mathematical formulation, possible problems and the calculation of the sets and parameters are discussed and explained. The chapter is concluded by adapting the two multi-period model evaluation concepts, the VMPS and the VMPP, to the MP-NC FRLM and discussing further situational model assumptions and their impact on the model.

3.1. Model Assumptions

The following paragraph explains and discusses the assumptions made in the MP-NC FRLM. Apart from adapting previous assumptions by Capar et al. (2013) and Kluschke et al. (2020), assumptions that have been used by Kluschke et al. (2020) but are not explicitly stated in their assumption list, have also been added. Furthermore, additional MP-NC FRLM modelling presumptions, have been appended alongside further suppositions, that provide a better understanding of the model circumstances and possible use cases. The assumptions are thus subdivided into General Modeling Assumptions, which define the general model setting and are needed for obtaining a feasible solution, and Case Specific Assumptions. The below-listed assumptions describe a more general modelling framework than Kluschke et al. (2020), as they have specifically tailored their model assumptions to their case study.

The *General Modeling Assumptions* are listed below, modified and additional assumptions are highlighted in italics. It is important to note that Assumptions 9 and 10 have already been used by Kluschke et al. (2020).

Kluschke et al. (2020) do not address these assumptions in their assumption listing, but chose to introduce them later within their application context. In the interests of completeness, they are added to the *General Modeling Assumptions* and also highlighted in italics, as they have not yet formally appeared in assumption form.

- 1. The traffic between an origin-destination pair flows on the shortest path through the network.
- 2. The traffic volume between OD pairs is known in advance for all periods.
- 3. Drivers have full knowledge about the location of the fuel stations along their path and refuel efficiently to complete their trips. To minimize the number of refuelling stops on the road, drivers will always refuel the maximum tank level until their last stop.
- 4. Only nodes of the network are considered as possible refuelling facility locations.
- 5. All vehicles *on the same OD path* are assumed to be homogeneous in terms of maximal driving range, initial fuel level and fuel consumption.
- 6. The fuel consumption is directly proportional to the distance travelled.
- 7. Nodes and fuel stations are capacitated.
- 8. The initial fuel level and the ending fuel level have to be known in advance for every path.

- 9. A station constructed at a node i will always have the maximal possible size, and the station capacity, therefore, equals the node-specific capacity limit.
- 10. The OD path is subdivided into $l_q = ceil \{ d_q / \theta_q \}$ route sections, with d_q being the total distance of path q and θ_q displaying the vehicle range. The amount of refuelling per vehicle is similar for each node of the corresponding route section if a station is built there. Each vehicle refuels once per route section.
- 11. The distances between two connected nodes are sufficiently small.
- 12. The number of periods is predetermined and each period has an equal length.
- 13. Once a facility is built at a node i, it has to remain open until the final period.
- 14. A periodic budget limits the number of fuel stations constructed per period.
- 15. The situation is modelled from a central planner's perspective.

The first eight assumptions were taken from Kluschke et al. (2020) with two minor adjustments so that further parametric specification is possible. Assumption 5 relaxes the presumption that all vehicles on all paths have to be homogeneous and represents the minimal vehicle requirements for obtaining a feasible solution. While it is not possible to differentiate between vehicles on one path, path specific vehicle characteristics, like the maximal range or the fuel consumption, can be respected. In the context of transportation, an example of different vehicle characteristics on different OD paths would be the use of different truck types for long-haul transportation and local good distribution.

With a similar relaxation, Assumption 6 allows a pathwise specification of the vehicles' initial and ending fuel level. As there are no conditions on the choice of the initial and ending fuel levels, the siting of fuel stations at the origin and destination nodes of paths is contrary to Kluschke et al. (2020) allowed. Even though it is not necessary for obtaining a feasible solution, it is still reasonable to assume that drivers refuel only the total trip distance and therefore end the trip with the initial fuel level.

Assumption 9 defines that the capacity of a station will always equal the maximum capacity of the corresponding node. Although the MP-NC FRLM hereby applies the same logic as Kluschke et al. (2020), the maximal node capacity in the MP-NC FRLM is not unitary and can be defined nodewise. Although the partial utilization of the maximal node capacity is not possible in this case, it could theoretically be modelled through different station sizes going along with additional variables and constraints.

Assumptions 10 and 11 provide the foundation for the heuristic calculation of the refuelling amount at a gas station represented through the previously discussed parameter r_{iq} . For the benefit of the model complexity, the refuelling amount at node *i* on path *q* is estimated and not precisely calculated through decision variables similarly to Kluschke et al.

(2020). When the network edges are relatively long (compared to the vehicle range) or the total trip distance of an OD path is close to an integral multiple of the vehicle range it can occur, that the number of refuelling occasions l_q is not sufficient for refuelling the path. In that case, it is advised to incrementally increase the path specific l_q value to be able to cover the trip entirely. This peculiarity is further discussed in the next section.

For formulating a multi-period optimization problem, the number of considered periods has to be known in advance. As dividing time into periods of equal length is common in optimization models and general planning, Assumption 12 can be considered as a relatively standard assumption.

It is further assumed that a gas station, once opened, cannot be closed or relocated due to the high cost involved in the process (Assumption 13).

Assumption 14 limits the number of stations constructed per period. Limiting the station numbers seems reasonable because the construction of fuel stations is resource-intensive and resources, like budget or labour, are limited. Finally, it is essential to, once again, emphasize, that the model aims at providing a plan for developing a refuelling infrastructure over time from a central planner's perspective. The MP-NC FRLM in its current form is not suited for profit maximization for, e.g., a gas station operating firm.

The *Case Specific Assumptions* are a non-definite set of assumptions, that are made in the context of the application case. They, for example, contain information about the presumed development of parameters over time, like the vehicle flow on a path, or the definition of the sets. In the belowpresented base formulation of the MP-NC FRLM, only three *Case Specific Assumptions* are considered. A more comprehensive list of possible *Case Specific Assumptions* and their impact on the model can be found in section 2.3.4.

- 1. The vehicle flow is expected to rise periodically due to an increase in the AFV market share.
- 2. The model mainly considers construction costs. Operating costs are not respected.
- 3. Different node capacities do not impact the facility construction cost.

Considering the fact, that AFVs currently stand at the beginning of their product life cycle and are mainly bought by "Early Adopters", it seems reasonable to assume an increase in market share and therefore a rise of the AFV vehicle flow (Assumption 1). The MP-NC FRLM models the development of alternative fuel refuelling structures from the perspective of a central planner who constructs fuel stations respectively subsidizes their construction. As the central planner is assumed not to be the operator of the fuel stations, Assumption 2 limits the budgetary expense to the siting of the facilities.

Even though drastic differences in node capacity limits, and thus large differences in the station sizes, have an impact on the facility construction costs, it is not considered in this model to reduce the estimation effort for parameters. The further *Case Specific Assumptions* and the extended model in section 2.3.4, on the other hand, do include the impact of station capacity on construction costs.

3.2. Mathematical Formulation and Possible Problems

In the upcoming section, the mathematical formulation of the MP-NC FRLM is presented as further explained. The main differences to the node-capacitated FRLM by Kluschke et al. (2020) are as follows:

- A maximal covering objective has been selected instead of a set covering.
- A time module has been added to consider multiple construction periods.
- A periodic budget was introduced, that limits the number of fuel stations constructed per period.

Furthermore, two problems of the formulation are discussed. To maximize the path coverage it can occur, that even though a majority of the paths is covered, only a small part of the total flow is covered. Two possible solutions are the introduction of a lower bound for periodic flow coverage in the constraints and the maximization of the flow instead of the path coverage. The second part of the problem discussion examines specific parametric constellations, where the prespecified number of l_q fuel stations are insufficient to cover the OD trip.

$$\max\sum_{t \in T} \sum_{q \in Q} y_q^t \quad (3.1)$$

s.t.
$$\sum_{i \in K_{j,k}^q} z_i^t \ge y_q^t \forall q \in Q, a_{j,k} \in A_q, t \in T$$
(3.2)

$$\sum_{q \in Q} f_q^t p r_{iq} g_{iq} x_{iq}^t \le c_i z_i^t \forall i \in N, t \in T$$
 (3.3)

$$\sum_{i \in K_{ik}^q} x_{iq}^t = y_q^t \forall q \in Q, \ a_{j,k} \in A_q, \ t \in T$$
 (3.4)

$$\sum_{i \in N} x_{iq}^t = y_q^t l_q \forall q \in Q, t \in T \quad (3.5)$$

$$x_{iq}^{t} \leq z_{i}^{t} \forall i \in N, q \in Q, t \text{ in } T \quad (3.6)$$

$$z_{iq}^{t} \leq z_{i}^{t+1} \forall i \in N \quad t \in T \setminus \{n\} \quad (2.7)$$

$$z_i^t - z_i^{t-1} \le k_i^t \forall i \in \mathbb{N}, t \in T \setminus \{1\}$$
(3.8)

$$z_i^1 \le k_i^1 \forall \ i \ \in \ N \tag{3.9}$$

$$\sum_{i \in N} o k_i^t \le b_t \forall t \in T \quad (3.10)$$

$$\sum_{t \in T} k_i^t \le 1 \forall \ i \in N \quad (3.11)$$

$$z_{i}^{t}, k_{i}^{t} \in \{0, 1\} \forall i \in N, t \in T \quad (3.12)$$

$$\leq x_{iq}^{t} \leq 1 \forall i \in N, q \in Q, t \in T \quad (3.13)$$

0

$$0 \le y_q^t \le 1 \forall q \in Q, t \in T \quad (3.14)$$

Sets	
Ν	Set of all nodes on the Graph G
Q	Set of all OD pairs
Т	Set of all time periods
A_q	Extended set of all critical arcs on the path
	$q \in Q$ from origin to destination
$K^{q}_{i k}$	Set of all potential station locations, that
) <u>,</u> ,,,	can refuel the directional arc $a_{j,k} \in A_q$
Variables	
z_i^t	Binary Variable that equals to one, if a re-
	fuelling facility is open at node i in time
	period <i>t</i>
k_i^t	Binary Variable that equals to one, if a re-
	fuelling facility is constructed at node i in
	time period <i>t</i>
x_{ia}^t	Semi-Continuous Variable that indicates
-1	the proportion of vehicles on path q that
	are refuelled at node i in time period t
y_a^t	Semi-Continuous Variable that indicates
4	the proportion of flow served on path q in
	time period <i>t</i>
Parameters	
р	Fuel efficiency / fuel consumption per ve-
	hicle range
0	Facility opening costs / construction costs
c _i	refuelling capacity at node <i>i</i>
d_q	total distance of path <i>q</i>
θ_q	vehicle range of vehicles on path q
l_q	Number of refuelling occasions on path q
-	depending on the total path distance, $l_q =$
	$\operatorname{ceil} \left\{ d_a / \theta_a \right\}$
b_t	Available budget in period <i>t</i>
f_{a}^{t}	Total vehicle flow on the OD path <i>q</i> in time
- <i>q</i>	period <i>t</i>
gia	Binary indicator, that is set to one, if node
0.4	<i>i</i> is a potential station location on path <i>q</i>
r _{ia}	refuelled driving distance at node <i>i</i> on path
-4	<i>q</i>
	•

Contrary to Kluschke et al. (2020), the MP-NC FRLM does not seek to minimize the total number of stations necessary to cover 100 % of the flow. The objective function (3.1) aims at maximizing the total number of refuelled paths over all periods. Thus, the early coverage of paths is rewarded, and a refuelling network is planned, that covers as many OD trips as possible as early as possible.

Constraints (3.2) - (3.6) are similar to Kluschke et al. (2020) except that it is now possible in (3.3) to set the node capacity limits node-wise to be more responsive to the local capacity restrictions.

Constraint (3.7) ensures, that once a facility is opened at a node i, it has to remain open until the final period. Constraints (3.8) and (3.9) define, that a facility is constructed, if it is either open in a period t, but has not been open in the previous period or if it is open in the first period. Constraint (3.10) states that the total amount spent on the construction

of fuel stations in a period t must be within the scope of the budget of the corresponding period. According to (3.11), a station can be constructed only once at a node over all periods. (3.12) - (3.14) conclude the model by defining the decision variables.

Objective Function and Model Purpose

Following the logic of the objective function, the MP-NC FRLM attempts to site fuel stations in a way that, at best, facilities contribute to refuelling multiple OD paths. In consequence, the model tends to construct a network of connected refuelled OD paths. As only the number of covered OD paths and not the covered flow volume is taken into account, it is possible, that even though a majority of the paths in a final period T is covered, the share of refuelled flow might be relatively low. This can be problematic, as a central planner, on the one hand, aims at covering a wide area, but on the other hand, wants as many drivers as possible to profit from the constructed fuel stations. An exemplary situation demonstrating this conflict is illustrated below.

Figure 6 shows a ten node network with the OD pairs (1,5), (1,6), (7,5) and (8,10). The periodic budget is sufficient to build one fuel station per period, and two periods are considered in this case. While the flow on OD paths (1,5), (1,6) and (7,5) amounts to two in every period, the flow on (8,10) is considerably greater with a value of 100.

As can be seen in table 2, constructing stations at nodes 3 and 4 is the optimal solution of the problem, as it covers the maximal possible amount of three OD paths while respecting the budgetary constraints of constructing only one station per period. For the optimal solution, it is irrelevant whether station 3 or 4 is constructed first. In the final period, even though 75 % of all OD trips are covered, only 5.67 % of the total flow is served.

Two possible approaches to address this issue are:

• Setting a lower bound to the minimum flow covered per period

A possible approach to respecting the flow volume while maximizing the number of paths covered is the introduction of a new constraint, that sets a lower bound for the fraction of total flow covered in period t. v^t represents this new lower bound, with $v^t \in [0, 1]$.

s.t.
$$\frac{\sum\limits_{q \in Q} y_q^t * f_q^t}{\sum\limits_{q \in Q} f_q^t} \ge v^t, \ \forall \ t \in T$$
(3.15)

When applying constraint (3.15) to the MP-NC FRLM, the proper selection of v^t is essential. In case the available budget is not sufficient to cover the predetermined minimal fraction of flow, the model becomes infeasible. While the dimensioning of v^t falls to the preferences of the central planner, the maximal lower bound is determined through solving the maximal flow covering formulation of the MP-NC FRLM (c.p.). The formulation



Figure 6: Exemplary display of potential problems with the max. path coverage objective function

Sets	Potential Station Locations	OD Trip	Possible station combinations	
$K_{3,4}^{(1,5)}$	z_1 z_2 z_3	(1,5)	$(z_1,z_4), (z_2,z_4), (z_3,z_4)$	
$K_{4,5}^{(1,5)}$	Z4	(1,6)	(z_3)	
$K_{3,6}^{(1,6)}$	z ₃	(7,5)	(z_4)	
$K_{4,5}^{(7,5)}$	z ₄	(8,10)	(z_9)	
$K_{9,10}^{(8,10)}$	z ₉			

Table 2: Set $K_{i,k}^q$ and potential facility combinations, that could cover the OD trips in the problem in figure 6

of the MP-NC FRLM including constraint (3.15) can be found in Appendix A.

• Maximizing the flow coverage instead of maximizing the path coverage in the objective function

Another possible approach to considering the flow volume in the MP-NC FRLM is to weigh the OD paths with the corresponding flow in the objective function. Weighting the OD paths leads to a maximization of the flow coverage instead of the number of paths covered.

$$\max \sum_{t \in T} \sum_{q \in Q} f_q^t y_q^t$$
(3.16)

While the base model has the natural tendency to create a coherent network of refuelled OD paths, the connectivity of refuelled OD paths in the maximal flow covering MP-NC FRLM solely depends on whether the OD paths with a high flow volume are linked. As refuelling paths with a higher flow volume are preferred over covering OD trips, that share the same route for most of their trip, the served OD paths can be scattered throughout the network. Thus, the refuelled routes are less likely to be interconnected in early construction stages, which, in turn, restrains the possibilities of free-roaming travel within the underlying road network. The formulation of the maximal flow covering MP-NC FRLM can be found in Appendix A.

Parameter l_a and the Coverability of Routes

Another potential problem for the functionality of the model can be posed by the current definition of the parameter l_q . As mentioned above, it can occur, that in some cases l_q refuelling locations are not enough to cover an OD trip. Although an insufficient number of ensured refuelling locations does not lead to an infeasible model, the optimal allocation of refuelling stations along the way becomes trivial, and the path will not be respected during the optimization. An exemplary situation demonstrating this problem is shown below.

Figure 7 shows a five node network with a single OD pair (1,5). The vehicle range is 200 km, the initial fuel range 100 km and the total trip length accumulates to 380 km. According to the above-defined formula, $l_q = \operatorname{ceil} \{d_q / \theta_q\} = 2$. Although two stations are assigned to this path, three would be necessary to cover the whole path. Due to the topological structure of the underlying network, drivers would have to refuel before every, but the first arc. In case the IFR was lower than the length of the first arc, 100 km, even four stations would be needed to refuel the OD path.

In consequence it is not possible to cover the path with $l_q = 2$ stations and the optimal solution is therefore $y_q = 0$. It is important to note that this result is a feasible solution and



Figure 7: Illustration of the problems with the definition of l_a in the MP-NC FRLM.

does not violate the model constraints.

While the 380 km long OD trip can not be covered under this parametric constellation, it is possible to refuel a similar path with two fuel stations, after changing the arc lengths of $a_{3,4}$ and $a_{4,5}$ (see figure 8).

While it has not been possible to identify non-coverable paths before the calculation reliably, one can say, that in general, l_q fuel stations are insufficient to cover an OD path, if the character respectively the length of the path edges make extra refuelling stops necessary. Additional refuelling stops become necessary, if the total amount of wasted but refilled fuel, exceeds a certain critical level. The amount of fuel wasted equals the total overflowing amount at the refuelling stops (fuel overflowing is further explained within the context of the definition of the parameter r_{iq} in section 2.2.).

The critical level respectively, the tolerable refuelling error margin declines, the closer the total trip distance gets to the next greater integral multiple of the vehicle range. In the extreme case, that the path length is only infinitesimally shorter than an integral multiple of the vehicle range, the error margin becomes zero. Then, every bit of fuel is needed to reach the destination with the IFR left in the tank. Therefore, the path edges would need to be entirely in line with the refuelling, meaning that every vehicle has to arrive at the gas stations with an entirely empty tank.

This issue becomes more evident when taking a closer look at the borderline example in figure 9.

Figure 9 shows two similar OD paths. The length of the first one is infinitesimally shorter than the doubled vehicle range, whereas the second path length is infinitesimally longer. In consequence, l_q equals two in the first case and three in the second case.

As can be seen in the figure, path one is not coverable, as three gas stations are needed, while only two are allowed by l_q . Two refuelling stops are insufficient because drivers need to fill up at z_3 , even though they still have enough fuel in the tank to travel another 100 km. If the arcs were perfectly in line with the refuelling, meaning $a_{3,4} = 100$ and $a_{4,5} =$

 $100 - \xi$, the OD trip would be fully refuelable. On the other hand, path two is fully coverable and has the maximal tolerable refuelling error, as its trip distance is as far away from the next greater integral multiple of the vehicle range as possible.

With the concept of non-coverable paths in mind, it is possible to find an upper bound for the number of necessary gas stations on a path. Therefore a generic path setting can be constructed, that maximizes the amount of overflowing by forcing the vehicle to refuel before every arc of the path, but one. Within this setting, every pair of adjacent arcs has to have a combined length that is greater than the vehicle range, except for the last pair of arcs. This way, every path length is representable in such a form.

In the exemplary path setting in figure 10, the length of every pair of arcs, except for the last one, is subdivided into $\frac{\text{vrange}}{2}$ and $\frac{\text{vrange}}{2} + \xi$. The IFR is insufficient, to travel the first arc, so vehicles have to refuel right at the beginning. Although the value of the IFR does not influence the upper bound, it does influence the location of the stations. In case the IFR is sufficient to travel the first arc of the path, vehicles have to refuel at every node but the first one. If the IFR is smaller than the length of the first arc, vehicles fill up at every node except for the destination node.

For the case, that the IFR equals the length of the first arc, it depends on the length of the two final arcs, whether vehicles refuel at the destination node.

The upper bound of l_q is calculated as following with θ_q representing die vehicle range on path q and d_q representing the total path distance of path q:

$$\binom{\max}{q} = \operatorname{ceil}\left\{\frac{d_q}{0, 5 \; \theta_q}\right\}$$
(3.17)



Figure 8: Illustration of the problems with the definition of l_q in the MP-NC FRLM 2



Figure 9: Borderline Case for the tolerable refuelling error margin in the MP-NC FRLM.

Hence, the difference between l_q and its maximal value is:

$$\Delta_{\max} = l_q^{\max} - l_q \tag{3.18}$$

$$= \operatorname{ceil}\left\{\frac{d_q}{0, 5 \ \theta_q}\right\} - \operatorname{ceil}\left\{\frac{d_q}{\theta_q}\right\}$$
(3.19)

$$=\operatorname{ceil}\left\{\frac{d_q}{\theta_q}\right\} \tag{3.20}$$

In consequence, the maximal possible discrepancy between l_q and its maximal value grows, the greater the total path distance and the smaller the vehicle range is.

The search for a better path-specific calculation method for l_q has not yet been successful, but would be of great benefit for the model. As l_q constitutes the number of refuelling occasions on a path q, it is crucial to find a method, so that l_q matches precisely the number of necessary fuel stations, because every excess fuel station built unnecessarily stresses the periodic budget.

Although the current calculation method does not achieve fitting results for every OD path, it will work for most, under the assumption of sufficiently short edges. Until there is a better method, it is advised to keep a closer look at the OD paths with a length close to an integral multiple of the vehicle range, check for their coverability and manually increase l_q as necessary, even though this might be laborious on larger problems.

3.3. Calculation of Sets and Parameters

In the previous section, the reader was familiarised with the mathematical formulation of the MP-NC FRLM and its main differences to Kluschke et al. (2020)'s formulation. The second part discusses two problems that go along with the model formulation: For once the difficult choice between a maximal path and maximal flow covering problem and for second the illustration of topological circumstances, where l_q facilities are insufficient to cover an OD trip.



Figure 10: Construction of the l_q upper bound in the MP-NC FRLM.

The following section thematizes the calculation of sets and parameters in the multi-period node-capacitated FRLM. Although the model components, that require a precalculation, namely the set $K_{j,k}^q$ and the parameter r_{iq} , have been discussed before, their computation differs from Capar et al. (2013) and Kluschke et al. (2020).

For the calculation of $K_{j,k}^q$, the MP-NC FRLM follows Jochem, Szimba, and Reuter-Oppermann (2019)'s idea of splitting the pre-generation of the set into two parts. In the first part, the set of critical arcs A_q is derived by removing all non-critical arcs from the set of all arcs on path q. Besides, a new virtual destination arc technique is applied to A_q to address the shortcomings of Kluschke et al. (2020)'s Adjusted Distance method in guaranteeing the equality of starting and ending fuel levels. In the second part, $K_{j,k}^q$ is calculated by determining all possible refuelling locations for the critical arcs in A_q .

Furthermore, an improved algorithm for the calculation of the parameter r_{iq} is presented. The new algorithm is more compact and solves a shortcoming in Kluschke et al. (2020)'s route sectioning, which can lead to a violation of the initial equals ending fuel level assumption.

Extended Set of all Critical Arcs Aq

The calculation of the extended set of critical arcs A_q is subdivided into two parts. In the first step, a new virtual arc technique is applied to A_q to ensure that the initial and ending fuel levels can be identical. The technique adds a virtual arc with the length of the initial fuel range (IFR) to each path that has to be fully travelable by the vehicles. In the second step, the set of critical arcs is determined by removing all non-critical arcs from A_q , according to Jochem et al. (2019).

In the first part of the A_q calculation, a virtual arc with the length of the initial fuel range is added at the end of each path q and thus appended to A_q . Following the addition, the new virtual arc has to be treated as a real arc, although vehicles will end their OD at the OD path's destination node. In the end, the remaining fuel in the tank must equal the exact amount necessary to fully travel the virtual arc. Adding this virtual arc and respecting it in the $K_{j,k}^q$ serves as a measure to ensure that the initial fuel level equals the ending fuel. This method is used instead of the Adjusted Distance method by Kluschke et al. (2020), as its use can lead to an infeasible model in some cases, which is illustrated below.

Problems of the Adjusted Distance method

As demanded in Assumption 8, drivers have to refuel in such a way, that they do not only reach the destination node but reach it with the initial fuel level left in the tank. Kluschke et al. (2020) solve this difficulty, through artificially prolonging the last arc of the OD paths.

While vehicles refuel sufficiently to exactly reach the destination node via the adjusted distance, drivers end the trip with the initial fuel level left in the tank, as the actual distance of the last arc is shorter than the Adjusted Distance. The Adjusted Distance is calculated as follows:

$$AD_q = d_{\text{origin},i} + d_{i,\text{destination}} + IFR_q - DO_q$$

The Adjusted Distance consists of the path distance from the origin to node *i*, $(d_{\text{origin},i})$, the length from node *i* to the destination $(d_{i,\text{destination}})$, the initial fuel range (IFR_q) and the access distance from the origin node to the network (DO_q) . DO_q is a case-specific parameter, that only has a value > 0, if the origin node does not lie within the examined network.

From the pseudo-code in figure 11 follows, that a node *i* counts as a potential station location, if the Adjusted Distance from *i* to the destination node is smaller than the vehicle range θ_q :

$$d_{i,\text{destination}} + \text{IFR}_q - \text{DO}_q \leq \theta_q$$

In cases, where *i* is the starting node of the last arc of a path *q* and $d_{i,\text{destination}} + \text{IFR}_q - \text{DO}_q > \theta_q$, no node satisfies the condition for being a potential station. In consequence, the final arc, and therefore the whole path, is not refuelable and the model is hence infeasible. As Kluschke et al. (2020) applied their model to cases with heavy-duty vehicles, that have a range of 800 km and an initial fuel level around 50



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Figure 11: Implementation of the Adjusted Distance method by Kluschke et al. (2020).

%, a situation where no node satisfies the condition for refuelling the last arc of a path never occurred. A possible situation, where the last arc is not refuelable, is illustrated in figure 12.

Figure 12 shows a five node network similar to the one in figure 14, except, that in this example, the initial fuel range is 150 km. Both origin and destination node, lie in the considered network. DO_q is, therefore, 0.

The constraint for node z_4 to be a potential station location, that can refuel the final arc $a_{4,5}$, is as follows:

60 km ($d_{i,\text{destination}}$) + 150 km (IFR_q) \leq 200 km

As this inequality is not right for the case-specific values, neither z_4 nor other nodes ($d_{i,\text{destination}}$ is greater for other nodes) can refuel the final arc. Therefore the whole path q is not refuelable.

Extended Set of all Critical Arcs A_q - Step 1

The shortcoming of the Adjusted Distance method is solved in the MP-NC FRLM by adding a virtual arc with the length of the initial fuel range at the end of each trip. Contrary to Kluschke et al. (2020), the ending fuel range is not seen as a part of the last arc. It is rather seen as an own edge at the end of the trip, that has to be travelled. In consequence, an own set $K_{j,k}^q$ is created for the virtual last arc. As the destination node of the trip is then the starting node of the virtual edge, it is a potential station location for refuelling this virtual arc. That way, all initial fuel levels, including 100 %, can be modelled. Contrary to Kluschke et al. (2020), it is, therefore, possible to model cases with private refuelling infrastructure and high IFRs with the MP-NC FRLM. One example would be BEV passenger car cases, where vehicles start fully loaded, as they can be charged at home.

Figure 13 shows the addition of the virtual arc a_{VD} to the OD trip from the previous example in figure 12.

Extended Set of all Critical Arcs A_q - Step 2

When removing all non-critical arcs in the second part of the A_q calculation, Jochem et al. (2019), unlike other authors, not only consider nodes within the initial fuel range as non-critical. For the case, that there is only one valid site for

a fuel station z_i , that can refuel a critical arc $a_{j,k}$ on a path q, it is certain, that this fuel station z_i will be built. If $a_{j,k}$ is not the last arc of the path and z_i therefore not the last refuelling stop on the route, it is also known, that drivers will refuel the maximal tank level according to the refuelling strategy (Assumption 3). In consequence, the travelability of all $a_{j,k}$'s subsequent arcs $a_{l,m}$, that lie within the vehicle range of z_i , is guaranteed. Hence, these subsequent arcs can be considered as non-critical and can as well be deleted from the set A_q .

The pseudo-code for the removal of all non-critical arcs from the set A_q is displayed in code Listing 5. For further illustration, a flowchart of the algorithm is added to Appendix A.

```
for all OD trips q \in Q:
    create an empty delete-items} list for all non-
    critical arcs on A_q
    for all arcs a_{j,k} \in A_q:
         # arcs within the vehicle range are
         deleted from A_q
         if arc a_{i,k} is travelable with the initial
         fuel level:
             add a_{j,k} to the delete-items list
         else:
             if a facility at node i is the only
             valid possibility to refuel a_{i,k}:
                  add all arcs a_{l,m} ,with m > l \geq k,
                  to the delete-items list that
                  are as well refuelled by the fuel
                  station at node i and are not the
                 last arc on path q
    remove all arcs from the delete-items list
    from A_q
```

Code Listing 5: Algorithm for determining the set of necessary arcs A_q in the MP-NC FRLM

As can be seen in the pseudo-code, for every new path q, that the algorithm iterates over, an empty *delete-items* list is created. Every time the algorithm identifies an arc on path q as non-critical, the arc is added to this list. After iterating over all arcs of the extended path q, the arcs on the *delete-items* list



Figure 12: Permissibility problem of the Adjusted Distance method by Kluschke et al. (2020).



Figure 13: Addition of a virtual arc in the new A_a calculation method.

are removed from the set A_q , before the algorithm continues with the next path. It is important to note, that although it is possible to delete the non-critical arcs directly after their identification, removing items from a list, that is currently being iterated over will most likely produce non-desired results. Therefore the *delete-items* list functions as temporary storage so that the non-critical arcs can be deleted from the set after iterating over it. Thus results are not negatively impacted.

For a better understanding of the algorithm, that removes the non-critical arcs from A_q , its functionality is illustrated in a simple example.

Figure 14 shows a 320 km long, five node network with a single OD pair (1,5) and the newly added virtual destination node from the first part of the A_q calculation. The maximal vehicle range is 200 km, and the initial fuel range 150 km %. To convert A_q from the set of all arcs on path q to the set of critical arcs, all non-critical arcs have to be removed. As z_2 is the only station location, that can refuel the arc $a_{2,3}$, it is marked as a certain station location. Hence, all arcs within vrange of the certain station are travelable and therefore non-critical. Table 3 shows the arc-wise iteration of the algorithm along with the changes in the *delete-items* list.

Set of all Potential Station Locations $K_{j,k}^{4}$

In the previous paragraph, the set of critical arcs A_q was obtained through appending a virtual arc with the length of the IFR at the end of each trip and afterwards removing all non-critical arcs from A_q . In the following, the A_q is used to calculate $K_{i,k}^q$.

The MP-NC FRLM algorithm for determining $K_{j,k}^q$ equals the *Identifying potential station locations* sequence of Kluschke et al. (2020)'s $K_{j,k}^q$ generation algorithm, which is marked blue in the flowchart in figure 22 (Appendix A). While Kluschke et al. (2020) iterate over every node on the way from origin to the destination node of the critical arc, to see whether it qualifies as a potential station location, the below-presented algorithm takes a different approach.

Instead of iterating forwards from the origin, the algorithm goes backwards on the path from the destination node of the examined critical arc $a_{i,k}$. If a node *i* is

- within the vehicle range of the destination node of the critical arc **and**,
- if the node qualifies as a potential station location (modelled through the parameter g_{iq}),

it is added to the set $K_{j,k}^q$.

When the algorithm reaches the first node, that is outside the vehicle range, it *breaks* the iteration and moves to the next critical arc, as all succeeding nodes would also be outside the vehicle range.



Figure 14: Usage of certain station placements on OD paths to identify further non-critical arcs

Step	Arc	delete-items list	Explanation
1 a _{1,2}			$a_{1,2}$ lies within vehicle range and is not the last
	<i>a</i> _{1,2}	$\{a_{1,2}\}$	arc of path (1,5)
			->add to delete-items
2 a _{2,3}			As a station at z_2 is the only possibility to refuel
			the arc $a_{2,3}$, subsequent arcs of $a_{2,3}$
			are checked for their criticalness
	$\{a_{1,2}, a_{3,4}\}$	1) $a_{3,4}$ is within vrange of z_2 and not the last arc	
		of path (1,5)	
			->add to <i>delete-items</i>
			2) $a_{4,5}$ is not within vrange of z_2
3	a _{3,4}	$\{a_{1,2}, a_{3,4}\}$	$a_{3,4}$ is already in the <i>delete-items</i> list
4	a _{4,5}	$\{a_{1,2}, a_{3,4}\}$	$a_{4,5}$ is not within vrange of z_2 and therefore critical
5	a _{VD}	$\{a_{1,2}, a_{3,4}\}$	a_{VD} is not within vrange of z_2 and therefore critical
6	$A_q = \{a_{2,3}, a_{4,5}, a_{VD}\}$		All arcs from the <i>delete-items</i> list are removed
			from A_q

Table 3: Set of all critical arcs A_q of the example in figure 14

The pseudo-code for the generation of the set $K_{j,k}^q$ is given below. A flowchart of the algorithm can be found in Appendix A.

```
for all OD trips q \in Q:
for all arcs a_{j,k} \in A_q:
for all nodes i on the reversed path q
with i \leq k:
if distance (i,j) \leq vrange and
a potential station location:
add node i to K_{j,k}^q
else:
break
```

Code Listing 6: Algorithm for determining the set $K_{j,k}^q$ in the MP-NC FRLM

Refuelled Driving Distance r_i^q

The last part illustrated the pre-generation process of the set $K_{j,k}^q$, which is split into the calculation of the set of critical arcs A_q and the computation of $K_{j,k}^q$. While the calculation of A_q and $K_{j,k}^q$ in the MP-NC FRLM follows a different

approach than Kluschke et al. (2020), the algorithm for the generation of r_{iq} adapts and improves Kluschke et al. (2020) pre-calculation process. The new and improved algorithm is more compact and solves existing problems by harmonizing the route sectioning.

As described in section 2.2.2, Kluschke et al. (2020) subdivide the OD paths for the estimation of the refuelling amounts, r_{iq} , in l_q route sections. A vehicle is supposed to refuel once per section and fill up the maximal tank capacity, respectively enough fuel, to reach the end of the last section with the initial fuel level. When refuelling once per route section, the vehicles fill up in total the exact amount of fuel consumed during the OD trip.

Although this works well for most cases with $l_q = 1$ and $l_q = 2$, the definition of the route sections for $l_q > 2$ can cause vehicles to refuel twice in the penultimate, but not at all in the last route section. In consequence, vehicles refuel more than the amount of fuel consumed on the trip. Therefore Kluschke et al. (2020)'s assumption, that each vehicle starts and ends its trip with the same fuel level is violated, and more than the necessary amount is refuelled. Depending on the

path's flow value, this can lead to greater distortions in the degree of capacity utilization and hence the model outcome.

As can be seen in the commented pseudo-code in figure 15, Kluschke et al. (2020) define the first route sections for the cases with multiple refuelling stops, $l_q = 2$ and $l_q \ge 2$, differently. $l_q = 2$'s first route section has the length of the initial fuel range and is therefore fully travelable from the origin. Contrary to that, all of $l_q > 2$'s route sections, except the last one, are defined by the maximal vehicle range, which makes the first route section not fully travelable with the initial fuel level, unless the vehicle's tank is full at the beginning.

In case the total trip length is close to $l_q \ \theta_q \ \text{km}, \ l_q \ge 2$, with the destination node being the only node in the last section, all refuelling opportunities for refuelling the last arc lie in the penultimate section, which leads to a double refuelling there. As the applied refuelling logic causes drivers to fill up maximal tank capacity in every section except for the last, the ending vehicle range is $l_q \ \theta_q - d_q$ higher than the initial fuel range. For better illustration, an example is given below.

Figure 16 shows a six node network with the OD trip (1,6) of length 450 km. The vehicle range is 200 km and the initial fuel range 100 km. Thus, l_q is 3, and the route is subdivided according to Kluschke et al. (2020)'s algorithm. As the vehicle is supposed to finish the trip with an ending fuel range of 100 km, possible refuelling locations can only be within 100 km of the destination node 6. Therefore z_5 is the only location for refuelling the final arc of trip q, but lies in the second, and not the last route section and will refill the maximal vehicle range, 200 km.

When optimizing this problem with the solver Gurobi, the optimal solution is the construction of stations z_2 , z_4 and z_5 . Thus, drivers would refuel 600 km instead of the trip length of 450 km.

The here proposed algorithm for the generation of the r_{iq} in Code Listing 7 addresses this shortcoming by harmonizing the route sectioning for all paths with $l_q \ge 2$ ß and reformulating the algorithm compactly. The primary adjustment is that the first route section for $l_q > 1$ will always have the length of the initial fuel range and vehicles refuelling at any node within this first section will fill up the maximum tank capacity. Furthermore, all potential route sections between the first and the last one (case $l_q > 2$) are defined by the vehicle range, and drivers will refuel the maximum tank capacity as well. Like in Kluschke et al. (2020), drivers will fill up the difference between the total trip distance and the sum of the previous refuelling amounts on the trip.

Figure 17 shows the route sectioning of the OD trip from figure 16 according to the improved algorithm for determining the parameter r_{iq} . While z_2 , z_4 and z_5 remain the optimal station location in this problem, due to the new definition of the route sections, the refuelling amount is equal to the total trip distance. The initial and ending fuel range are therefore equal.

```
1 for all OD trips q \in Q:2for all nodes i on path q:3if the number of refuelling occasions4l_q \leq 1:5r_{iq} = total path distance6else:7if the distance (origin,i) \leq (initial8fuel range + vehicle range *9max{0, l_q - 2}:10r_{iq} = vehicle range11else:12r_{iq} = total path distance -13vehicle range * (l_q - 1)
```

Code Listing 7: Algorithm for determining the parameter r_{iq} in the MP-NC FRLM

3.4. Measuring the MP-NC FRLM's Additional Benefit

In the previous section, the calculation of sets and parameters for the MP-NC FRLM was illustrated. Although no additional set respectively parameter that requires pre-generation was added compared to Kluschke et al. (2020), their computation differs. The set $K_{i,k}^q$ is calculated in two steps. In the first step, a virtual arc is added to A_q before removing all noncritical arc from the set. Subsequently, $K_{i,k}^q$ is generated on bases of A_q . The new r_{iq} pre-generation algorithm is more compact than Kluschke et al. (2020)'s formulation and has harmonized the route sectioning. For $l_q \geq 1$ the first route section now has the length of the IFR. For assessing the additional benefit of the MP-NC FRLM over non-multi-period models, the following paragraph introduces two of the most frequently found evaluation concepts, the "Value of the Multiperiod Solution" and the "Value of Multi-Period Planning" and discusses their calculation in the context of the MP-NC FRLM. VMPS and VMPP respectively display the relative value difference between the MP-NC FRLM and pre-specified comparison models.

Value of the Multi-Period Solution

As stated in section 2.1.4, "Assessment of multi-period models", the VMPS is defined as the relative improvement of a multi-period model compared to its static counterpart. Laporte et al. (2015) While there are several ways to define the counterpart, for the application in context with the MP-NC FRLM, it is calculated as follows:

In the first step, the static counterpart is defined as the optimal solution of a single period NC-FRLM, that considers only the last period of the planning horizon. While the time-invariant parameters remain constant and the model flow equals the flow of the last period f_q^n , the budget in the counterpart has to be altered so that the potential amount of constructed stations in the dynamic and the static problem are equal. The outcome is a set of facilities that maximizes the value of the objective function in the static counterpart.

For the static counterpart to be comparable to be the MP-NC FRLM solution, it is necessary to determine a step-wise construction plan for the set of optimal facilities, that respects the budgetary constraints b_t for each period. Therefore, the



Algorithm for determining r_{iq} in the NC-FRLM

Figure 15: Definition of the	e l_a route sec	tions in Kluscl	1ke et al	. (2020).
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Sets	
T = n	Only the last period <i>n</i> of the planning hori-
	zon is considered in the static counterpart
Parameters	
n	
$b = \sum b_t$	The budget of the static counterpart is the
t = 1	sum of the periodic budgets from periods
	1 to <i>n</i>
$f_n = f^n$	The vehicle flow in the static counterpart
Jq Jq	equals the vehicle flow in the last period
	equais the venicle now in the last period
	t = n

MP-NC FRLM is optimized with the set of optimal facilities from the static counterpart being the only possible station locations. In case the set of optimal facilities in the multi-period model and the static counterpart are identical, the solution values will be identical as well.

In the last step, the Value of the Multi-Period Solution is obtained by subtracting the value of the objective function of the static counterpart MP-NC FRLM from the value of the objective function of the MP-NC FRLM and standardizing the difference with the counterpart's solution. For a VMPS greater than zero to occur, it is necessary, that the set of optimal facilities in the MP-NC FRLM and its counterpart differ. The variable *V* represents the value of the multi-period model, respectively of its counterpart.

Nonetheless, a difference in the set of optimal facilities does not necessarily mean that there is a VMPS greater than zero. On the other hand, if the two sets are identical, the VMPS is always zero. After all, the static counterpart can be seen as a building-site constrained version of the MP-NC FRLM. Its solution value will be lesser than or equal to the one of the original model with the full set of available building sites.

$$VMPS = \frac{V_{MP-NC-FRLM} - V_{Counterpart}}{V_{Counterpart}}, VMPS \ge 0$$

Value of Multi-Period Planning

The value of Multi-Period Planning quantifies the additional benefit of considering future periods while planning, contrary to continuously solving static problems for each period, given the results of the prior calculations. Although this definition would fit for the Forward-Myopic and the Backwards-Myopic method alike, it seems, from an economic point of view, more reasonable to optimize from the current period on forwards.

For retrieving comparable results and measuring the additional benefit, it is essential to assume that demand and economic data can be accurately predicted for every considered period. The Value of Multi-Period Planning is obtained by subtracting the solution value of the F-Myopic method from the value of the multi-period model and standardizing it with the F-Myopic value. The variable *V* represents the value of the multi-period model, respectively of its counterpart.

Compared to the multi-period model, its counterpart for the VMPP calculation can be considered as a greedy algorithm, as it makes the locally optimal choice for each period. Hence, the VMPP is zero, only if the locally optimal station placements in each period are as good as respectively identical to the siting choices made when considering other periods as well.



Figure 16: Illustration of the problem of the l_q definition by Kluschke et al. (2020)



Figure 17: Implications of the adjusted l_a calculation method.

$$\text{VMPP} = \frac{V_{\text{MP-NC-FRLM}} - V_{\text{F-Myopic}}}{V_{\text{F-Myopic}}}, \text{ VMPP } \ge 0$$

3.5. Further Case-Specific Assumptions and their Impact on the model

In the previous chapter, the two evaluation concepts for multi-period models, the VMPS and the VMPP have been introduced and adapted for assessing the MP-NC FRLM's additional benefit. The VMPS displays the relative value difference between the MP-NC FRLM and its static counterpart. On the other hand, the VMPP displays the difference between the MP-NC FRLM and a corresponding F-Myopic model.

As briefly discussed in section 2.3.1, assumptions for the multi-period node-capacitated FRLM are subdivided into two groups. While the *General Modeling Assumptions* define the general model setting and are needed for obtaining a feasible solution, the *Case Specific Assumptions* are a non-definite set of assumptions, that are made in the context of the application case. Although only three *Case Specific Assumptions* are made in the base case defined in section 2.3.2, a

more comprehensive list of possible further situational assumptions and their impact on the model is presented below:

- 1. The vehicle flow is expected to rise periodically due to an increase in the AFV market share.
- 2. The driving range is assumed to increase due to technological advances.
- 3. Fuel station construction costs are assumed to be linear depending on the storage capacity.
- 4. Fuel station construction costs are influenced by local characteristics of the building site (e.g. topography).
- 5. Fuel station construction costs are expected to decline over time due to economies of scale and learning effects.
- 6. Certain nodes (e.g. origins, destinations, route intersections) are discarded as station locations.
- 7. refuelling is only required on trips longer/shorter than XX km.

The MP-NC FRLM considers the OD flows of alternative fuel vehicles, which currently stand at the beginning of their
product life cycle. It is possible to include changes in the vehicle flow into the model by adding a temporal dimension to the vehicle flow on path q. The two main drivers of the AFV flow on path q in period t, f_q^t are

- · the total vehicle flow and
- the AFV market share.

As both drivers, total vehicle flow and AFV market share, are expected to rise all around the world, Ahlswede (2020); FEV (2018), it is reasonable to assume an increase in AFV flow like in Assumption 1.

Assumption 2 thematizes the possible changes in vehicle range over time, which might be worth considering when applying the MP-NC FRLM to a BEV case. In the model, the vehicle range consists of

- the maximal tank/battery capacity and
- fuel/energy consumption per km.

An increase in the vehicle range has multiple implications for the model and causes the addition of a temporal dimension to A_q , $K_{j,k}^q$, r_{iq} , l_q and p. While adding an index t to the fuel consumption parameter p seems rather obvious, the necessity for adjusting the rest of the parameters mentioned above becomes clearer at a second glance.

When determining the set of critical arcs from A_q , all arcs, that lie within the vehicle range of the origin node or another certain fuel station, are considered uncritical and therefore removed. Hence, the set of critical arcs must be updated every time, the vehicle range changes.

The set $K_{j,k}^q$ is influenced by a changing vehicle range not only through an adjusted set of critical arcs A_q^t . Furthermore, a greater vehicle range can enlarge the set of potential facility locations, that can refuel an arc $a_{j,k}$ on path q. Therefore an updated set $K_{j,k}^q$ is needed for every period $t \in T$.

 l_q is the number of necessary refuelling stops on a path q. It is calculated by rounding up the solution of dividing the total path distance through the vehicle range and thus needs a temporal dimension as well. Apart from ensuring the number of refuelling occasions on a path in a model constraint, l_q and the vehicle range influence the route sectioning when calculating the parameter r_{iq} . Among possible changes in the route sectioning, the values for r_{iq} change alongside the vehicle range.

Like in the base model, it is still assumed, that the constructed fuel station at a node i will always have the maximal possible capacity (= node capacity). While the base model does not consider the impact of station capacity on construction costs, it is possible to do so. Assumption 3 presumes a correlation between the capacity of a station and its construction costs and assumes it for simplification purposes to be linear. In consequence the construction cost of a fuel station is calculated as follows: $o_i = c_i \text{ cost per kg stored H}_2$.

To provide a more accurate estimation of the utilized budget, Assumption 4 gives the possibility to respect the impact of local characteristics of the building site on the station cost at a node *i* via a parameter α_i , $\alpha_i \ge 0$. An exemplary factor with an impact on the construction costs is the topography of the building land.

While it is more expensive to construct a station on hilly ground compared to the baseline cost o_i , with $\alpha > 1$, a plane construction site might be cost-wise more attractive, $\alpha < 1$. Possible other local factors influencing the construction costs could be the energy grid connection, forest vegetation or pre-existing stations.

Assumption 5 considers the possibility of economies of scale and learning effects, that might arise due to a large number of alternative fuel stations constructed within the project time. The parameter β^t , with $\beta^t \in \{0, 1\}$, displays a time-dependent cost reduction factor for o_i . Like in Kluschke et al. (2020), it might be desired to discard specific nodes, e.g. origins, destinations or route intersections as a station location. (Assumption 6) Discarding can be achieved by setting the parameter g_{iq} for the discarded locations to zero. Assumption 7 restricts the set of all OD paths Q, considering only paths, whose lengths exceed respectively are below a certain threshold. Limiting the set of considered trips can be reasonable when focusing, e.g. on long-haul transportation or reducing Q to benefit the solving time of the model, like in Kluschke et al. (2020).

The following formulation is an extended version of the MP-NC FRLM that respects the above mentioned, possible *Case Specific Assumptions*.

$\max \sum_{t \in T} \sum_{q \in Q} y_q^t$	(3.21)
s.t. $\sum_{i \in K_{j,k}^{q,t}} z_i^t \ge y_q^t \forall q \in Q, a_{j,k} \in A_q, t \in T$	(3.22)
$\sum_{q \in Q} f_q^t p^t r_{iq}^t g_{iq} x_{iq}^t \leq c_i z_i^t \forall i \in N, t \in T$	(3.23)
$\sum_{i \in K_{j,k}^{q,t}} x_{iq}^t = y_q^t \forall q \in Q, a_{j,k} \in A_q, t \in T$	(3.24)
$\sum_{i \in N} x_{iq}^t = y_q^t l_q^t \forall q \in Q, t \in T$	(3.25)
$x_{iq}^t \leq z_i^t \forall i \in N, q \in Q, t in T$	(3.26)
$z_i^t \le z_i^{t+1} \forall \ i \ \in \ N, \ t \ \in \ T \setminus \{n\}$	(3.27)
$z_i^t - z_i^{t-1} \le k_i^t \forall \ i \in N, \ t \in T \setminus \{1\}$	(3.28)
$z_i^1 \leq k_i^1 \forall \ i \ \in N$	(3.29)
$\sum_{i \in N} \alpha_i \beta^t o_i k_i^t \leq b_t \forall t \in T$	(3.30)
$\sum_{t \in T} k_i^t \le 1 \forall \ i \ \in \ N$	(3.31)
$z_i^t, k_i^t \in \{0,1\} \forall i \in N, t \in T$	(3.32)
$0 \leq x_{iq}^t \leq 1 \forall i \in N, q \in Q, t \in T$	(3.33)
$0 \leq y_q^t \leq 1 \forall q \in Q, t \in T$	(3.34)

Sets	
Ν	Set of all nodes on the Graph G
Q	Set of all OD pairs
Т	Set of all time periods
A_q	Set of all directional arcs on the path $q \in Q$
1	from origin to destination
$K_{j,k}^{q,t}$	Set of all potential station locations, that can refuel the directional arc $a_{j,k} \in A_q$ in period <i>t</i>

Variables

z_i^t	Binary Variable that equals to one, if a refu-
	elling facility is open at node <i>i</i> in time period
	t

- k_i^t Binary Variable that equals to one, if a refuelling facility is constructed at node *i* in time period *t*
- x_{iq}^t Semi-Continuous Variable that indicates the proportion of vehicles on path q that are refuelled at node i in time period t
- y_q^t Semi-Continuous Variable that indicates the proportion of flow served on path q in time period t

Parameters

p'	Fuel efficiency / fuel consumption per ve-
	hicle range in period <i>t</i>
<i>o</i> _{<i>i</i>}	Facility opening costs / construction costs
	for a facility at node <i>i</i> , $o_i = c_i * \text{ cost per}$
	kg stored H_2
v^t	Fraction of the minimal amount of flow
	covered in period <i>t</i>
ci	refuelling capacity at node <i>i</i>
d_q	total distance of path q
θ_q	vehicle range of vehicles on path q
l_q	Number of refuelling occasions on path q
	depending on the total path distance, $l_q =$
	$\operatorname{ceil} \left\{ d_a / \theta_a \right\}$
b_t	Available budget in period t
f_a^t	Total vehicle flow on the OD path q in time
4	period <i>t</i>
8 _{iq}	Binary indicator, that is set to one, if node
*	i is a potential station location on path q
r _{iq}	refuelled driving distance at node <i>i</i> on path
	q
α_i	Semi-Continuous parameter, that depicts
	the impact of local factors (e.g. topography
	of the building land,) on the construction
	cost of a station
β^t	Semi-Continuous parameter, that indicates
	the general cost reduction for construction
	fuel stations compared to $t = 0$ due to
	learning effects and possible economies of
	scale

4. Numerical Experiment: Additional Benefit and Computational Complexity

The previous chapter introduced the new FRLM extension of Capar et al. (2013)'s and Kluschke et al. (2020)'s models, the multi-period node-capacitated FRLM, to the reader. The section discussed the new MP-NC FRLM model assumptions and presented the model's mathematical formulation. After addressing two modelling problems, the calculation of the sets A_q and $K_{j,k}^q$ and the parameter $r_i q$ was illustrated. The chapter concludes by adapting the two multi-period model evaluation concepts, the VMPS and the VMPP, to the MP-NC FRLM and discussing further case-specific assumptions and their impact on the model.

To understand the implications of the MP-NC FRLM and to identify cases and parametric constellations, where the use of the MP-NC FRLM provides the most additional benefit, a numerical experiment is conducted. The two applied assessment criteria are the concepts of the Value of the Multi-Period Solution (VMPS) and the Value of Multi-Period Planning (VMPP), which are defined above in section 2.3.4. In the first step, the VMPS and the VMPP are illustrated through an exemplary network. After proving the existence of a VMPS, respectively a VMPP greater than zero, several hypotheses about parametric constellations driving the values of the assessment criteria are discussed. As the benefits of applying a multi-period model come at the cost of increased complexity and hence, a higher solving time, the final paragraph will assess the maximal complexity for the problem to be solved efficiently within ten minutes.

4.1. Illustrating the Benefits: VMPS and VMPP in the MP-NC FRLM

In the following, the VMPS and the VMPP are illustrated, each through an exemplary network. In a first step, the existence of a VMPS, respectively VMPP, greater than zero is proven, before taking a closer look at why and how VMPS and VMPP greater than zero occur and which factors might benefit these two assessment values. For a better understanding of the VMPS and VMPP, the chosen examples will only have a value greater than zero for the assessment criterion, that is examined in the particular paragraph. While it is likely, that larger problems have both, a VMPS and a VMPP greater than zero, this is also possible on smaller networks, as shown in Appendix A (Appendix A: network in figure 25, OD flows in table 12, solution values in table 13). All of the belowpresented problems were solved with Gurobi Version 9.0.

Value of the Multi-Period Solution

Figure 18 shows the thirteen node network, which is used for further examining the VMPS. There are seven OD trips, of which the four trips, (1,5), (1,6), (1,7) and (1,13), share the same edges for their first 350 km. The maximal vehicle range is 400 km, and the initial fuel level 50 %. The considered time horizon is three periods, and the budget is sufficient for building one fuel station per period. Each OD trip has a flow amount of ten in the first period, fifteen in the second and twenty-five in the third and final period.



Figure 18: Exemplary problem in the numerical experiment with VMPS > 0 and VMPP = 0

While the MP-NC FRLM and the F-Myopic model have the same solution (leading to a VMPP of zero), the results of the multi-period model and its static counterpart differ. Following its definition, a VMPS greater zero could occur, as the set of optimal facilities in the multi-period model and its static counterpart differ.

As described in section 2.3.4, the set of optimal facilities in the counterpart is determined, by solving the static problem, given the OD flows from the last period and the possibility of building three facilities. Even though the flows of (1,6), (1,7) and (1,13) cannot be fully served due to the limited capacity of the fuel stations, it is optimal to serve them, as these three OD flows can be served with the two stations z_1 and z_5 (see table 4). Hence, the y_q value for these paths is below one.

After solving botch, the multi-period problem and the static counterpart, the total number paths covered over all periods, $\sum_{t \in T} y_q$ appears to be equal. The solution value of the static counterpart is smaller than the one of the multi-period model because the stations in the counterpart can not serve all flows on the refuelled paths as shown in table 4. The VMPS, therefore, amounts to 6.51 (see table 5).

While a disparity in the sets of optimal facilities is necessary for a VMPS greater than zero, the sole existence of this discrepancy does not make any predictions about the amount of the benefit. Although exact VMPS drivers have not yet been scientifically identified and confirmed, some parametric constellations and patterns frequently occurred while testing the model. This leads to the following hypotheses about the VMPS:

Although it is certain, that other factors, like the number of possible fuel station constructions per period or the length of the deviation paths, do influence the VMPS, it has not been easy to assess their exact effects. One of the primary reasons for that is that changing these factors also has consequences on other model parameters.

A good example is the possible influence factor "constructed fuel stations per period". The differences in the sets of optimal facilities mainly occur, because in the static model, station placements are optimal that cover multiple and mostly overlaying paths at the same time. In the multiperiod model, these paths might be suboptimal, as it, for example, takes more time to cover them entirely. Hence, it seems logical, that the more time it takes to cover them, the longer it takes for the path to contribute to the solution value. In consequence, the solution value of the counterpart would decline and the VMPS rise.

However, this is difficult to prove because changing the number of constructed stations per period has consequences on at least either the total number of stations built or the number of considered periods. In case the number of periods remains constant, the total number of stations built changes, which affects the set of optimal facilities in both, the multiperiod model and the static counterpart. When keeping the number of stations constant, while altering the number of periods, the solution values will differ significantly from the previous ones, as the objective function sums over all y_q variables over all periods.

Nonetheless, further analysis of VMPS drivers and influence factors might be useful for further research.

Value of Multi-Period Planning

For the illustration of the VMPP, the thirteen node network from above is extended by two nodes. OD trips, as well as their flows, have also been adapted (see figure 19. In this problem, there are six considered OD trips, (1,5), (1,6), (1,7), (1,12), (1,13) and (2,9). All of them have a flow amount of five in the first period, ten in the second and fifteen in the third period. The maximal vehicle range is 400 km, and the initial fuel level 50 %. The considered time hori-

Stations constructed	Paths Covered
z_8	$y_{1,6} = 0.817$
z_1	$y_{1,7} = 0.816$
z_5	$y_{1,13} = 0.816$
	$y_{1,9} = 1$
	$y_{2,9} = 1$

Table 4:	Op	erating	Stations and	covered	paths o	f the	static co	unterpa	art of the	e numerical	experimer	nt in f	igure	18.
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		Period t=1	Period t=2	Period t=3
MP-NC	Operating Stations	z ₈	z ₈ , z ₃	z_8, z_3, z_{11}
FRLM	Paths Covered	(1,9), (2,9)	(1,9), (2,9), (1,5)	(1,9), (2,9), (1,5), (1,12)
Static	Operating Stations	z ₈	z ₈ , z ₁	z_8, z_1, z_5
Counterpart	Paths Covered	(1,9), (2,9)	(1,9), (2,9)	(1,9), (2,9), (1,6), (1,7), (1,13)
Solution Valu	ıe		Assessment Criter	ion
MP-NC FRLM		9.0	VMPS	6.51 %
Static Counterpart		8.45	VMPP	0 %
F-Myopic		9.0		

 Table 5: Solution value and assessment criteria of the numerical experiment in figure 18.

zon is three periods, and the budget is sufficient to build one fuel station per period.

While the MP-NC FRLM and the static counterpart model have the same solution (leading to a VMPS of zero), the results of the multi-period model and the F-Myopic differ. As described in section 2.3.4, the F-Myopic model can be considered a greedy algorithm, that makes the optimal decision for each period. Table 6 illustrates the differences in the decision making between the F-Myopic model and the MP-NC FRLM: From a holistic perspective it is optimal to first construct a station z_5 , as z_5 contributes to refuelling multiple paths, that need more than one refuelling stop en route. With the construction of z_1 in the next period, three paths, (1,6), (1,7) and (1,13) can be refuelled at the same time. As the F-Myopic model, on the other hand, only aims at maximizing the payoff of the current period, it misses out on the opportunity of covering the paths (1,6), (1,7) and (1,13), because the paths take two periods to be covered.

Hence, the MP-NC FRLM achieves an overall better solution at the possible cost of a worse performance within the time horizon. This means that whenever the MP-NC FRLM and its F-Myopic correspondent do not have the same value, the solution of the F-Myopic model has a higher solution value in at least one time period.

Solving both, the MP-NC FRLM and the F-Myopic model leads to a VMPP of 16.67%.

Although there has not been an extensive scientific study examining potential VMPP drivers, frequently observed parametric constellations lead to the following hypotheses about the VMPP:

• The VMPP strongly depends on the network and OD trip topology as well as on OD trip quantity

For a VMPP to exist, it is necessary, that the station placements for maximizing the benefit of the current period and for maximizing the overall benefit differ in at least one period. Contrary to the greedy F-Myopic model, the MP-NC FRLM accepts a short term worse solution value to invest into station combinations, that refuel several paths at the same time, take several periods to build and pay off in a later period (see table 6). As covering these paths requires "long-term planned" investments, these paths are in the following called "invest paths". Hence invest paths are necessary for a VMPP greater than zero.

To be considered an invest path, OD trips have to fulfil the following two topological requirements:

- 1. Invest paths can not be covered with the budget of one period.
- 2. Covering an invest path refuels multiple other paths along the way.

In the above-given example (figure 19) either (1,6), (1,7) or (1,13) would count as an invest path, as covering one of these paths automatically covers the other two paths along.

The more invest paths there are in a problem, and the more OD trips are refuelled along with an invest path, the higher the VMPP gets. The impact on the VMPP is exemplified in table 7, as there are step-wise OD trips



Figure 19: Exemplary problem in the numerical experiment with VMPP > 0 and VMPS = 0

		Period t=1	Period t=2	Period t=3	
MP-NC	Operating	z5	z_5, z_1	z_5, z_1, z_8	
FRLM	Paths			(1,6), (1,7), (1,13),	
_	Covered		(1,6), (1,7), (1,13)	(2,9)	
	Operating	%10	710 Vo	710 70 70	
F-Myopic	Stations	~10	~10, ~8	~10, ~8, ~3	
	Paths	(1 12)	(1 12) (2 0)	$(1\ 12)$ $(2\ 9)$ $(1\ 5)$	
	Covered		(1,12), (2,7)	(1,12), (2,7), (1,3),	
Solution Value			Assessment Criterio	on	
MP-NC FRLM		7.0	VMPS	0 %	
Static Counterpart		7.00	VMPP	16.67 %	
F-Myopic		6.0			

Table 6: Operating stations and covered paths of the numerical experiment in figure 19.

added to the simultaneously coverable invest paths. With each addition of the two trips (1,14) and (1,15), the VMPP grows.

• The VMPP is negatively correlated with the amount of non-coverable flow passing through the MP-NC FRLM's "invest paths"

Similar to the "deviation path effect" for the VMPS, the lesser flow is covered on the "invest paths", the smaller is the MP-NC FRLM's solution value. Hence, the VMPP declines.

This effect is illustrated in table 8 by varying the flows of the invest paths (1,6), (1,7) and (1,13) in t = 3 in the previous problem in figure 19. As described above, one can see, that with the increase of the invest flows, the MP-NC FRLM solution value declines to the point, where the F-Myopic solution becomes optimal.

As the invest paths are already covered in period two, it is contrary to the "deviation path" example in the VMPS, possible to alter the MP-NC FRLM solution by also varying the flow parameters in period two. Varying flows in prior periods has not been done for better clarity. Either way, the minimal MP-NC FRLM solution value hereby equals the F-Myopic value of six.

• The VMPP is positively correlated with the number of considered periods as long as the sets of covered paths are not identical.

As described above, whenever there is a VMPP greater than zero, the MP-NC FRLM's solution value will, at least at one point in time, be lesser than the F-Myopic value as a tradeoff for future benefit. That means that the value of covering an invest path is greater than the value of paths that are covered in the meantime by the F-Myopic model. The additional value of covering an invest path can, for example, be seen in table 6, as the MP-NC FRLM achieves a surplus of one covered path compared to the F-Myopic model in period two, due to

OD trips on invest paths	Stations MP-NC FRLM	Value MP-NC FRLM	VMPP
(1,6), (1,7), (1,13)	5,1,8	7	16,67%
(1,6), (1,7), (1,13), (1,14)	5,1,8	9	50,00%
(1,6), (1,7), (1,13), (1,14), (1,15)	5,1,8	11	83,33%
Stations F-Myopic Value F-Myopic	3,8,10 6		

 Table 7: Effects of network and OD trip topology on the VMPP in the problem in figure 19.

Invest Flows in t = 3	Stations MP-NC FRLM	Value MP-NC FRLM	VMPP
15	z_5, z_1, z_8	7	16,67%
16,75	z_5, z_1, z_8	6,99	16,0%
20	z_5, z_1, z_8	6,74	12,33%
30	z_5, z_1, z_8	6,24	4,00 %
37	z_5, z_1, z_8	6,01	0,17%
37,5	z_3, z_8, z_{10}	6	0%
40	z_3, z_8, z_{10}	6	0%
Stations F-Myopic Value F-Myopic	z_3, z_8, z_{10} 6		

Value F-Myopic

Table 8: Effects of invest flow variations on the VMPP in the problem in figure 19.



Figure 20: MP-NC-FRLM and F-Myopic solution values and VMPS development over time.



Figure 21: MP-NC-FRLM and F-Myopic solution values and VMPP development over time.

varied parameters	constant parar	neters
number of nodes	x coordinate min/max	0/660
node connection probability	y coordinate min/max	0/880
number of OD paths	start value of the OD flows	5
number of periods	flow increment per period	5
	construction budget	5 facilities/period
	maximal vehicle range	400
	initial fuel range	200

Table 9: Parameters used in the randomised problem generation in the numerical experiment.

covering the invest paths. Until these invest paths are as well covered by the F-Myopic model, the surplus will contribute to an increasing VMPP in each period. Once the sets of covered paths concur, the VMPP declines with every further period.

Figure 20 exemplifies this effect by depicting the solution values of the MP-NC FRLM and the F-Myopic model as well as the VMPP for different periods in the problem in figure 19.

Until the two sets of covered paths are identical and the invest paths are also covered by the F-Myopic model (see period t = 5; all six paths are covered), the VMPP grows. While the absolute value difference remains constant, the relative value difference lessens with every period.

Figure 21 shows the graph of a situation, where it is no longer possible to build fuel stations respectively to cover paths after period three. Since the sets of covered paths never concur, the VMPP grows with every period.

4.2. Computational Complexity of the MP-NC FRLM

While the previous paragraph has shown, that the multiperiod model can provide even significantly better results than its static, respectively its F-Myopic counterpart, the superior performance comes at the cost of higher computational complexity.

The assessment of the model complexity in the following section is approached from a practical standpoint. How complex can a problem in terms of network topology, OD path quantity and periods be so that it can be solved with the MP-NC FRLM in under ten minutes?

For testing the solution time, the optimization was performed on problems, where the network, as well as the OD paths, were randomly generated. The models were run with an Intel Core i5-6200 CPU with 2,40 GHz and 8 GB RAM.

The parameters used for the generation of the problems are displayed in table 9.

The network is generated using the parameters "number of nodes", "x/y coordinate maximum" and "node connection probability". In the first step, nodes are randomly placed on

varied paramete	rs	Results	
number of nodes	1500	average solution time	10:01
node connection probability	10%	standard deviation	5:07
number of OD paths	150	minimal solution time	4:34
number of periods	10	maximal solution time	19:34
		% solution time under 10 minutes	70%

Table 10: Results of the computational complexity test for ten randomly generated optimization problems with 1500 node network with 150 OD paths, a node connection probability of 10% and ten considered periods.

varied parameters		Results		
number of nodes	1500	average solution time	25:32	
node connection probability	10%	standard deviation	21:45	
number of OD paths	175	minimal solution time	5:36	
number of periods	10	maximal solution time	1:16:28	
		% solution time under 10 minutes	40%	

Table 11: Results of the computational complexity test for ten randomly generated optimization problems with 1500 node network with 175 OD paths, a node connection probability of 10% and ten considered periods.

an experiment plane, which is defined by the minimal maximal values of the x/y coordinates.

In this case, the plane has an expansion of 880 km on the y-axis and 660 km on the x-axis. These values correspond to the maximal extent of Germany in the north-south, respectively the east-west direction. In a second step, the edges of the graph are created, whereas each potential connection between two nodes, except for self-connections, has a certain likelihood of existence. Hence, the expected amount of edges amounts to *node connection probability* * *number of nodes* * (*number of nodes* - 1). The maximal vehicle range is 400 km, the initial fuel range 200 km. Origin and destination of the OD trips are randomly chosen from the set of nodes on the graph.

As the computation varies along with the network topology and the length of the OD trips, each parametric constellation has been tested ten times of random problems.

The results of the experiment indicate that an optimization problem over ten periods and on a 1,500 node network with an edge probability of 10% and 150 OD paths seems to be the largest problem, that can regularly be solved in under ten minutes. Although the average solving time amounts to 10:01 minutes, a total of 70% of the tested problems could be solved within the designated time. The standard deviation for solving the problems is 5:07 (see table 10).

When increasing the number of OD paths c.p., problems with 175 OD trips already have a considerably higher solving time and standard deviation. Solving the randomly generated problems took an average time of 25:32 minutes with a standard deviation of 21:45 minutes. Only 40% of the problems with 175 OD trips could be solved in under ten minutes (see table 11. It is noteworthy that the maximal solving time for a problem with 175 OD trips is at 1:16:28 nearly one hour higher than for problems with 150 OD trips.

The results of the experiment indicate, that optimization problems over ten periods and on a 1,500 node network with an edge probability of 10% and 150 OD paths seems to be the largest problem, that can regularly be solved in under ten minutes with a computer with a 2.4 GHz processor and 8 GB RAM. Furthermore, it was shown that the more complex the problems are, the greater become average solving time and its standard deviation. Although the results of this complexity assessment are not statistically significant, they, nonetheless, provide general reference points for real-life application and further research.

5. Conclusion and Recommendations for Further Research

For alternative-fuel vehicles, like BEVs and FCEVs, to succeed, a comprehensive alternative fuel station network is vital. However the development of such a refuelling network constitutes a "chicken-egg problem": On the one hand, companies are unlikely to invest until AFS operations promise to be profitable, whereas on the other hand consumers hesitate to buy AFVs unless there is an agreeable level of refuelling infrastructure. One possible solution for this problem is strategic multi-period planning, which is incentivized, respectively led by a central authority.

This thesis introduces a new flow-refuelling location model, that aims at providing a multi-period construction plan for an alternative fuel station network. Based on the idea of covering each arc of a path, the MP-NC FRLM maximizes the number of paths covered. Depending on the problem at hand, it is as well possible to either maximize the total flow covered or introduce a lower bound of flow coverage while maximizing the refuelled paths.

Besides including nodal capacity restrictions for fuel stations, the model respects changing demand flows and limitations of the construction capacity and is an extension of Kluschke et al. (2020)'s node-capacitated FRLM. Apart from the model extension, the pre-generation process for the set of potential station locations $K_{j,k}^q$ and the heuristic estimating the refuelling amount r_i^q at the nodes has been improved.

To illustrate the benefits of the multi-period model over a static counterpart and a comparable F-Myopic model, the two measures "Value of the multi-period Solution" and "Value of multi-period Planning" were adapted to this context and applied in a numerical experiment. The VMPS and the VMPP quantify the relative additional value of the MP-NC FRLM's solution to the ones of the static counterpart respectively the F-Myopic model. The VMPS and VMPP have proven to be positive, and several hypotheses were made about parametric constellations and patterns, that drive VMPS and VMPP.

The additional benefit of the MP-NC FRLM, however, comes at the cost of higher computational complexity due to the incorporation of the time module. Another potential problem, which has to be borne in mind, is the calculation of the number of ensured refuelling locations alongside a route l_q . In some cases, l_q locations can be insufficient to cover an OD trip due to unfavourable topological characteristics. The existence of unfavourable paths does not cause any calculation errors but are not respected by the model during the optimization.

Following the findings of this thesis, there are several possible streams for further research:

• Providing further analysis of VMPS/VMPP drivers

Providing a better understanding of the VMPS/VMPP and its value drivers might help to detect early, where the application of the MP-NC FRLM compared to static models provides sufficient benefit.

• Reducing the MP-NC FRLM model complexity

Reducing the model complexity, e.g. by linearising the bi-linear constraint, leads to a decreasing calculation time, which can prove valuable in the application.

• Finding a precise calculation method for l_a

Especially in greater problems, it can be challenging to identify whether a path was not covered, because it was suboptimal to refuel or because the covering solution was trivial. Finding a precise calculation method for l_q , where the number of built stations equals the minimum number of necessary stations will eventually provide better, cost-effective results.

• Applying the MP-NC FRLM to a real-world case setting

An application of the model on a real-world case might provide further insights into the additional model benefit. It would also be useful to compare these outcomes to other FRLM models in various settings.

· Integrating deviation paths into the MP-NC FRLM

To make the model more realistic, one option could be, extend the MP-NC FRLM in a way, that considers the drivers' willingness to deviate from an optimal path to refuel. Considering deviation paths might prove useful especially for simulating the early stages of the AFS network construction, where the network is significantly less mature than that of conventional gas stations.

· Including the stochasticity of demand

For the comparison of the MP-NC FRLM with the F-Myopic model, it is assumed, that future demand can be precisely predicted, which is a substantial simplification of reality. The model's accuracy and significance could profit from considering the uncertainty of demand flows.

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Junior Management Science

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Pathways from Role Identification Level to Attention Residue in Multiple Team Membership

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Abstract

More than two third of knowledge workers are assigned to multiple teams simultaneously. Participating in several teams can also mean enacting several roles. Psychosocial experiences like role switching have been neglected in research so far but are crucial for the success of multiple team membership (MTM) in organizations. Therefore, this paper considers the pathways from role identification level in one role to attention residue in another role. This relationship is explained with the role transition and self-regulation theory and two mechanisms: Personal engagement and interrole conflict. It is assumed, that the role identification level leads to personal engagement, moderated by role identification dispersion and to interrole conflict, moderated by interruptions. Personal engagement in the preferred role leads to attention residue in the other role, as well as interrole conflict leads to attention residue. This conceptual model shows that unbalanced person-role matches can result in a negative, cognitive outcome of MTM.

Keywords: Multiple team membership; attention residue; role identification; role transition; self-regulation.

1. Introduction

"Paying attention and awareness are universal capacities of human beings." (Jon Kabat-Zinn). Nowadays, 65% - 95% of knowledge workers are assigned to two or more teams simultaneously for a certain time period and divide their attention to several contexts (O'Leary, Mortensen, & Woolley, 2011, p. 461). In literature, this is referred to as Multiple Team Membership (MTM) or multi-teaming (K. M. Chudoba, Wynn, Lu, & Watson-Manheim, 2005, p. 20; O'Leary et al., 2011, p. 461). Organizations implemented MTM in the last three decades to leverage their employees' expert knowledge more effectively and to respond with higher flexibility to a constantly changing environment (Espinosa, Cummings, Wilson, & Pearce, 2003, p. 157; O'Leary, Woolley, & Mortensen, 2012, pp. 144–145). That is one reason why MTM is particularly common in knowledge intensive industries, where information access is unlimited, whereas cognitive resources are limited (Kahneman, 1973, pp. 7-11). Besides beneficial factors on the organizational level, there are also challenges MTM creates for organizations, teams or employees. Many scholars have recognized structural and systematic challenges like managing the effectiveness

of MTM, some others have focused on psychosocial challenges like dealing with project overload (Margolis, 2020, p. 2; Patanakul & Milosevic, 2008, p. 118; Zika-Viktorsson, Sundström, & Engwall, 2006, p. 392). However, hardly anyone has focused on challenges like how to handle multiple identities and its effect on time or attention allocation (Mathieu, Maynard, Rapp, & Gilson, 2008, p. 442; O'Leary et al., 2011, p. 471; Ramarajan, 2014, p. 591). Although multiple identities often come with working in multiple teams. Especially a role perspective is rarely taken even though it is highly related to multiple identities (Chen, Jiao, Yang, & Wang, 2020, p. 2). Roles are known "as a position in a social structure" (Ashforth, 2001, p. 4). Those social structures can be society, but also sub-systems like organizations. The importance of roles in an organizational context grows, so does the interaction between work roles and organizations as well (Ashforth, 2001, p. 1). One crucial factor is the institutionalization of roles in organizations, the "colonization of the private" (Ashforth, 2001, p. 2). This means that many activities are nested in organizational settings and mediated through roles, which were handled private or communal in earlier times. Individuals who want to train their fitness enrol in online courses and are fitness members nowadays,

and employees are rather known by their role description like developer or manager than by their name. Therefore, individuals must interact with different kind of roles and adapt these roles on a daily basis (Ashforth, 2001, pp. 1-2)). Institutionalization results in interchangeable positions (Ashforth, 2001, pp. 1-2). The role of a data analyst in an organization for example is crucial and will be needed for the following years but the person, filling out this position can be substituted which strengthens the organizations stability. However, employees may be hindered to completely identify with this specific role, that they only hold for limited time (Ashforth, 2001, p. 3). Globalization and the trend towards a fast-changing environment leads to a new understanding of jobs – from the traditional perception of stable and long-lasting jobs towards unstable and changing jobs. Additionally the arrangement of those jobs in multiple teams keep changing (Ashforth, 2001, pp. 1-3). Because of this development, there is a call for a better understanding of multiple role identities in combination with MTM (Chen et al., 2020, pp. 13-14; Pluut, Flestea, & Curşeu, 2014, p. 343). Chen et al found in their study that multiple identities in multiple innovation teams can lead to identity conflict or identity synergies (Chen et al., 2020, p. 2). Identity conflict can arise through impeding roles which can hinder innovation, whereas identity synergies can come from overlapping and mutual inspiring experiences and enhance innovation (Chen et al., 2020, p. 5). Rapp and Mathieu mentioned in their paper research concerns about the pathways from high team identification with one team, to which attention and effort are aimed, to potential negative impacts on the other teams (Rapp & Mathieu, 2019, pp. 314-315). A similar issue on task level was studied by Leroy (2009, p. 169), named as attention residue and defined as the difficulty of switching the attentional focus on the current task, because the prior task is still in mind. For an individual, having a MTM means fulfilling several roles and being confronted with the roles' perceived requirements (Ashforth, Kreiner, & Fugate, 2000, p. 475). The requirements, goals, values and beliefs of a role are called role identity (Ashforth, 2001, p. 6). During a workday, employees need to switch between their roles, dependent on the current team, they work in (O'Leary et al., 2011, p. 463). The process, to physically and psychologically disengage from the current role and engage in the next role is called role transition (Ashforth et al., 2000, p. 472). To transition between roles entails overcoming difficulties such as switching the attentional focus from one role to another (Ashforth et al., 2000, p. 475). The difficulty of the transition process depends on the extent of the employees' role identification (Ashforth, 2001, p. 13). This raises the question, how role identification level in MTM relates to attention residue. To reduce complexity this question is examined as a theoretical concept looking at individuals participating in two teams and occupying two different roles. It will be assumed that employees split their time autonomously and evenly between two teams. The theoretical contribution of this paper is the convergence of the role transition theory on individual level and the self- and attention regulation theory

which is so far just implemented on task level. To my knowledge, this is the first thesis about the role identification in MTM situations and the connection to negative outcomes on attentional level. Several sub-theories and interviews will underline the relationship between role identification level and attention residue. They will lead to the theory that a high role identification level in one role can lead to attention residue in another role with respect to the personal engagement theory (Kahn, 1990), the role and role boundary theory (Ashforth, 2001) and the self-regulation theory (Muraven & Baumeister, 2000) as well as the attention residue theory (Leroy, 2009). In the beginning of this thesis, there will be a short overview over the MTM framework, the trend towards this way of collaboration and the benefits and challenges that can arise. In the third chapter, the relationship of role identification level to attention residue, moderated by engagement and interrole conflict will be explained while integrating the mediators role dispersion and interruptions. The conceptual thesis will end with a discussion, practical implications and limitations of the developed model.

2. Multiple Team Membership

Even though the majority of research still treat teams as stable and clear workgroups, without considering the appearance of MTM, employees often participate in two or more teams for a certain time period (K. Chudoba & Watson-Manheim, 2007, p. 67; Mathieu et al., 2008, p. 442; Zika-Viktorsson et al., 2006, pp. 391-393). Therefore, MTM has been mentioned as one of the most important topics to be researched (Mathieu et al., 2008, p. 442). Latest paper showed, that organizations feel the need to increase productivity and enhance individual and team learning through assigning them to multiple teams (O'Leary et al., 2011, pp. 461-462). Besides these positive outcomes, MTM brings additional benefits with it, as well as challenges (O'Leary et al., 2012, p. 158). To understand the new possibilities and potential downsides of MTM, it is crucial to have a look on the streams that lead to that new state of work arrangement and in which forms MTM can emerge.

2.1. Trend toward MTM

In recent years, the understanding of what should be regarded as team, changed (Wageman, Gardner, & Mortensen, 2012, p. 301). Traditionally a team was defined as a "bounded and stable set of individuals for a given time period, interdependent for a common purpose" ("Handbook of organizational behavior", 1987, pp. 366-367). In the last two decades, following simultaneously developed trends led to a new understanding of teams and the emergence of MTM (Wageman et al., 2012, pp. 1-2). Firstly, the environment in which organizations operate became more complex. The complexity comes from multinational organizations that have to operate within a fast changing environment and answer to its' diverse needs (Cummings & Haas, 2012, p. 316). Due to trends like the digitalization, globalization and

the dominance of communication technologies new forms of collaboration were possible that gave organizations the possibility to react flexible to the environment (Wageman et al., 2012, p. 303). Organizations can increase their flexibility through geographically dispersed employees with expert knowledge, who are assigned to several projects and participate in those when required (Cummings & Haas, 2012, p. 316; Hackman, 2012, p. 429). This results in collaborations of geographically dispersed members of different organizations who find encompassing solutions for complex problems (Hackman, 2012, p. 429). The employees' workloads are adjusted to current organizational needs which means that crucial projects can be developed faster through increasing the members workload in these projects while slowing down less crucial projects to reduce the members workloads in those projects (O'Leary et al., 2011, p. 467). As a second trend, the rise in the knowledge work economy lead to upturn in MTM (Higgs, Letts, & Crisp, 2019, pp. 154-155). Therefore, MTMs are most commonly used in highly competitive and knowledge intensive areas such as consulting, IT, new product development (O'Leary et al., 2011, p. 462; Wheelwright & Clark, 1992, p. 2) or academia (González & Mark, 2004, p. 113). In 1999, knowledge workers were expected to be the most important institution in the 21st century (Drucker, 1999, p. 79). Now, they are considered the most valuable competitive advantage of an organization (Dul, Ceylan, & Jaspers, 2011, pp. 715-716). Knowledge workers primary contribution is to create new knowledge and apply it to generate a new outcome (Mládková, Zouharová, & Nový, 2015, p. 768; Shujahat et al., 2019, p. 443). Knowledge workers are characterized by their specialized expertise in one field. They can deepen their expertise through using it in multiple, slightly different situations (O'Leary et al., 2012, pp. 144-145). Therefore, assigning them to multiple teams, means leveraging their knowledge best and supporting it by applying it to a broader spectrum of similar problems. Because of their scarce expertise and their increasing demand, organizations need to assign them in several teams to deploy their knowledge in an effective way (O'Leary et al., 2012, pp. 144-145). Therefore, the development of the knowledge work economy led to the growing usage of MTM. As the knowledge economy is a high competitive one and resources are scarce, there is a big competition for employees (O'Leary et al., 2011, p. 462). So, a third important trend towards MTM is the need to motivate and retain ones' employees (Dychtwald, Erickson, & Morison, 2006). One way to design the work of employees more attracting is to use MTM to create a compelling workplace (O'Leary et al., 2012, pp. 145-146). Hence, MTM is not only increasingly requested by organizations to leverage their resources more effectively, but also needed to retain their employees through an appropriate work environment. Besides the trends that see MTM as opportunity to adjust to environmental needs, MTM partly occurred incidentally. Due to new organizational structures such as flat hierarchies, dispersed work and matrixed organization, managers lack an overview over the projects and commitments their employees have (O'Leary et al., 2012,

p. 146). There may be situations in which employees are subordinated to two or three managers who independently assign them to projects and teams. Therefore, some employees are assigned to multiple teams unintentionally. Due to the development towards fluid, overlapping and geographically dispersed team members, the traditional definition of teams with clear and stable boundaries is not suitable anymore (Mortensen & Haas, 2018, p. 1). A more suitable definition of teams nowadays was mention by Pluut et al. (2014) describing teams as "flexible working units that help organizations to gain and maintain a competitive advantage" (p. 333). Although the new understanding and allocation of teams increases flexibility, innovative-thinking and more efficient work-styles in organizations, the resulting blurring of team boundaries create a challenge for individuals, teams and the organization itself (Mortensen & Haas, 2018, p. 1). Once MTM is implemented, it is hard for organizations to go back to traditional work situations (O'Leary et al., 2012, pp. 159-160). Once organizations notice the benefits through allocating their experts to certain projects with a requested skill set, organizations will not be willing to give this opportunity up (O'Leary et al., 2012, p. 161). There are different kinds of MTM allocations, that can occur in organizational contexts. Before the challenges and benefits of MTM are highlighted, the variety of MTM is going to be outlined.

2.2. Role Allocations within MTM

Due to the broad definition of MTM, different contexts can be interpreted as MTM. A very broad understanding of MTM is the concept of side-hustles, also called multiple jobholding (Caza, Moss, & Vough, 2018, pp. 703-704; Sessions, Nahrgang, Vaulont, Williams, & Bartels, 2020, p. 42). This concept emerged with the rise of communication and information technology and due to a trend towards the gig economy (Ashford, Caza, & Reid, 2018, p. 23; Wood, Graham, Lehdonvirta, & Hjorth, 2019, pp. 64-71). The gig economy offers the opportunity to supply labour via platforms and exercise it remotely or locally (Wood et al., 2019, p. 57). Employees can easily supplement their full-time job with one or more side-hustle jobs like being an Uber-driver or being a freelancer in blogpost writing (Ashford et al., 2018, pp. 24-25). In the US for example, around 44 million workers have additional jobs besides their core work (Clark, 2018). These side-hustles are chosen autonomously by the individuals in regard to the working time, the workplace, what kind of work and the amount of work (Sessions et al., 2020, p. 7). Sessions et al. (2020, p. 36) found, that the feeling of empowerment in a side-hustle has effects on the affective and cognitive behavioural states in full-time work through work engagement. The effects on the full-time job are positive if there is increasing motivation in the side-hustle and a spill over from side-hustle empowerment to the full-time job (Sessions et al., 2020, pp. 22-23). But also negative effects can occur if potential conflicts with the core-job exist, like time constraints (Sessions et al., 2020, p. 44). All in all, the positive influences of side-hustle outweigh the negative ones (Sessions et al., 2020, p. 36). Side-hustles cannot directly be

referred to MTM but help to understand the concept. A narrower form of MTM within one organization instead of two is operationalized with employees being assigned to one team in which they spend most of their time with, and work with colleagues who allocate their time among multiple teams infrequently (Margolis, 2020, p. 5). In this scenario, employees are assigned to one core team with which they work on one core project and have a few side tasks to exercise. A third type and the most common form of MTM is often used in consulting firms for instance (O'Leary et al., 2011, p. 462). Here employees are assigned to two or more teams and divide their time on each team equally (Margolis, 2020, p. 5).

Those kinds of MTM differ in their structure of time fragmentation, the focus on teams and number of teams. To get a better understanding of the consequences of MTM, the individual differences in these settings must be regarded as well. Individuals differ in their characteristics and in the subjects, they value the most (Ashforth, 2001, p. 30). One consequence that received less attention yet, is the transition process within MTM. If so, mainly transitioning between tasks is studied, but there is a range within team contexts in which transition processes play an important role (Newton, LePine, Kim, Wellman, & Bush, 2020, p. 3). "Those team contexts often include different tasks, roles, routines, technologies, locations, and so forth, which make switching between them both more effortful (in terms of time and attention) [...]" (O'Leary et al., 2011, p. 463). As the relevance of roles gains in importance, simultaneously with the emergence of MTM, a closer look into the mutual interaction may give helpful insights. Pluut et al. (2014, p. 333) underlined that the transition between teams means employees enact different roles. Looking at role identification and MTM in combination provides two possible scenarios: Employees take the same role in several teams or employees take several roles in several teams. The first scenario is more common today, because employees nowadays are rather trained with specific skills that belong to one role, instead of general skills that can be used for several roles (Drucker, 1999, pp. 84-87). But there are still working fields, in which one person takes different roles, such as in academic research (González & Mark, 2004, p. 113). In academia, a broad range of activities must be fulfilled. One part of academic work is the teaching assignment, either as professor or as an assistant. This requires the design and preparation of study material courses which is organized in different team constellations. Additionally, they participate in several research projects (González & Mark, 2004, p. 113). These various projects require them to hold several different roles, depending on their research focus and their personal traits of analysing data, leading interviews or preparing information, for instance (González & Mark, 2004, p. 113). All of the five interview candidates who work in academia stated, that they fulfil several roles as researcher and research and teaching assistants like being a supervisor for bachelor or master students, being a data analyst or a project lead during the same time period within different teams (Interviewee I1-I5, personal communication, October 19, October 21, 2020, Appendix 1). Besides in academia, also in start-ups or

in the function of being a manager multiple roles in multiple teams is common (González & Mark, 2004, pp. 113-114). So far, less is known about how employees handle multiple roles in organizational settings (Rapp & Mathieu, 2019, p. 442). This paper assumes the possibility, that holding different roles in multiple teams has an impact on the outcome of MTM. This impact is provoked by the person-role match within the role theory, which perceives, that it makes a difference in ones' cognitions whether employees can express themselves in the role or not. Before the relationship of role identification in MTM and the negative outcome of attention residue is studied, general positive and negative outcomes in MTMs are mentioned. These following external factors in the success of MTM in organizations should be known, because they are hold at an optimal level when focusing on the internal processes in the third chapter.

2.3. Benefits and Challenges of MTM

To gain insights in internal processes of individuals, the external conditions that facilitate or hinder a successful MTM should be regarded. The implementation of MTM nearly always comes with both, challenges and benefits (O'Leary et al., 2012, p. 158). In the US for example, around 70 million employees are faced with opportunities and risks of MTM and from a management perspective, it is a key to success to manage them accordingly (Chen et al., 2020 in Margolis, 2020). To control external conditions, the individual level, the team level and the organizational level should be considered separately.

For Individuals, being assigned to multiple teams subsequently means managing and completing tasks on their own while balancing time or schedule conflicts (Mortensen, Woolley, & O'Leary, 2007, pp. 218-219). MTM is often perceived as job demand for individuals, because it is effortful to allocate time and energy to different teams, communicate to a range of team members and coordinate team activities. Therefore, teamwork can be perceived as exhausting and team conflict can occur, especially if the communication is not supported by team leads or managers (Pluut et al., 2014, p. 343). The strain from coordination issues employees accept, may be compensated by having autonomy to work in projects they are interested in and strive for (Mortensen et al., 2007, p. 219). Moreover, job strain can be reduced over time, when employees learn to balance their workload and implement routines and opportunities for more efficiency between team contexts. However, this can lead to a "more task-focused and less relationship-focused" (p. 344) work which therefore reduces social support between team colleagues (Pluut et al., 2014, p. 344). Related to the attention and social network theory, productivity and learning as potential benefits of MTM arises (O'Leary et al., 2011, p. 461). Thereby, attention theories deal with competing demands that ask for ones limited attention, whereas social network theories cover the question how the wide access to information influences individuals' learning and productivity (O'Leary et al., 2011, p. 464). O'Leary et al. dealt with the problem of

infinite access to knowledge and information, but limited resources to process and handle this information, pending on the number of teams and the variety within them (O'Leary et al., 2011, pp. 471-474). The productivity of a single employee can increase with the number of teams he or she is assigned to, but only until a certain saturation point is reached (O'Leary et al., 2011, p. 466). More teams enhance individuals to focus on priorities and develop mechanisms to work more efficiently to master the workload. However, at some amount of team assignments fragmented attention, coordinating problems, and waiting lines outweigh the achieved efficiency which can lead to decreasing productivity (Chan, 2014, pp. 82-83; O'Leary et al., 2011, p. 466). Regarding the variety of the different teams, a higher variety leads to lower productivity because of the information and management overload and costs of switching contexts, work roles or styles (O'Leary et al., 2011, p. 468). However, moderate differences in the teams enhance employee learning because of new or more diverse information access (Mark, Gonzalez, & Harris, 2005, pp. 321-322; O'Leary et al., 2011, pp. 469-470). Related to innovation related theories, with increasing team memberships individuals cannot take time for finding creative solutions and applying new knowledge because of time pressure (Amabile & Mueller, 2008, pp. 33-35). Therefore, MTM may not enhance creativity processes. The impact of MTM on an employee's effectiveness depends on the level of MTM. If individuals are assigned to a minimal or maximal amount of teams at the same time, they will perform less than at a moderate level of MTM (Chan, 2014, pp. 82-83).

At the team level, it can be difficult to manage the team members time and attention on several projects or tasks for a given period (Mortensen et al., 2007, p. 219). However, working across teams can enhance team learning and lead to spill over effects but only at a moderate degree of simultaneously running teams and with less overlapping memberships (O'Leary et al., 2011, p. 270). In this case, the different backgrounds of team members spill over and facilitate the team with backgrounds and expertise that can be used to create new solutions (O'Leary et al., 2011, p. 469). Boundary spanning activities can increase the teams' cognitive ability by learning from each other and therefore increase their productivity (Ancona & Caldwell, 1992, p. 656; Pluut et al., 2014, p. 334). Based on social network theories, team productivity also increases with the number of teams, due to the effort taken as a whole team to manage their team work in a more efficient way (Chan, 2014, p. 84). Like on individual level, also on team level the focus shifts from relationships to tasks and routines that are implemented to design the work process more efficient (O'Leary et al., 2011, p. 467). By the same amount of simultaneously running teams but higher variety, team productivity decreases because of the higher coordination and management effort of time schedules or information processing (O'Leary et al., 2011, p. 469). Working across varying teams can enhance team learning. New knowledge acquired in one team can be adopted to a problem in another team to find solutions in a creative way under the condition of a moderate degree of overlapping memberships (O'Leary

et al., 2011, p. 470). The more teams work simultaneously, the less teams can integrate new knowledge due to time constraints and rare opportunities to share learning and opinions (Wilson, Goodman, & Cronin, 2007, pp. 1054-1056).

Looking at the organizational level, managing and coordinating multiple teams is complex, because a clear overview of the work schedules and team assignments of every employee is essential (Mortensen et al., 2007, pp. 219-220). Unpredictable time lags in one project can lead to huge consequences in other projects and to a new bundle of work to manage and reorganize time schedules (Mortensen et al., 2007, p. 220). Organizational mismanagement of teams can lead to less organizational productivity and a stressful work environment (Mortensen et al., 2007, p. 225). A stressful and therefore unattractive work environment will not attract high performing knowledge workers which are a key resource for organizations (O'Leary et al., 2011, p. 146). However, managing MTM right, organizations can benefit from MTM through increasing social networks across work units (Mortensen et al., 2007, p. 220). Overlapping, and sometimes even geographically dispersed memberships create networks through teams and locations and offer ways to leverage expertise the best (Mortensen & Haas, 2018, p. 1). Through unique networks, organizations can gain a competitive advantage as highly valuable resource (O'Leary et al., 2012, pp. 160-161). The intra-organizational connectivity is higher, the more projects or teams share the same members and the more connected the projects and teams are (O'Leary, Mortensen, & Woolley, 2009, p. 23). MTM in general leads to intra-organizational connectivity which therefore leads to lower redundancy and efficient use of information but also decreases information diversity through tightly coupled team structures (Lazer & Friedman, 2007, pp. 689-692; Roloff, Woolley, & Edmondson, 2011, pp. 250-251). Team members, who work in several teams, may notice if another team deals with a similar question or has already found a solution for the problem one team seeks (Hansen, 1999, pp. 103-105). Moreover, they can share knowledge and information they gathered (Newell, Swan, Bresnen, & Obembe, 2008, p. 50; Roloff et al., 2011, pp. 263-264; Wimmer, Backmann, & Hoegl, 2019, pp. 710-711). On the other side, increased interconnectivity leads to tightly coupled teams. Trough tight couples, project or team failure can spill over to other teams as well as interruptions can occur (Hansen, 1999, pp. 103-105; Lazer & Friedman, 2007, pp. 689-692). These negative developments are assumed to occur only in high levels of interconnectivity. In general, high interconnectivity increases organizations productivity, but at some point the tight coupled teams result in costs like failure spill over, interruptions and time schedule conflict (O'Leary et al., 2011, pp. 23-26). Besides leveraging their knowledge workers efficiently, they also can attract new ones (O'Leary et al., 2012, pp. 145-146). Motivated and resilient employees select themselves in high compelling work environments. Organizations with MTM structures, offer this demanding environment for high performers and attract new high performing knowledge workers.

Integrating MTM as collaboration option in organizations can lead to benefits in productivity, learning or motivation but can also give rise to a series of challenges in coordinating and managing these teams, allocating their attention and time and handling competing demands. Whether the advantages or disadvantages overweigh, is a question of managing and balancing the conditions of MTM (O'Leary et al., 2012, p. 158). Additional influencing factors can be the duration of the collaboration, the personal attitudes or characteristics of individuals like their work role, cognitive abilities and stress level or the members turnover (Dibble & Gibson, 2018, pp. 925-928). The fragmentation of time and task and the composition of team members also plays an important role (Cummings & Haas, 2012, p. 317). From transition perspective, it can be helpful, to assign employees to complementary teams to reduce schedule conflict and the amount of context switching (O'Leary et al., 2012, p. 162). Another way to reduce context switching is restructuring the tasks in larger bundles that can be accomplished as a whole (Interviewee I3, personal communication, October 19, 2020, appendix 1.1.). To minimize additional blocks in employees' time schedule, team meetings and strict working hours can be designed in a more flexible way. Thus, employees can focus on their work with less interruptions and meeting blocks in their workday (O'Leary et al., 2012, pp. 162-163). One negative outcome and new form of context switching could emerge through interruptions via short messages in skype, Microsoft teams or e-Mail from team colleagues to compensate the reduced team meetings (Jett & George, 2003, p. 494). Besides external conditions that influence organizations' success, the internal process of role-person match has been neglected in literature so far (Caza et al., 2018, p. 705). Holding the number of teams, their variety and context switching at an optimal level, the role allocation can still have a huge impact on an individuals' performance in multiple teams.

3. Conceptual Framework: Role Identification and Attention Residue

To understand roles and the role identification process, a closer look into the identity theory is useful (Ashforth, 2001, p. 23). The Identity Theory (IT) has its roots in the symbolic interactionism which claims that the self is a product of other's perceptions (Ashforth, 2001, p. 26). Further developed, the IT assumes that the self is socially constructed through the roles that are taken by every individual in the society. Every interaction takes place through the lens of a role, such as the role of an employee, a consumer, or a child. A role identity consists of values, goals, norms, interactions and beliefs that are defined and constructed by society (Ashforth, 2001, p. 27). A role identification means individuals define themselves with the role identity (Ashforth, 2001, p. 28). To identify with a role, they must know which role they have to fulfil and categorize themself in this role. Additionally, the individual has to be aware of the roles' requirements and values (Ashforth, 2001, p. 25). The stronger people are

affected by their role identity, the more they focus their attention on this role (Ashforth, 2001, p. 51). This goes so far, that individuals ascribe the roles' attributes to ones' self and strive for acting out this highly identified role (Ashforth et al., 2000, p. 483). Moreover, the individuals may decrease the boundaries, to integrate the preferred role into their other roles (Ashforth et al., 2000, p. 483). In that sense occupants will easily transition into the favoured role, often even psychologically with their thoughts before physically, like changing the work location, but find it difficult to exit the preferred role. Organizations should not underestimate the influence of role identification on their employees. Individuals decide for activities or tasks that are align with their identity (Ashforth, 2001, pp. 82-83). Employees with high role identification will show organizational commitment and citizenship, prosocial behaviour, higher job satisfaction as well as good performance. They may be better in decision making processes and will lead to lower turnover (Ashforth & Saks, 1996, pp. 155-162; Bullis & Tompkins, 1989, pp. 298-307; Cheney, 1983, pp. 350-357; Dukerich, Golden, & Jacobson, 1996, pp. 37-39; Mael & Ashforth, 1995, pp. 312-315; Pratt, 1998, pp. 196-198). Identifying with the role means doing good at and for the role, and this subsequently means doing well for the own self (Ashforth, 2001, p. 83). Combining the identity theory with the transition theory potential downsides become clear. Role transition processes can be divided into macro and micro role transitions (Ashforth, 2001, p. 7). Marco role transitions mean switching between "sequentially held roles" (Ashforth, 2001, p. 7) like transitioning into a promoted role, whereas micro role transitions means switching between "simultaneously held roles" (Ashforth, 2001, p. 7) like transitioning from the colleague role into the friend role. The special characteristics about micro role transitions are the duration of holding a role. Micro role transition processes occur frequently, therefore often temporary and recurrently (Ashforth, 2001, p. 261). The difficulty of frequent, temporal transitions is shifting the attention. Every transition consists of psychologically unfreezing the current role state, moving towards the following role with full attention and freezing the new state of role. Individuals try to minimize the difficulty of transitioning as well as the frequency of unwanted transitioning (Ashforth, 2001, p. 262). Role transition processes are determined by their difficulty and valence (Ashforth, 2001, p. 88). The difficulty describes the effort needed to exit one role and to enter the other role, whereas valence describes the attraction of the upcoming transition for the occupant. These two factors work together: If one perceives the valence as negative, the difficulty of transitioning will be higher and vice versa An employee who has a high role identification will perceive the transition process into another role as more difficult and negatively attracted (valence), because exiting a preferred role is exhausting and less attractive than exiting a less preferred role (Ashforth, 2001, pp. 88-89). As the identity theory states, the employee will focus effort and attention to the preferred, highly identified role, which can lead to less effort and attention within other roles in MTM. This phenomenon is called attention residue

(Leroy, 2009, p. 169). It builds on the assumption, that individuals have limited attentional capacity and that it is possible to pay attention to one issue, but difficult to split attention to multiple objects (Kahneman, 1973, pp. 4-7). Due to cognitive limitations, employees must completely transition their attention from one object, like a work role, to the other object (Leroy, 2009, p. 169). Because of the positive relationship between role identification and transitional effort, it is relevant to research the link between role identification and attention residue under the transition theory. In the following, this relation is studied under a conceptual model, assuming an employee having MTM, fulfilling a different role in each team and fragmenting his or her work time equally and autonomously on both teams. The conceptual model is shown in Figure 1.

3.1. Role Identification Level and its Aftermaths

When speaking about role identification, the degree of identification should be made measurable with the term of role identification level. Throughout this paper, the extent of identification with one role and its requirements is called role identification level (Ashforth, 2001, p. 28). Ashforth (2001, p. 74) describes the identification as "a continuous variable ranging from zero to very high". In multiple teams the assigned roles are relatively stable. The extent of the role identification level does not vary from day to day but is a balanced state around an identification point (Ashforth, 2001, p. 7). Therefore, it can be assumed that the level is a state, balancing out around low, medium and high role identification (Ashforth, 2001, p. 74). A high role identification level means that the individuals can identify themselves with the position and the requirements, goals, values and beliefs and strive for fulfilling the role and integrating it into the other roles (Ashforth, 2001, pp. 27-28; 73). A low identification level stands for a mismatch between person and role (Ashforth, 2001, pp. 75-76). Whether one identifies with a role or not can influence the work behaviour (Ashforth, 2001, pp. 82-84). Within high role identification, the employee may show high personal engagement in this role and will tend to react to interactions from the preferred role while fulfilling another role. These two possible mechanisms are going to be explained in the following which will both lead to attention residue.

3.1.1. Role identification and engagement

Academic research teams often face the situation in which several research topics are executed during the same time period (González & Mark, 2004, p. 113). As the interviewed researchers outlined, they usually work on three to five projects simultaneously (Interviewee I1-I5, personal communication, October 19, October 21, 2020, Appendix 1). Due to different specializations and preferences of researchers, everyone might fulfil several and varying roles. Besides, also age and experience from the other team members shape the role one fulfils, like being the less experienced often means doing data work, while being the most experienced means guiding the team (Interviewee I3, personal communication, October 21, 2020, Appendix 1.3). In the following theoretical considerations, hierarchical differences will be not included, to reduce complexity. There could be a work situation, in which one employee has the role of a data coordinator in research team 1 and the role as regulatory coordinator in team 2. Both positions are on the same hierarchy level and differ in their tasks and requirements. It is assumed, that the employee has the same scope of work in both teams and can decide when to work on which task in which team. As stated in the interviews, all interviewees can organize 60-95% of their work time completely autonomously (Interviewee I1-I5, personal communication, October 19, October 21, 2020, appendix 1). We assume that individual A has a high role identification level with being the data coordinator. To understand the relation between the high identified role in team 1 and a potential attention residue in team 2, the theory about personal engagement and disengagement (Kahn, 1990) should be considered. Kahn (1990, p. 700) studied the issue that individuals vary in their investment of themselves in roles or tasks. Employees who personally engage in a role, express and employ their favoured self into the activity and attaches "personal presence" (p. 700) cognitively but also physically and emotionally in role performance. Individuals decide for every role and activity how much personal resources they want to engage and therefore how much of themselves they want to express and employ. If they decide to fully personally engage, they nearly merge themselves with the role and focus their cognitive attention on the related activities (Ashforth, 2001, p. 72; Kahn, 1990, pp. 700-701). Therefore, if the employee perceives a high role identification level with the role data coordinator, he or she will personally engage in this role. The high role identification level leads to personal engagement in this role, regardless of the identification level with roles in other teams. If employees do not perceive a high role identification level, they are somewhere between personal engagement and disengagement. Depending on their perception of emotional person-role fit, they engage more or less of their personal self into the work role (Kahn, 1990, pp. 699-700). Kahn's model is further developed and new antecedents of engagement were discussed (Rich, Lepine, & Crawford, 2010, p. 617). One of those antecedents is called value congruence and describes the situation in which the assigned work role and its requirements and expectations are congruent to the persons self (Rich et al., 2010, p. 621). Hence, employees engage in work roles, in which they can express their identity and therefore, experience a high role identification. Engaged employees tend to perceive a higher job satisfaction and seem to be more effective in their work. On organizational level, the individual effectiveness can be transferred to overall effectiveness and profitability (Harter, Schmidt, Killham, & Agrawal, 2009, pp. 25-28).

3.1.2. The moderating role of role identification dispersion

If an individual highly identifies with one role, he or she will experience personal engagement in this role (Rich et al., 2010, p. 621). This effect can be strengthened, if the individ-



Figure 1: From role identification level to attention residue.

ual experiences a role identification dispersion between the assigned teams. A low identification dispersion means, the employee identifies with the role of a data coordinator and with the role of a regulatory coordinator both low, medium or high. In this first case there would be no preference for any of those two roles, as shown in Table 1. Therefore, the relation from role identification level in role 1 to engagement in this role would not be strengthened. A high identification dispersion would mean, the employee has a high role identification level with being data coordinator in team 1, but a low role identification level with being regulatory coordinator in team 2 or vice versa. In this second case, a high identification level with one role leads to personal engagement. Inversely, a low identification level can lead to personal disengagement under certain conditions, but not necessarily has to (Kahn, 1990, pp. 701-702). Personal disengagement occurs, when an individual is cognitively, emotionally and physically absent while taking the role. The individuals feel the need to distance themselves from the role and turn down any effort and energies from this role (Kahn, 1990, p. 702). Imagining the situation, in which the individual perceives a high identification level with being the data coordinator, and a low identification level with being a regulatory coordinator. In the first role, he or she would be personally engaged, and would focus attention and effort into this role performance. In the second role, he or she would potentially be personally disengaged, and would remove attention and effort from this role. It can be assumed, that the negative valence of the second role would strengthen the perceived positive valence of the first role. The positive valence of the first role strengthens itself and the individual even more identifies with it (Ashforth, 2001, p. 54) Thereby it might be, that the individual engages even more in the preferred role. Thus, through high role identification dispersion the positive relationship between role identification level and personal engagement would be strengthened for this identified role. Consequently, role identification dispersion functions as moderator.

3.1.3. Role identification and interrole conflicts

Role Identification not only leads to personal engagement but can also lead to interrole conflict. Interrole conflict arises, when one experiences competing demands within their different roles (Kopelman, Greenhaus, & Connolly, 1983, p. 201; Pluut et al., 2014, p. 335). Whether an employee perceives interrole conflict or not depends on the roles' boundaries (Ashforth et al., 2000, pp. 474-475; 480-481). Role boundaries are defined in terms of their flexibility and permeability (Ashforth et al., 2000, p. 474). The role boundary characteristics facilitate or hamper the transition process (Ashforth, 2001, p. 263). Permeability means the roles' possibility to be psychologically in one role, while being physically in another role. Flexibility means that roles can easily be entered in terms of time and place (Ashforth, 2001, p. 263). The different roles an individual enacts are embedded within the same organization. Therefore, the location and time the roles are enacted is probably overlapping, thus flexible. Additionally, there are no predefined time slots when to engage in which role and no monitoring of the employees' thoughts therefore they could physically be in role 1 but actually think about role 2 activities, thus the roles are permeable. According to personal experiences from researchers and research assistants, it often occurs that the thoughts wander to another role which is not enacted currently (Interviewee I1-I5, personal communication, October 19, October 21, 2020, appendix 1). Flexible and permeable boundaries can facilitate the transition process and therefore weaken interrole conflict potential, because the employee can easily transition from one role to another without switching location or agreeing with someone about the time schedule. However, flexible and permeable boundaries can increase interrole conflict because the loose boundaries can confuse the employee when to engage in which role (Ashforth, 2001, p. 263; Ashforth et al., 2000, pp. 474-475). Besides role boundaries, team boundaries also must be considered. Especially through MTM, teams developed towards permeable boundaries in regard of knowledge- and information flows (Wimmer et al., 2019, p. 711). However, permeable team boundaries also lead to higher conflict potential because everyone is every time for all teams he or she is assigned to, available (Wimmer et al., 2019, p. 711). One reason for the trend towards permeable team boundaries is the modern work environment that facilitates open offices and information technology for fast and easy communication via E-Mail, Skype or Microsoft Teams (Jett & George, 2003, p. 494). Therefore, role bound-

	Scenario 1	Scenario 2	Scenario 3
Identification Level Role 1	Low	High	Medium
Identification Level Role 2	Low	Low	Low
Role Identification Dispersion	Low	High	Moderate

 Table 1: The Role Identification Dispersion Degrees Resulting from different Role Identification Levels.

aries as well as team boundaries are permeable and offer the possibility of conflicting demands. All candidates interviewed, have already experienced conflicting demands from several teams (Interviewee I1-I5, personal communication, October 19, October 21, 2020, appendix 1). Due to their high percentage of autonomously choosing worktime, they regularly face the decision-process which role to enact. The role, with which one can identify more is therefore highly salient and pulls the employee to be fulfilled. The salience and identification are manifested through the personal investment, someone already gave (Interviewee I3, personal communication, October 21, 2020, appendix 1.3). Hence, role identification gives the employee a direction how to decide in case of interrole conflict but does not facilitate it. Not only the identification with a role, but especially the priority of the research project regarding deadline and importance helps researchers to decide for one project (Interviewee I1-I5, personal communication, October 19, October 21, 2020, appendix 1). In the following it will be discussed whether an interruption from the preferred role while being in the less identified role, will lead to interrole conflict.

3.1.4. The moderating role of interruptions

In the case of permeable team and role boundaries crossrole interruptions are very common, because the individual fulfils the different roles in the multiple teams in the same organization with same internal information and communication technologies (Ashforth et al., 2000, pp. 478-480). All interview candidates are interrupted on a regularly basis (Interviewee I1-I5, personal communication, October 19, October 21, 2020, appendix 1). It is therefore likely, that a colleague from team 1 poses a question via Skype while an individual enacts a role in team 2. Sticking to the prior implemented example, role 1 has a higher identification level than role 2. Every few hours the individual decides which role activities to execute. Because of the higher role identification level of role 1, there is a motivational pull towards this role that may lead the individual rather fulfilling this role's activities (Leroy, 2009, p. 169). Nevertheless, the individual has the same amount of work in both roles and must allocate work and time equally. Within the decision-making process of which role to enact, there is not necessarily interrole conflict triggered by the identification level of the data coordinator role. Consider, the individual works in team 2, therefore enacts the role of the regulatory coordinator. As soon as this role enactment is disturbed through a cross-role interruption from a colleague in team 1, where the individual has the preferred role of data coordinator, an interrole conflict

may emerge. The individual should proceed with regulatory coordinator activities, but at the same time wants to help the colleague from their preferred role. The individual has to decide between two competing demands. This underpins that when being interrupted from the preferred role while being in the less preferred role, interrole conflict can emerge. The possible consequences of this decision-making process within the interrole conflict are outlined in the following.

3.2. Attention Residue as cognitive Outcome

New forms of collaborations like MTM result in transitioning between several roles during a workday (O'Leary et al., 2011, p. 463). Transitioning from one role to another can probably affect the cognitions in the following role (Leroy, 2009, pp. 168–169). In the following two mechanism that influence attention residue are highlighted.

The self-regulation theory supports the assumption that managing cognitive behaviour and disengagement is effortful (Muraven & Baumeister, 2000, pp. 247-248). Selfregulation means overcoming an usual impulse and behaving the way a person should regarding rules, standards or ideals (Baumeister & Heatherton, 1996, p. 2; Baumeister, Schmeichel, & Vohs, 2007, p. 2). Leroy (2009, p. 170-178) transferred the self-regulation theory to an attention regulation theory, highlighting the shift of attention from one task to another. In the role context, this means for example that employees with high attention regulation can more easily shift attention, thoughts and behaviour towards another role, they are asked to (Leroy & Glomb, 2018, pp. 381–382). Self- or attention regulation as well as cognitions are limited (Baumeister & Heatherton, 1996, p. 3). Besides the effort and difficulty of regulating ones' behaviour and thoughts, irrelevant thoughts decrease performance (Leroy, 2009, pp. 169-170; 174). Irrelevant thoughts mean having less cognitive resources available for handling the amount of information and demands appropriately (Gilbert, Pelham, & Krull, 1988, p. 738). Therefore, to be fully present in every role, the employee must put off unrelated thoughts. Combining the difficulty of attention-regulation with the transition theory it becomes clear, that employees must fully transition their attention to the respective role to perform well. If the employee cannot fully transition the attention to the subsequent role, it is called attention residue (Leroy, 2009, pp. 168–170). The prior activity is still active in working memory and hinders the whole cognitive capacity to focus on the current activity. One reason for not being able to transition attention can be a strong motivational pull towards the current role (Leroy, 2009, p. 169). The motivational pull can

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come from the high identification with a role for example and the resulting personal engagement.

3.2.1. Engagement and attention residue

Being identified and engaged with a role, means the role may be a motivational pull factor for the employee. Bridging the gap to attention residue, a closer look on similar studies is useful. Newton et al. (2020, p. 4) transferred personal engagement on task level and researched spill-over from task engagement in one task, to task engagement in subsequent tasks. He studied a positive effect of task engagement on the engaging behaviour and performance in another task, but also found a negative effect of attention residue on the following task. Newton et al. (2020, p. 13) mentioned the possibility of transferring his results from task engagement to micro role transitions, because a role is a bundle of multiple tasks (Ashforth et al., 2000, p. 486). As the personal engagement and disengagement theory originally focuses on work role performance, the negative spill-over from engagement in one role to attention residue in another role can be argued with the transition theory. Kahn (1990, p. 700) already mentioned that high personal engagement comes with effort and attention and an intense attachment of the self with the role. An intense attachment of the self with the role increases the difficulty of the transition process, because the individual intrinsically strives for fulfilling this role (Ashforth et al., 2000, p. 483). Increased difficulty leads to increased negative valence of the transition process (Ashforth, 2001, p. 88). Within the role identification dispersion, the valence of the role 2 is negative, because the individual has a higher identification with role 1 and a lower identification level with role 2. Therefore, exiting the preferred role and entering the less preferred role is not attractive. Hence the higher difficulty, the more the transition process is impeded through negative valence. However, even if the employee transitions into role 2 the attention may not fully switch and the role 1 is still in his or her mind. This is due to the motivational factor of role identification. Motivation directs the individuals attention towards an activity that has the highest value for them (Locke, 2000, p. 411). As the personal value of an activity is subjectively perceived as something good, the attentional focus leads back to the role, with the highest identification (Locke, 2000, p. 411). To sum up, the role identification level of an individual leads to personal engagement. This effect is strengthened through identification dispersion as moderator. As one has a high identification dispersion and therefore can highly identify oneself with the role of being a data coordinator in team 1 and not identify oneself with the role of being a regulatory coordinator in team 2, he or she will even more personally engage in team 1. Because of the difficulty and negative valence of the transition process from role 1 to role 2 the cognition and attention may not fully switch to role 2. Due to limitations in cognitive resources, the individual will experience attention residue in role 2. A similar mechanism was found with side-hustle engagements. The individuals' engagement in side-hustles led to focusing the whole attention on this job while fulfilling

it, but still leaving attention and thoughts in this job while performing the full-time work (Sessions et al., 2020, p. 16). The side-hustle empowerment can at least to some parts be transferred to a high identification level and therefore support the assumption that personal role engagement through a high role identification level can lead to attention residue in the second team.

3.2.2. Interrole conflict and attention residue

Not only the actual role and attention transition process can be effortful, but also the decision process whether to transition or not. Getting interrupted by a highly identified role activity can lead to interrole conflict while enacting a second role activity. That is because of the confusion the role occupant experiences while deciding which role to fulfil. It can be more relevant for the individual to stay in the current role activity even if he or she strives for fulfilling the interrupted demand. If this is the case, the individual has to self-regulate to resist the intrinsic motivational pull to follow the interrupted role activity and direct the behaviour and thoughts towards the current role activity (Muraven, Tice, & Baumeister, 1998, p. 774). The self-regulation process also includes regulating attention (Muraven et al., 1998, p. 775). Regulating the attention from the highly identified role to the current role activity, is effortful (Leroy, 2009, pp. 168-170). This makes self-regulation a limited resource, because there is less self-regulation and also less attention remaining for actually fulfilling the current role activity (Muraven & Baumeister, 2000, p. 248). Considering again the example from above this would mean, that withstanding an interruption from a colleague who operates in team 1, while being in role 2 leads to attention residue in team 2 for the following activities.

The preceding argumentation assumes, that a high role identification level in one role can lead to attention residue in the second role. This relationship is mediated by personal engagement in highly identified roles and interrole conflicts that can emerge through interruptions. All of the five interviewees already experienced the situation in which they thought about a role while fulfilling another role (Interviewee I1-I5, personal communication, October 19, October 21, 2020, appendix 1). The identification with a role and the therefore resulting motivational pull toward this role is one possible explanation for this. However, the conceptual model is based on theories and therefore, several limitations and have to be considered. Nonetheless, the model can give implications on how the relevance and handling with multiple roles in multiple teams. Those implications and limitations are outlined in the following discussion.

4. Discussion: Practical Implications and Limitations of the Model

Many researchers highlighted the lack of understanding of individuals' psychosocial experiences when working in MTM settings (Pluut et al., 2014, p. 343). This paper

examined the development towards MTM and its impact on individuals. Employees nowadays fulfil several roles in several teams during their workday. They can identify themselves with some of their roles more than with other roles, which impacts their engagement in the preferred role and their attention on the other roles. Moreover, their role identification level can lead to interrole conflict, if interruptions from the higher identified role occur. This interrole conflict can lead to attention residue in the other roles. This conceptual framework outlines, that even if external conditions, like time fragmentation or the number and variety of teams are kept at an optimal level, individuals' internal processes still can influence the success of MTM in organizations. The interviews underlined the impact of role identification but raise new factors that determine work behaviour. In research teams, individuals can define the scope of their role and the projects they participate in. Through the self-selection of employees in projects and roles, the person-role match is high, by default. That is why the interviewed researchers named the hierarchical position of team members, the stage of the project, the personal involvement and the quality of the project as factors that influence their work behaviour (Interviewee I1-I5, personal communication, October 19, October 21, 2020, appendix 1). Due to a lack of empirical data about the actual impact of role identification on attention residue, a field study would provide greater insights. In this study, factors like the team member constellation, the project-stage and the quality of the project, as well as the personal importance of the project regarding career possibilities can be captured and their correlation and stand-alone impact researched. Besides academia as work field, a similar empirical field study would make sense in economic sectors like in consulting agencies. In this work field employees have less opportunity to self-select in projects and to define their role, wherefore the role identification may have more impact. The thesis showed that the switching processes are not only relevant on structural levels like tasks or jobs, but that the transitioning between team contexts like roles should not be neglected. The match between person and role is more important than ever before, especially in economic sectors. To sustain their competitive advantage, organizations should try to retain their qualified workers and one possibility to do this is through offering them a suitable role. This implies, that organizations should invest in person-job and personorganization fittings to select employees that have the right starting conditions, by default. If employees are already recruited into an organizational setting, the team assignments should be selected by the employees' manager in the same diligence as the recruiting assignment. Ideally, employees should have a voice in the decision process in which teams they are assigned. But even after taking care of a good matching between the employee and the several roles, role switching and differences in the role identification can occur. Then, organizations should keep an eye on minimizing the role transitions. This can be achieved through encouraging employees to coordinate their time slots for certain role activities accordingly. The interviewed researchers try not to enact several roles within one workday to prevent distracting thoughts and exhausting switches (Interviewee I1, personal communication, October 19, 2020, appendix 1.1; Interviewee I3, personal communication, October 21, 2020, appendix 1.3). Organizations could offer time and selfmanagement trainings for employees to assess their work and attention behaviour and learn to manage it. Possible key takeaways for employees could be to plan time slots in their calendar in which they do not want to be interrupted to focus on less satisfying activities. Even if this conceptual framework about the relationship from role identification level to attention residue gave meaningful insights into the role and transition theory within MTM, there are also a few limitations to mention. Firstly, this model was simplified regarding the amount and time fragmentation of teams. Employees will not have the possibility to manage their complete working hours per week autonomously but will have already organized team events or meetings during their workday. Therefore, a few interruptions and transitions are prescribed. Additional interrole conflicts may emerge trough deadlines in a team project which are not predictable. Moreover, there will be rare situations in which the time allocation to each team is clearly communicated, but often blurred and changing. MTM will often come together with multiteam systems (MTS), which mean the interdependence of inputs like team members, several team processes and outcomes. Taken MTM and MTS together, the relationship of role identification is more complex because one employee can take several roles in several teams which are dependent from each other and work together to a common goal (O'Leary et al., 2012, p. 141). This situation may be an interesting topic for future research regarding role blurring and the resulting interrole conflict that could occur. Attention residue is experienced by employee's day by day but positive spill-over from one role to another role, too (Interviewee I1-I5, personal communication, October 19, October 21, 2020, appendix 1). It is still not clear, if attention residue or learning spill-over overweighs. Research about MTM should not slow down, because the increasing gig economy and knowledge industry will offer even more opportunities for employees to work in several teams or in several projects simultaneously. It is assumed, that online labour platforms will grow at a rate of 14% per year which will increase the side-hustle employments (Kässi & Lehdonvirta, 2018, p. 12). This example shows that the increasing trend towards digitalization and the steady improvements in communication and information technology leads to the necessity of implementing new forms of collaboration like MTM to keep up with the rapidly changing environment. Attention and awareness are human capacities, wherefore psychosocial experiences and effects on attention should not be neglected.

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Is Visiting the ESB Website Deteriorating the Air Quality of our Countries? A Statistical Analysis of the Relationship Between Air Pollution Levels and Information & Communication Technologies

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Abstract

Information and communication technology (ICT) is often praised for reducing emissions, however, data centres enabling these technologies have a high energy demand which produces emissions due to CO2-intensive energy production. The purpose of this paper is to investigate whether a relationship between ICT categories and air quality exists and how ICT affects it. This will contribute to a greater understanding of how to mitigate the effect of the rise of new digital technologies.

This paper examines the effects of ICT aspects (Knowledge, Technology, Future Readiness) on air quality in 57 countries by using multilinear regression. The results show that a linear relationship between ICT factors and air quality exists. Technology has a negative effect on air quality, whereas Future Readiness has a positive effect. The effect of Future Readiness on air quality is almost twice as high compared to Technology. A relationship between Knowledge and air quality, as proposed in the literature, could not be proven by the model. It can be concluded that this combination of findings provides some support for the conceptual premise that the net effect of ICT on air quality might be positive and that the share of the total carbon footprint of the ICT sector might have been forecasted too high.

Keywords: Information technology; air quality; energy consumption; sustainability.

1. Introduction

1.1. Is the Internet an Energy Guzzler?

Within one year and with an estimate of over 10.000 monthly page views, the ESB website (www.esb-businessschool.de) emits 50.66kg CO_2 . The same amount of CO_2 that three trees can absorb in one year (Website Carbon, 2020). This is just an example of a website, but even in 60 seconds, a lot happens on the internet. Based on estimations published by Statista (2019), about 1 million people log in to Facebook. Additionally, 4.5 million videos are being viewed on YouTube and 188 million Emails are being sent every 60 seconds. The internet works through large servers that run 24 hours a day, 365 days a year. Each file, video, Snapchat or WhatsApp must be routed through different servers, searches must be managed and files must be stored. This consumes energy and generates heat (Dayarathna, Wen, & Fan, 2016). The total energy consumption of server farms in Germany was 13.2 billion kilowatt-hours (kWh) in 2017 (+25% compared to 2010) (Hintemann, 2018). In a study commissioned

by the German Federal Ministry of Economics and Energy, it is predicted that the energy demand of data centres will rise to 16.4 billion kWh by 2025 (Stobbe et al., 2015). Projected onto the world, data centres could be responsible for onefifth of global electricity consumption - with correspondingly negative effects on the environment (Lima, 2017).

The energy consumption of data centres and CO_2 emissions are closely connected to the current electricity mix. Energy can be produced by using renewable sources, such as wind or hydropower, or by non-renewable energy sources. These include natural gas and coal which are burned and emit tonnes of CO_2 and other pollutants during the process (EIA, 2020a) which affects the air quality and our health (Ohlström, Lehtinen, Moisio, & Jokiniemi, 2000). In Germany, 46% of the electricity mix in 2019 was renewable (Fraunhofer, 2020). However, because not all servers are located in Germany, the electricity mix varies. In the US, the majority of electricity sources are coal and natural gas; methods of power generation that release relatively large amounts

of CO₂ (EIA, 2020b). CO₂ in this context belongs to the greenhouse gasses (GHG) and is often used as an umbrella term when analysing its effects as an air pollutant (Bereitschaft & Debbage, 2013; Ramanathan & Feng, 2009).

The Information and Communication Technology (ICT) sector defines the infrastructure needed to enable digital applications and systems (OECD, 2002). Innovative companies such as Google and other cloud services were associated with high hopes to save resources (Schmidt, 2019) and make Information Technologies (IT) greener. Even though the internet consumes an incredible amount of energy, it theoretically saves energy as well. Every search query avoids a trip to the library or a long search in various shops for the best price (Google, 2009). For example, an Email requires neither paper nor delivery by car. But does that also make it more climate-friendly? Not necessarily. Smartphones, computers and the internet also need electricity whose production emits air pollutants.

In terms of energy-saving effects, some studies predict the CO_2 reduction potential of ICT by up to 15% in other sectors (Malmodin & Bergmark, 2015). While economists Hintemann and Hinterholzer (2019) say that in any case, there is no doubt among experts that the internet has long since become a CO_2 slingshot. To date, there has been little agreement on what the actual impact of the ICT sector on CO_2 levels and air quality is.

The rising demand for digital applications indicates that the ICT sector has a pivotal role in mitigating its environmental impacts. Most studies in the field of ICT and sustainability have only focused on the effects of ICT devices on the environment (Andrae & Edler, 2015; Malmodin & Lunden, 2016). Such approaches, however, have failed to address the opposing effects of increased energy demand or saving caused by indirect effects of ICT applications, such as investments and IT integration.

This study aims to analyse the effect of digitalisation on environmental sustainability, more specifically the air quality. A statistical model conducted with a multilinear regression is estimated to show the significant influence of different aspects of the ICT sector (Knowledge, Future Readiness and Technology) on the air quality of different countries. The analysis of the model will provide answers whether a linear relationship between ICT aspects and air quality exists and which aspects, in particular, deteriorate or improve our air quality, based on the assumption that ICT can save, but also demands more energy. Overall, the model investigates how green IT is possible and what this implies for businesses around the globe, also in regard to the global COVID-19 pandemic.

1.2. Theoretical and practical relevance and structure

This analysis contributes to the existing literature in two ways. First on a theoretical level, as the statistical model classifies which aspects of digitalisation help improve or deteriorate environmental sustainability. And secondly on a practical level, based on the theoretical model it provides concrete steps to prevent digital innovation and improvements from contributing to climate change and deteriorating air quality. This is essential to solve the climate crisis as the ICT infrastructure becomes progressively accessible to more people (GeSI, 2015) and it is hoped that this thesis will contribute to a deeper understanding of the relationship between ICT factors and air pollution.

The first part of the thesis will be a profound literature review introducing two theoretical frameworks to categorise ICT factors. Followed by a derivation of research hypotheses. Secondly, the method, research design and context, data collection including robustness checks will be described. Lastly, after summarizing the data and an in-depth evaluation of the regression results an interpretation and an outlook on further steps of action will be provided to answer the questions whether the ESB website is contributing to the deterioration of our air quality.

2. Literature Review

There is no consensus on ICT's effect on energy consumption and the actual impact on the environment in the literature. While some scholars emphasise the high emission reduction potential (Ericsson, 2020; GeSI, 2012; Malmodin & Bergmark, 2015), some warn about the growing energy and carbon footprint of ICT (Belkhir & Elmeligi, 2018; Van Heddeghem et al., 2014).

A study conducted by Malmodin and Lunden (2016) analysed the carbon footprints of the ICT and the Entertainment & Media (E&M) sector. Illustration 1 indicates that despite an increasing amount of data traffic, the footprints had peaked in 2010 and had deceased since then. The researchers argue that the switch from PCs to smartphones and tablets with lower energy consumption is responsible for the trend change.

Other studies confirm this negative relationship between ICT and energy consumption and found the relationship to be U-shaped with a turning point in 2014 (Han, Wang, Ding, & Han, 2016).

The controversy is fuelled by various scholars claiming that ICT causes a tremendous increase in GHG emissions or electricity demand (Kishita et al., 2016; J. W. Lee & Brahmasrene, 2014). Andrae and Edler (2015) disagree with the previously presented opinions in the literature and predict that ICT "electricity usage could contribute up to 23% of the globally released greenhouse gas emissions in 2030" (p.117). Even though Acharyya (2009) published an update of his 2015 study and the numbers deviate from the previous estimations, he still projects a continuous increase in electricity consumption of the ICT sector. Belkhir and Elmeligi (2018) found that from 2010 to 2020, the contribution of data centres will increase from 33% to 45%. Hence, the energy consumption of data centres is expected to increase rapidly (Illustration 2). This contradicts the findings of the previously introduced studies that increasing data traffic does not affect energy demand.



Figure 1: ICT and E&M sector carbon footprint projections in Sweden 1990-2020 (Malmodin & Lunden, 2016)



Figure 2: Energy consumption of data centres forecast (Hintemann & Hinterholzer, 2019)

2.1. ICT, GHG emissions and air quality

Whether the ICT sectors saves energy or not, the infrastructure of this sector needs electricity. The global energy mix, however, is still highly dependent on traditional nonrenewable energy sources (Smil, 2017). Even though studies argue that the carbon footprint of the ICT sector could be reduced by 80% by switching to renewable energy sources (Ericsson, 2020), GHG emissions caused by the ICT sector still prevail. The increased carbon dioxide mainly is caused by burning fossil fuels and deforestation. Both contribute to air pollution (Feldman et al., 2015). West et al. (2013) argue that air pollutants can be reduced by any endeavours to reduce GHG emissions which benefits our air quality and health. Previous research has established that energy production emits air pollutants, especially $PM_{2.5}$ (Particle matter) (Ohlström et al., 2000).

The net effect theory and the three orders of impact the-

ory are being used to categorize different ICT factors and further investigate the controversy of ICT and its effect on air quality.

2.2. Net effect theory and Hypothesis 1

According to Takase and Murota (2004), ICT can have an income and a substitution effect, which results in an overall net effect on energy consumption levels. The economic growth from increased use of ICT increases energy consumption and is called the income effect. ICT equipment and products require electricity for production and daily operation (Sadorsky, 2012). The substitution effect suggests that ICT has the potential to reduce energy usage because it replaces more energy-intensive and traditional products (Zhou, Zhou, & Wang, 2018). The IT sector, for example, is growing and is less energy-intensive than traditional industries such as manufacturing (Romm, 2002). The effect distinction suggests differentiating effects of various ICT components. A reduction or increase in energy consumption (and the corresponding GHG levels caused by energy production) depends on which trend, the substitution or the income effect, will prevail (Takase & Murota, 2004).

Derived from the previous literature review the first hypothesis states:

H₀: ICT aspects do not influence Air Quality

H₁: ICT aspects do influence Air Quality

Hypothesis 1 serves to verify the general assumption that a relationship between ICT aspects and air quality exists to extend on the prevailing concepts found in the literature. As a first step in the analysis, this validates the context between CO_2 emissions, ICT and their direct air quality impacts.

2.3. Three orders of impact theory – First Order; Hypothesis 2

The three orders of impact theory was introduced by (Berkhout & Hertin, 2001) and further developed by Hilty and Aebischer (2015). In all of the three stages ICT is part of the problem, but also part of the solution regarding the environmental impact. Illustration 3 shows that ICT has direct effects due to its lifecycle. Essentially this is the direct carbon footprint of ICT (Ericsson, 2020) and hence summarized under the term technology. According to Hilty and Aebischer (2015), the direct impacts of ICT are problematic for our environment, as the production and use of devices consume resources and energy (Schickling, 2020). The IMD (2019) defines technology as everything that "enables the development of digital technologies" (p.29), hence the life cycle including capital and the regulatory/technological framework.

According to Statista, the number of internet users worldwide has quadrupled between 2005 and 2019 to 4.121 million users (2020). The causal conclusion would be that more users consume more energy because more devices are needed which leads to an increase in CO2 emissions. Malmodin and Lundén (2018) found that the emissions per subscription (internet user) decreased from 21.5 to 19kg CO₂ per subscription due to the replacement of old ICT equipment. This indicates that the emissions caused by ICT devices keep rising due to more internet users, despite the small savings. Ericsson (2019) supports this idea by stating that the largest share of carbon emissions are produced by user devices. In a study investigating the optimal equipment replacement cycle of ICT equipment, Chan et al. (2016) reported that the energy consumption and resulting carbon footprint/air pollution, due to rising network life cycle energy demands, could skyrocket if kept unchecked. A big part of the ICT life cycle are hightech exports. Pan et al. (2017) demonstrate that the bigger the export volume, the higher the CO_2 emissions accordingly. Scholars predict a sharp increase in CO₂ emissions and this trend is driven by the short life cycle of a smartphone (approximately 2 years) and the low recycling efforts (less than 1%) (Belkhir & Elmeligi, 2018).

Indirect effects of the Technology aspect include investment (IMD, 2019). A study conducted in South Korea investigated the effects of ICT investment on electricity consumption (Cho, Lee, & Kim, 2007). The authors concluded that ICT investment contributed to increasing electricity consumption in most of the analysed sectors. This negative correlation was also found between investment and air pollution/CO₂ emission (Acharyya, 2009; Liang, 2008).

As the review of the existing literature largely agrees on the negative direct impacts of ICT (Technology), it leads to the following hypothesis:

 H_0 : Technology has no negative effect on Air Quality

 H_1 : Technology has a negative effect on Air Quality

2.4. Three orders of impact theory – Second Order; Hypotheses 3 and 4

The second order of the theory addresses enabling effects such as indirect emission effects from using ICT, positive and negative ones (Ericsson, 2020). Indirect effects refer to the application of ICT services. From an environmental sustainability viewpoint, the enabled effects can be advantageous or disadvantageous.

Unfavourable effects include induction and obsolescence effects. The induction effect describes the situation where ICT increases the usage of other resources. For example, printers demand more paper than typewriters (Mansell & Hwa, 2015). Furthermore, e-commerce can lead – depending on the product type - to more freight transport (Hilty, 2008). Hilty and Aebischer (2015) define the obsolescence effect, as the situation where other resources' useful life is influenced by ICT services or products. This is the case of incompatibility when ICT solutions become obsolete when, for example, software updates do not support the hardware anymore or when "smart" tags make it more difficult for bottles or cardboard to be recycled (Wäger, Eugster, Hilty, & Som, 2005).

Substitution and optimization effects are expected to reduce the environmental impact of ICT (Illustration 3). Any replacement of physical elements by ICT is summarized under the term substitution effect. During the COVID-19 pandemic, videoconferences replaced business travel. Due to the substitution effect, resources can be saved which can have a positive impact on the environment (Yi & Thomas, 2007). Internet retailing and e-commerce - despite the negative effects due to induction effects - is also part of the substitution effect and is found to reduce consequent CO₂ emissions (Weber, Koomey, & Matthews, 2010). Another aspect of substitution is the robots' distribution (IMD, 2019). In an analysis of the air pollutants of robotic tractors, the scholars concluded that the robotic tractors could be responsible for a 50% reduction in emissions in a best-case scenario (Gonzalez-de Soto, Emmi, Benavides, Garcia, & Gonzalez-de Santos, 2016). Especially, robotic applications are projected to reduce greenhouse gas emissions (Harris, 2019).

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Figure 3: Three orders of impact grid (Hilty & Aebischer, 2015)

The optimisation effect is defined as the usage reduction of other resources because of ICT applications, for example, smart homes can save energy, hence, increase energyefficiency (Jahn et al., 2010). This effect is also closely linked to smartphone and tablet possession because the usage of them can reduce the carbon footprint of the ICT sector (Malmodin & Lunden, 2016). Other analyses showed, however, that emissions due to smartphones will continually rise and will make up 11% of total ICT emissions by 2020 (Belkhir & Elmeligi, 2018). Not only houses can be optimized by ICT, but also governmental processes which is called eGovernment. This refers to the increased use of modern IT technologies and electronic media for government and administrative processes (BMI, 2020). Online participation can benefit climate change adaption by improving the efficiency of decision-making (Bojovic, Bonzanigo, Giupponi, & Maziotis, 2015).

Other studies working with the model concluded that the enabling effects of ICT (2. Order) are more significant than technological impacts and have a positive effect on the environment (Erdmann, Hilty, Goodman, & Arnfalk, 2004).

In the following the second order will be called "Future Readiness" to define the "Level of a country's preparedness to exploit digital transformation" (IMD, 2019) and match the terminology of the data used. This includes adaptive attitudes, business agility and IT integration.

The literature indicates that the positive effects of Future Readiness on air quality and emissions outweigh the negative effects. This suggests the following hypotheses:

H₀: Future Readiness has a no positive impact on Air Quality

 H_1 : Future Readiness has a positive impact on Air Quality

 H_0 : Future Readiness has not a bigger impact on Air Quality than Technology

H₁: Future Readiness has a bigger impact on Air Quality than Technology

The statistical analysis will show whether positive effects of ICT might outweigh the negative ones and contributes to better air quality.

2.5. Three orders of impact theory - Third Order

The second order enables behavioural and structural changes (third order) which can promote more sustainability. However, rebound effects and emerging risks can diminish these desirable patterns. The (Umweltbundesamt, 2019b) defines the rebound effect as impacts where efficiency increase oftentimes reduces costs, which can in turn ramp up consumption, thus partly cancelling out the original savings. SMARTer2030 quantified the rebound effect at 1.4 gigatons CO_2 in 2030 (GeSI, 2015). Scholars note that rebound effects are often not considered when calculating the carbon footprint of the ICT sector causing misleading results (Pohl, Hilty, & Finkbeiner, 2019). Since these effects are long-term reactions and linked to behavioural changes, this study will refrain from deriving a hypothesis based on the third order.

2.6. Knowledge and Hypothesis 5

A large and growing body of literature has investigated the effects of knowledge on the environment. This is an important indirect aspect both theories are missing. In this context, it is defined as "Know-how necessary to discover, understand and build new technologies" (IMD, 2019, p.29). Developed nations are often described as knowledge economies because their economic system is based on intellectual capital (Powell & Snellman, 2004). According to the World Bank (World Bank, 2007), access to ICT infrastructures represents a fundamental pillar of the definition. Human capital, such as education, contributes to the development and improvement of ICT structures. A Portuguese study found a negative relationship between education and energy intensity, hence, more education reduces environmental impacts (Sequeira & Santos, 2018). Other studies come to the same conclusion while analysing the relationship between R&D and carbon emissions (K. H. Lee & Min, 2015) or air pollution (Cole, Elliott, & Shimamoto, 2005).

The existing literature is mainly characterized by positive effects associated with knowledge on air pollution which leads to the following hypothesis:

 H_0 : Knowledge has no positive impact on Air Quality

 H_1 : Knowledge has a positive impact on Air Quality

This hypothesis will show whether empirical effects suggested in the literature can be proven by a statistical model.

3. Method

3.1. Research design

The central hypothesis stated in Section 2 regarding the relationship between ICT aspects and air quality was tested by using a multilinear regression. Previous studies have based their research on top-down and bottom-up modelling approaches (Malmodin, Bergmark, & Lundén, 2013; Malmodin & Lunden, 2016). The benefits of a multi linear regression are the ability to quantify relative influences and to determine outliers (Weedmark, 2018). A multiple regression analysis studies the simultaneous effects that various independent variables have on one dependent variable (Cochran, 2014). It is assumed that the multiple regression model takes the following form:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_n x_n + \epsilon$$

y is a linear function of x_1, x_2, \ldots, x_n plus the error term ϵ . The dependent variable (y) and independent variables (x_1, x_2, \ldots, x_n) represent the observed data, whereas the multiple linear regression algorithm computes the values of the intercept (β_0) and coefficients $(\beta_1, \beta_2, \ldots)$. This modelling minimizes the residual or error (ϵ) in the model. To calculate the predicted values y_i the observed values (x_1, x_2, \ldots) are multiplied with their corresponding coefficients $(\beta_1, \beta_2, \ldots)$ and the intercept β_0 is added. The difference between the observed value of y_i and the predicted value \hat{y}_i is defined as the error term (Boslaugh, 2013).

3.2. Data

The multiple regression used for all hypotheses is based on the Environmental Performance Index (EPI) 2018 and the IMD World Digital Competitiveness Ranking (WDC) 2019.

The EPI is a data-driven index that uses 32 performance indicators across 11 issue categories of 180 countries developed by two US-American universities (Yale/New Haven and Columbia/New York) on behalf of the Davos World Economic Forum (Wendling et al., 2018a). It targets environmental health and the vitality of the ecosystem. For this study the Air Quality issue category was chosen as a dependent variable which measures direct impacts of air pollution on human health (Wendling et al., 2018a). This category makes up 26% of the complete index (Appendix A.2). The indicators of this category include PM2.5 (Particulate Matter) exposure, household solid fuels and PM_{2.5} Exceedance of WHO guidelines (Wendling et al., 2018b). PM_{2.5} describes particulate matter whose diameter is smaller than 2.5 μ m (Zheng et al., 2005). Particulate matter is not only emitted directly (primary particles) but also forms of precursors (including sulphur dioxide, nitrogen oxide and ammonia) in the atmosphere (secondary particles) (Umweltbundesamt, 2019a). The component "household solid fuels" measures the impact of exposure to indoor air pollution caused by household use of solid fuels (Wendling et al., 2018b). The EPI was chosen because previous research has established that energy production contributes to the global PM_{2.5} levels (Ohlström et al., 2000). The score data (0-100) was chosen. The final sample used included 57 countries (N = 57) and as a whole had a relatively high Air Quality (M = 79.39, SD = 15.43, 95% CI [75.30, 83.48]) (Appendix C.1).

In 2008 the German Environment Agency criticised the EPI because they found the significance of the country ranking for Germany was particularly low due to clear methodological shortcomings of the index (Kraemer & Peichert, 2008). However, the index was published every other year since 2006 and improvements of data validation were implemented as the variables used were adapted and data generation improved (Wendling et al., 2018b).

The WDC "ranks the extent to which countries adopt and explore digital technologies" (IMD, 2019, p.28) in the areas of Knowledge, Technology and Future Readiness. These three categories include 51 criteria (Appendix A.1). Knowledge is defined as the "know-how necessary to discover, understand and build new technologies" (p.29) and it includes the sub-factors scientific concentration, training/education and talent. The WDC interprets Technology as the infrastructure needed to run digital technologies such as regulatory framework, capital and technological framework. Lastly, Future Readiness is the "level of country preparedness" (p.29) in terms of digital innovations which included adaptive attitudes, business agility and IT integration. The yearly published ranking is computed by comprising hard data (statistics) and survey data (opinions, panels) of 63 countries worldwide. Knowledge, Technology and Future Readiness are the independent variables used for the regression. The score data (0-100) was chosen. The descriptive statistics show that the mean score for Knowledge was 67.70 (SD = 13.83, 95% CI [64.03, 71.34]), for Technology it was 68.77 (SD = 14.14, 95% CI [65.02, 72.53]), and for Future Readiness it was 68.21 (SD = 15.62, 95% CI [64.07, 72.36]) (Appendix C.1). This indicates that the countries performed on average better in the categories Technology and Future Readiness.

Both indexes were chosen because of the continuity of the data collection over several years and their profound methodological approach.

The data evaluation described in the following was performed with the statistics programme SPSS (Statistical Package for the Social Sciences) Version 25 and significance levels were set to 5%. To ensure the traceability of the results all outputs were documented in the Appendix.

3.3. Robustness check

To determine whether the model is robust and matches important prerequisite assumptions of multiple regressions, the following aspects were investigated.

3.3.1. Linearity

The individual Q-Q-Plots meet the assumption of linearity (Appendix B.1.3, B.2.3, B.3.2, B.4.2). The partial regression plots also indicate that Air Quality and Technology have a negative linear relationship, whereas Air Quality and Future Readiness/Knowledge have a positive linear relationship (Appendix C.7). Additionally, the linearity assumption is proven because the values follow the least-squares fit line in the P-P-diagram (Appendix C.5).

3.3.2. Normally distributed

The histogram of standardized residuals indicates that the data is normally distributed (Appendix C.4). The normal P-P plots of standardized residuals contained approximately normally distributed errors, which is indicated by the points being close to the line (Appendix C.5).

3.3.3. Independence of errors

The data met the assumption of independent errors (Durbin-Watson value = 1.989) (Appendix C.3). The assumption of non-existing auto-correlation of the residuals is upheld as long as the value is close to 2 (Field, 2018).

3.3.4. Multicollinearity

Tests to see if the final model meet the assumption of collinearity indicated that multicollinearity was not present (Technology, Tolerance = .229, VIF = 4.374; Future Readiness, Tolerance = .229, VIF = 4.374) (Appendix C.3).

3.3.5. Misspecification

To control whether nonlinear combinations of the independent variables influence the dependent variable, a Ramsey Reset Test was conducted (Ramsey, 1969). The variable RAM2 is not significant and (t(56) = -1.308, p = .196) misspecifications can be eliminated (Appendix C.10).

3.3.6. Endogeneity and measurement error

A common mistake in the empirical specification is to forget about possible endogeneity (Kennedy, 2011). In this research, it is unlikely but cannot be ruled out completely. Both indices conduct their research regularly. Therefore, the measurement error is expected to be low, but cannot be eliminated 100%.

3.3.7. Heteroskedasticity

The standardized residuals shown in the scatterplot are scattered uniformly and randomly around zero which indicates homoscedasticity (Appendix C.6). Besides that, a Breusch-Pagan test was conducted which led to the acceptance of H_0 , stating the homogeneity of variance (Appendix C.9).

3.3.8. Non-zero variances

The data also met the assumption of non-zero variances (Air quality, Variance = 237.875; Technology, Variance = 200.076; Knowledge, Variance = 191.234; Future Readiness, Variance = 243.895) (Appendix C.1).

3.3.9. Causality

The model claims that Knowledge, Technology and Future Readiness have an impact on Air Quality. This is a causal relationship derived from existing literature: More energy consumption by the ICT sector causes more CO_2 emissions due to electricity production or energy savings effects reduce the CO_2 emissions. A conclusion that Air Quality impacts ICT aspects does not seem likely.

3.3.10. Outliers

India, China and Venezuela were identified as outliers by boxplots (Appendix B.1.1, B.3.3). South Korea and South Africa were excluded from the sample to smooth out the model as indicated by an analysis of the standardized residuals. The sample size then included 57 countries.

3.3.11. Sample robustness

The robustness of the model was checked by conducting a regression with 80% of the original sample. The model is still significant and all assumptions can be upheld (Appendix D).

No breach of the assumptions was identified, therefore, the interpretation of the results of the multiple linear regression is considered trustworthy under these aspects. The results are presented in the following section.

4. Results

A multiple regression was carried out to investigate whether Technology, Future Readiness and Knowledge could significantly impact a country's Air Quality. Results of the multiple linear regression indicated that there was a collective significant effect between the variables Technology, Knowledge, Future Readiness (F(3, 53) = 17.729, p < .001, $R^2 = .501$) (Appendix C.2). While Technology (t(56) =-3.544, p < .001) and Future Readiness (t(56) = 5.003, p< .000) contributed significantly to the model, Knowledge did not (t(56) = .980, p = .331). Knowledge appeared to be a non-significant variable. Using the enter method and excluding Knowledge it was found that Technology and Future Readiness explain 47.3% of the variance of Air Quality ($F(2, 54) = 26.132, p = .000, R^2 = .492, R_{Adiusted}^2 = .473$) (Appendix C.3). This adjustment only has small effects on the remaining variables: Technology (t(56) = -3.434, p < .001) and Future Readiness (t(56) = 6.058, p < .000). Interestingly, the $R^2_{Adjusted}$ decreases after the variable Knowledge was removed and the F statistic of both tests is significant despite the non-significant t-test of Knowledge. The final predictive model can be summarized as follows:

Air Quality = 48.84 - 0.76*Technology + 1.214*Future Readiness

The coefficient of Technology is negative, indicating that countries with higher technological impacts have on average lower Air Quality. While Future Readiness has a positive coefficient, which means that the higher the future readiness of a country is the better its Air Quality. Looking at the standardized coefficients beta shows the absolute impact of the variables on the model (Technology: $\beta = -.697$; p < .001; Future Readiness $\beta = 1.229$; p = .000) (Appendix C.3). Hence, the influence of Future Readiness on Air Quality is almost twice as high as that of Technology in absolute terms.

5. Discussion of the results

The regression aimed to analyse the impact of various ICT factors on air quality. In this section, all the statistical results from the multilinear regression outlined in Section 4 are being discussed and examined in detail. The effects of the variables on the level of air quality are being explained, and various implications for business, also taking note of the COVID-19 pandemic, are being introduced.

In line with Hypothesis 1 that ICT aspects do influence Air Quality, H_0 is rejected and H_1 accepted, at least for the variables Technology and Future Readiness. An impact of Knowledge on Air Quality could not be shown. These results support previous research into this area which links ICT usage to an income and substitution effect (Takase & Murota, 2004). This confirms the general assumption of the environmental impact of ICT, in both positive and negative ways, as proposed in the literature and proves the net effect theory.

In accordance with the present results, previous studies have demonstrated that every internet user causes CO₂ emissions. Even though these could be reduced by replacing old ICT equipment it might explain the negative effect of the variable Technology on Air Quality found in the regression analysis (Hypothesis 2). The findings are also consistent with them of Pan (2015) and Chan et al. (2016) that Technology has a negative effect on Air Quality and H₀ is rejected in favour of H₁. Agreeing with the present results, previous studies have demonstrated that investments in the ICT sector have a negative impact on air pollution, more CO₂ emissions and cause an increase in energy consumption (Acharyya, 2009; Liang, 2008). The negative impact of Technology on Air Quality might be explained by the fact that user devices account for the majority of the ICT carbon footprint (Ericsson, 2019). The rising amount of internet users (Statista, 2020) might cause an increase in ICT carbon emissions. Overall, these results correspond with existing evidence of the negative impacts of the life cycle of Technology on the environment found in the literature (Belkhir & Elmeligi, 2018).

The regression model indicates that Future Readiness impacts Air Quality positively (Hypothesis 3). This builds on existing evidence of Malmodin and Lunden (2016) who argue that the overall carbon emissions of the ICT sectors had peaked in 2010 despite rising data traffic. A possible explanation for these results may be the increasing efficiency of new devices. Internet retailing is a factor of the Future Readiness variable and the literature disagrees on the effect of ecommerce on the environment. The results, however, are in agreement with those arguing that the net effect of the induction and substitution effect caused by online retailing has a positive environmental impact (Weber et al., 2010).

These results further corroborate the idea that the impact of the substitution and optimisation effect is substantially greater than those of the induction and obsolescence effect. This interpretation is in accord with previous studies indicating that enabling effects of ICT and the subsequent environmental impacts are more substantial than those of the direct effects of ICT (Technology) (Erdmann et al., 2004; Hilty et al., 2006). Consequently, H₀ of Hypothesis 4 is rejected in favour of H₁.

These results should be considered when discussing the net effect of ICT emissions on air quality. Future Readiness has a positive impact on Air Quality and this impact is almost twice as high compared to the negative impact caused by Technology. This combination of findings provides some support for the conceptual premise that the net effect of ICT on air quality might be positive. This finding, while preliminary, suggests that the overall carbon footprint of the ICT sector is significantly smaller than previously forecasted. This interpretation further supports the idea of Malmodin and Lundén (2018) who come to a similar conclusion and various studies which emphasize the emission reduction potential enabled by ICT (Ericsson, 2020; GeSI, 2015). This result may be explained by the fact that Internet of Things subscriptions are growing (Ericsson, 2019) and energy-intensive devices are becoming more efficient (Malmodin & Lundén, 2018).

The regression analysis has been unable to demonstrate an effect of Knowledge on Air Quality (Hypothesis 5), H_0 is being accepted, and therefore the results contradict the claims of K. H. Lee and Min (2015) that Knowledge has a positive impact on air pollution and CO₂ emissions, hence air quality (Cole et al., 2005). Due to the broad definition of the variable, it is difficult to investigate what exactly is causing this deviation. This provides new insights into the relationship between Knowledge factors and Air Quality. While previous research found a causal effect, these results demonstrate that the relationship might be not as significant as once anticipated.

A possible explanation for the decrease in $R^2_{adjusted}$ after the exclusion of the variable Knowledge might be that if the number of predictors increases, R^2 is artificially increased, since it also increases by the inclusion of insignificant regressors and thus never becomes smaller (Field, 2018). The significance of the F statistic despite non-significant t-tests could be attributed to a correlation problem (see limitations) (Archdeacon, 1994).

This statistical output contributes a clearer understanding of how digitalisation can mitigate the effects of environmental delegation partly caused by rising CO_2 emissions.

5.1. Theoretical and practical implications

5.1.1. Business implications

Increased visibility of environmental impacts of business practises and environmental degradation caused societal concerns and forced managers to find new ways of decreasing the environmental externalities of their corporations (Porter & Reinhardt, 2007). The theoretical findings of the regression imply that businesses need to invest more in their future readiness, while making the life cycle of their ICT applications more efficient. This includes embracing their business agility and IT integration.

Referring back to the findings of the model, business agility as part of the Future Readiness variable plays a significant role in mitigating the environmental impacts of businesses. It refers to a certain degree of flexibility of a company by reacting quickly to marketplace changes and customers demand (Tsourveloudis & Valavanis, 2002). IT integrations included using ICT-enabled conferencing tools and benefitting from an IT network to make operations run more efficiently.

The overall implication for businesses is that they should switch to renewable energy sources for their overall supply chain (Greenpeace, 2017). In compliance with the Paris Agreement, the ICT industry commits to reduce its GHG emissions by 45% from 2020 to 2030. The Secretary General of the International Telecommunication Union (ITU), an agency specialized on ICT of the united nations, calls this agreement a "guidance on the pathway towards net zero emissions for the ICT industry" (ITU, 2020). Microsoft, for example, announced in early 2020 that their goal is to be carbon negative by 2030. Steps to reach that goal include investing in carbon reduction and removal technology and empower customers to deploy more digital technologies (Smith, 2020).

Businesses not in the ICT sector need to join these efforts. Institutions, such as ESB Business School also need to be aware of their carbon footprint caused by various online tools, such as their website, should set sustainability goals and consider green hosting (Website Carbon, 2020). Other measures could include energy transparency, renewable energy commitment, energy efficiency & mitigation, renewable procurement and advocacy (Greenpeace, 2017).

Mitigating the environmental impact of companies can benefit their financial performance due to cost savings caused by increased efficiency. Although researchers disagree on how severe the effect is, most agree on the causal link between going "green" and better financial performance (Clarkson, Li, Richardson, & Vasvari, 2011; Riillo, 2017).

5.1.2. COVID-19

During the global COVID-19 pandemic streaming providers saw a spike in new memberships (Schuler, 2020) and a majority of the working force started working from home using online meeting tools (Bary, 2020). Here the substitution effect becomes visible. The DE-CIX, one of the largest internet exchange points worldwide, recorded an all-time high and broke a data traffic world record during the pandemic (DE-CIX, 2020). As indicated in the literature review, it is debated whether the energy demand of data centres increases with rising data traffic (Belkhir & Elmeligi, 2018; Malmodin & Lunden, 2016). The film Birdbox, for example, was viewed over 80 million times which leads according to a British study to an equivalent of 66.133.333kg CO₂ (SaveOnEnergy, 2019). On the other side, video conferences replaced business travel and air traffic was at a standstill. Some early studies identified a reduction of 26% CO₂ emissions worldwide (Le Quéré et al., 2020), others argue that it is not possible to draw conclusions about the net effect of these opposing influences and the health-relevant air pollution caused by the pandemic (Umweltbundesamt, 2020). Nevertheless, the COVID-19 pandemic demonstrates how important it is to integrate more renewable energy sources into the system. The rising demand for online applications during the global pandemic revealed the problems of rising emissions contributed by conventional energy sources used to keep the system running (GeSI, 2015). Mitigating the energy consumption of the net also includes making data centres even more efficient (Ivanova, 2020). The economic consequences of the coronavirus pandemic made the already abandoned climate targets for 2020 still achievable (Zeit, 2020). The question is whether these savings are only temporary (Le Quéré et al., 2020).

5.2. Limitations and future research

Nonetheless, the results and implications presented should be considered in light of some limitations. First, the similarity of the independent variables increases multicollinearity effects (Daoud, 2017). The distinction between closely related ICT aspects combined with substitution and income effects both found in individual aspects can cause the standard error to increase and can lead to a biased model. Second, the data used summarised many aspects under one variable which makes it difficult to fully analyse the effects of individual factors. Both indexes used data of different years which could interfere with the practicability of the model. And lastly, the overall causality of the study could be confirmed, however causalities within the variables do not always line up with the overall assumption. For example, credit rating is part of the Technology variable, and scholars have found a significant impact of climate risk on the country credit rating (Mathiesen, 2018). This refers back to the previous limitation of more distinguishable data.

Future research should include a clear differentiation between different ICT aspects. The results of various studies use different research approaches and designs which makes it difficult to compare the effects. As many forecasts made predictions for the year 2020, considerably more work will need to be done to determine what the actual environmental impact of the ICT sector in 2020 was, also focusing on the implications of the COVID-19 pandemic.

6. Conclusion

The present study was designed to determine the effect of ICT factors on air quality. Multiple regression analysis revealed that a significant linear relationship between ICT factors and air quality exists and that the different factors have different impacts on air quality.

One of the more significant findings to emerge from this study is that technical aspects such as the usage of ICT devices have a negative impact on Air Quality, whereas Future Readiness which includes online retailing has a positive effect on Air Quality. In absolute terms, the effect of Future Readiness is twice as high as the effect of Technology on Air Quality. Furthermore, the results of this study indicate that factors such as R&D and other forms of education summarized as Knowledge do not significantly influence Air Quality. Taken together, these findings suggest a role for Future Readiness in promoting Air Quality, hence, environmental sustainability.

These findings have significant implications for the understanding of how the whole IT sector can become greener. This includes making devices become more efficient and making the life cycle of technologies more sustainable, but also investing in the adoption of technologies to exploit digital transformation.

The relevance of the analysis is clearly supported by the current findings. The global COVID-19 pandemic and increasing environmental degradation cause a new approach to the usage of ICT and the study shows that digital technologies offer solutions to some of the corresponding problems. The implications showed that the emissions caused by the ICT sector are closely related to CO_2 -emitting energy sources. A reasonable approach includes investing in renewable energies to reduce the carbon footprint of the ICT sector further.

The findings from this study make several contributions to the current literature. First, they provide a statistical model to support an impact analysis of ICT elements on the environment. Second, they indicate a positive net effect of ICT on the air quality and third, show that the carbon footprint might be forecasted too high in the past and calls for further research to quantify the net effect of ICTs. Lastly, the approach of this study differs from others, as it combines different factors of ICT and builds an impact model to define the direct and indirect effects of ICT on the environment, rather than analysing solely the direct effect of individual devices.

In conclusion, to answer the question raised in the introduction: Yes, the ESB Website is partly deteriorating our air quality, but switching to green hosting would help the ESB to emit 9% less CO_2 (Website Carbon, 2020). Besides that, data centres will become more efficient and the effect can be offset by the energy-saving potential of ICT in other areas of the university or by the planting of three trees.

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Junior Management Science

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The Exercise of Power in Strategy Meetings: A Comparison of Political Behavior in Online and Offline Meetings

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Abstract

Understanding how power is exercised in strategy meetings is a vital step toward increasing the effectiveness of strategic undertakings. The objective of this master thesis is to gain important insights into issues of power and politics by investigating strategists' micropolitical tactics in online and offline meetings. Existing research has examined the exercise of power in meetings, yet there is little understanding to date regarding the evolution of political behavior in online meetings. Hence, conducting a qualitative case study, this research aims to uncover and compare the applied political tactics in online and offline meetings. Specifically, several problem-centered interviews were conducted and analyzed by means of a grounded theory approach. Furthermore, by integrating different power theories, a theoretical framework was developed. The empirical study reveals that different contextual factors impact power dimensions in meetings. Furthermore, it indicates that employees draw on specific power resources depending on whether meetings are conducted online or offline. Finally, by highlighting a paradigm shift of the exercise of power with the trend from offline to online meetings, particular attention is paid to consequences for strategic work. With these findings, the thesis contributes to the existing strategy-as-practice literature. Moreover, the generated insights provide managers with knowledge regarding the psychology of the political function of online and offline meetings.

Keywords: Meeting; power; politics; political behaviour; strategy theory; strategic work.

1. Introduction

Meetings are at the heart of an effective organization, and each meeting is an opportunity to clarify issues, set new directions, sharpen focus, create alignment, and move objectives forward. (Paul Axtell)

Undoubtedly, meetings are ubiquitous and a necessity for any organization. As reflected by the above quote from Paul Axtell, author of the award-winning book *Meetings Matter*, planned business gatherings represent an essential part of organizations and thus employees' working lives. As early as the 1970s, various researchers devoted their attention to the analysis of meetings by highlighting that millions of meetings occur every day, comprising 7-15% of companies' personnel budgets (Doyle & Straus, 1976) and consuming up to 70% of managers' daily working hours (Mintzberg, 1973). Over the past few years, however, the way of communicating business matters has changed significantly for several reasons. Globalization and advances in technology have allowed online meetings to creep from a futuristic mode of communication to an everyday experience by complementing and replacing physical interaction forms (Cichomska, Roe, & Leach, 2015). This trend away from offline (physical) to online (virtual) meetings will continue in the near future because the arguments for them are gaining strength with the recent coronavirus outbreak. During the coronavirus disease (COVID-19), per-day online meeting minutes increased from approximately 900 million to nearly 2.7 billion within a few weeks (Spataro, 2020). The shift from physical to virtual collaboration forms will impact the majority of businesses, which makes it more important than ever before to dive deeper into the concept of meetings.

Generally, the analysis of meetings has received considerable attention in various academic disciplines. The purpose of this thesis is to study the dynamics of strategy meetings since they are essential for shaping stability and change within an organization. To this end, authors of more recent studies on strategy research (Jarzabkowski, Balogun, & Seidl, 2007; Johnson, Langley, Melin, & Whittington, 2007; Johnson, Melin, & Whittington, 2003; Whittington, 2006) have proposed to treat strategy as "something people do" (Whittington, 2006, 613) rather than something organizations have. Consequently, by focusing on the many micro-actions, social practices such as meetings become indispensable in the strategy formulation process. According to this strategy-as-practice (SAP) perspective, a meeting is defined as an "event that involves several participants collocated in the same (physical or virtual) space and whose purpose is ostensibly related to the functioning of the organization" (Seidl & Guérard, 2015, 5). However, strategy meetings not only have significant effects on the future of the organization by shaping its strategic orientation (Boden, 1994; Schwartzman, 1989), but they also provide strategists an opportunity to combine various resources to influence strategic undertakings (Reckwitz, 2002). Consequently, the analysis of influence in organizational research is inevitably linked to notions of power and politics in social science. The recent turn in strategy research has already been considerably influenced by contemporary social science to analyze and explain issues of power in the context of strategizing (e.g., Knights & Morgan, 1991, Laine & Vaara, 2007, Mantere & Vaara, 2008, Samra-Fredericks, 2005). Nevertheless, various scientists highlight the importance of focusing more closely on political actions from a practice perspective (e.g., Carter, Clegg, & Kornberger, 2008, Clegg, Carter, & Kornberger, 2004, Ezzamel & Willmott, 2004).

Motivated by this critique, this paper employs different power concepts from social science to generate a more comprehensive understanding of the exercise of power in meetings. Therefore, power is conceptualized as an ability or capacity (Clegg, Courpasson, & Phillips, 2006) to reach personal or organizational goals, whereas politics is "power in action" (Hardy, 1996, S3). From this perspective, a social actor's political behavior becomes a key activity in meetings, in that it describes the mobilization of certain power dimensions to influence strategic work. An extensive literature review (Dittrich, Guérard, & Seidl, 2011) has identified that strategists can politically utilize meetings by setting and advancing the agenda (Adams, 2004; Tepper, 2004), exerting influence (Clifton, 2009; van Praet, 2009; Wodak, Kwon, & Clarke, 2011), bargaining (Boden, 1995; Mintzberg, 1973), keeping topics on the agenda (Jarzabkowski & Seidl, 2008; Tepper, 2004), suppressing new ideas (Jarzabkowski & Seidl, 2008; Schwarz, 2009) and forming alliances and building support (Adams, 2004; Kangasharju, 1996, 2002). Despite these six dimensions of the political function of meetings, however, little is known about the many everyday micropolitical practices that strategists employ in meetings. Moreover, previous studies primarily focus on physical meetings while neglecting the importance of digital meetings. Thus, this thesis analyzes the exercise of power in strategy meetings by comparing the political behavior in online and offline meetings. More precisely, this work aims to integrate a power-related perspective into the analysis of meetings to answer the following research question: *How do strategists politically utilize online and offline meetings to influence strategic work?*

To answer the research question, a holistic multiple case study (Yin, 2003) was conducted. Additionally, a qualitative approach enabled an analysis of the complexity of this social phenomenon from the researcher's perspective (Williams, 2007) and provided deep insight into the individual case (Flick, von Kardorff, & Steinke, 2000). Data was primarily gathered from problem-centered interviews (PCIs; Witzel, 2000) with 10 individuals from two hierarchical levels and five heterogeneous companies. These interviews were further coded and analyzed according to grounded theory (Glaser & Strauss, 1967). More precisely, this approach sought to develop a theoretical framework by continuously comparing data, codes, categories and concepts. The findings of the empirical data are presented utilizing first- and second-order concepts (Gioia & Chittipeddi, 1991; Gioia, Corley, & Hamilton, 2013). More precisely, respondents' answers have been, first, truthfully replicated and second, interpreted at an abstract level by examining them in relation to the theoretical background (van Maanen, 1979).

The study provides revealing insights into the redistribution of power caused by the online meeting trend. With its findings, this thesis contributes to the existing literature not only by integrating a micropolitical approach into the analysis of meetings, but also by highlighting the importance of web conferencing in SAP research. Moreover, the study offers important practical implications by drawing managers' attention to the hidden political tactics applied in business gatherings. Understanding the exercise of power in physical and virtual meetings generates useful insights for managing power relationships in times of digital transformation and home office regulations.

The remainder of this thesis is organized as follows: Chapter 2 introduces the background on meetings, power and politics in the context of strategizing. Accordingly, evidence from existing studies is presented in detail and critically reflected on by the author of this thesis. Furthermore, based on the previous literature, differences in political behavior between online and offline meetings are deduced and the research question is derived. Chapter 3 provides an overview of the empirical study, which is designed to answer the research question. Chapter 4 presents the research findings as well as the developed framework. Chapter 5 discusses the design and insights of the study, and Chapter 6 concludes the thesis.

2. Literature Review

This chapter discusses essential terms fundamental to the thesis by providing information on meetings, power and politics in the context of strategizing. Therefore, the literature review consists of three parts. First, (1) general characteristics of strategy meetings are presented. Further, (2) the concepts of power and politics are introduced, and a micropolitical approach in strategizing is outlined. Finally, (3) a summary of

essential findings on power and politics in meetings is presented to derive the research question for the empirical part of this thesis.

2.1. Meetings

The next section reviews the literature on meetings. Meetings in strategy research are defined, characteristics of physical as well as online meetings are displayed and compared, and the general functions of meetings are presented. The final section of this chapter presents the extended framework for studying meetings that is utilized for the remainder of this thesis. To provide an overview of the meeting literature, Figure 1, which is displayed in the next subchapter, highlights the relevant topics and sources. The shaded areas are of particular importance for this thesis and are presented in more detail.

2.1.1. Definition and conceptualization of meetings

Generally, a meeting can be defined as a "communicative event involving three or more people who agree to assemble for a purpose ostensibly related to the functioning of an organization or group" (Schwartzman, 1989, 7). The traditional literature views meetings as rather useless and irrelevant for the success of an organization. Meetings are considered to be a neutral frame for organizational processes without having profound consequences (Schwartzman, 1989). In contrast to this traditional view, however, papers written after the 1970s highlight the importance of business gatherings. Mintzberg (1973), for instance, suggests in his seminal study of managerial work that upper managers attend approximately eight meetings per day. As previously mentioned, he finds that CEOs spend up to 70% of their daily working hours in scheduled (60%) as well as unscheduled (10%) meetings discussing fundamental organizational problems. These results are supported by subsequent studies, although differences across organizational functions and levels have been found (e.g., Ives & Olson, 1981, Mosvick & Nelson, 1987, Tobia & Becker, 1990). Furthermore, other studies emphasize the millions of dollars that globally operating companies spend each year on meetings (e.g., Doyle & Straus, 1976, Monge, McSween, & Wyer, 1989). According to Doyle and Straus (1976), such meeting expenses can comprise 7-15% of companies' personnel budget. As one can see, meetings are no longer considered to be useless and irrelevant but rather an important part of business life and a factor capable of shaping organizational processes (Boden, 1994; Schwartzman, 1989).

In SAP research, scholars including Johnson et al. (2003) pave the way for micro-strategy by emphasizing the many micro-actions that strategists utilize to shape strategic work. In contrast to the traditional strategy discipline, practice-based theorizing focuses on *human activity* that is consequential for an organization's future. According to this view, strategy is treated as "something people do" (Whittington, 2006, 613) rather than something organizations have, as previously stated. Meetings are, therefore, fundamental to strategy formulation processes and are conceptualized as practices, that

is, routinized types of behavior, consisting of different interconnected elements. By combining various resources such as specific forms of language and nonverbal behavior, actors can reach collective action (in meetings), which is consequential for strategic work (Reckwitz, 2002). At this point, it is important to emphasize that practices, in addition to their nature of routinization, are alterable due to different combinations depending on the occasion, time and actors (Jarzabkowski et al., 2007).

In SAP research, meetings are often called *strategy meetings* (Clarke, Kwon, & Wodak, 2012; Kwon, Clarke, & Wodak, 2014). However, meetings that are not explicitly called *strategy meetings* are also relevant for many SAP researchers (Hendry & Seidl, 2003; Jarzabkowski & Seidl, 2008; Wodak et al., 2011) because meetings often concern strategic issues and are therefore important for the future of the firm (Seidl & Guérard, 2015). Hence, Jarzabkowski and Seidl (2008, 392) define *meetings* as "social practices that have implications for stabilizing or destabilizing the flow of strategy activity within organizations." The meeting analysis in this paper is well in line with this definition insofar that it explores meetings that are only implicitly called *strategy meetings* as well as meetings that are only implicitly called *strategy meetings* but have strategic relevance.

As Figure 1 highlights, this paper follows the rather broad definition of Seidl and Guérard (2015), who define meetings as:

a planned and episodic communicative event that involves several participants collocated in the same (*physical* or *virtual*) space and whose purpose is ostensibly related to the functioning of the organization. (Seidl & Guérard, 2015, 5)

The general definition mentioned above captures various characteristics of meetings that are the same for physical (offline) and virtual (online) meetings. More precisely, business gatherings are not only planned and episodic, but they are also characterized by talk and other forms of interaction among the participants. Furthermore, there exist different types of meetings such as regular or irregular and open or closed meetings (Seidl & Guérard, 2015). The next two sections focus on the space aspect of meetings and the differences between offline and online meetings. First, specific characteristics of offline meetings are outlined. Second, these characteristics are compared to the idiosyncratic features of online meetings. Last, the accelerated trend toward virtual meetings and therefore the need to include online meetings in the analysis is highlighted.

2.1.2. Characteristics of offline meetings

In physical meetings, strategists are co-located in a physical space where they can interact face-to-face. Thereby, materiality, in the sense of the furniture in the meeting room and the tools utilized during the meeting, can play an important role. On the one hand, the furniture, such as the arrangement of tables and chairs, can have a strong influence on the interaction of the participants (Seidl & Guérard,



Figure 1: Overview of meeting literature; Source: Author's creation, in accordance with Dittrich et al. (2011), Seidl and Guérard (2015).

2015). For example, the chair of the group leader is often situated at the head of the table, which demonstrates authority over the other meeting participants (Asmuss & Svennevig, 2009). Furthermore, one could argue that a seating arrangement in which the chairs in the meeting room are set far apart could create a physical barrier between strategists and consequently lead to a more formal and distanced interaction approach. On the other hand, utilizing meeting equipment, such as whiteboards or flipcharts while presenting, is crucial for the nature of physical meetings (Asmuss & Svennevig, 2009; Seidl & Guérard, 2015). Hence, strategists may be better able to gain the attention and respect of their colleagues by standing in the front of the room and illustrating their ideas with physical tools. Another important characteristic to mention is the physical location where the meeting occurs (Jarzabkowski & Seidl, 2008), as is further discussed below.

2.1.3. Characteristics of online meetings

Virtual meetings share many but not all of the characteristics of physical meetings. In line with the definition mentioned previously, they are also planned and episodic business gatherings where different forms of interactions occur (Seidl & Guérard, 2015). However, in comparison to physical meetings, those that occur over an electronic network involve other interaction forms and tools due to participants' virtual presence rather than face-to-face attendance. Meeting participants are no longer co-located in a physical room but rather linked online through the usage of audio, video and text. Suddenly, the office room and its furnishings as well as the location where the meeting occurs lose relevance while newly available tools gain importance (Cichomska et

al., 2015).

There exist various platforms, such as Zoom, Microsoft Teams, or Google Hangouts, that enable online meetings. These online platforms are characterized by different features. For instance, employees can customize their backgrounds which allows them to stage themselves. A raise hand feature allows the moderator to control the discussion flow. Another important feature of online meetings is the team chat, which enables the exchange of files, information and ideas behind the scenes. Finally, meeting participants can either turn their cameras on or switch them off depending on the meeting occasion and mood (Spataro, 2020).

The new online format of meetings has advantages as well as disadvantages compared to physical meetings. On the one hand, it is argued that the meeting moderators are better able to control the discussion flow by privately texting other participants in the background. This backchannel conversation can therefore be utilized to encourage quiet participants to speak more and to inform more vocal people that they are contributing excessively. Such notes to other participants are not possible without being noticed in face-to-face meetings. On the other hand, electronic meetings are less personal. As a social species, humans are accustomed to seeing and reading the body language of other people, which is only possible to a limited extent in online meetings and assuming that the cameras are turned on (Price, 2020).

Virtual meetings have gained remarkable importance over the past few years. Increasingly, companies are conducting online meetings in addition to physical ones. Additionally, online meetings are often both less expensive and less time-consuming (Cichomska et al., 2015). Furthermore,

the recent coronavirus outbreak has turned not only the world upside down, but also the way of strategizing. COVID-19 spread within a short time from person to person and thus from one country to another. When governments realized the threat, billions of establishments, schools, events and businesses were shuttered worldwide to avoid the spread of the virus. Hence, for companies, this meant that people were no longer allowed to enter their offices to conduct strategic work but had to remain at home, as the precautionary measures required (BAG, 2020). Consequently, firms had no other choice than to move strategy meetings online. Therefore, COVID-19 and the related shutdowns significantly accelerated the trend toward online meetings. Billions of people started working remotely full-time. The previously mentioned increase of per-day meeting minutes from approximately 900 million to nearly 2.7 billion corresponds to a 200% increase in online meeting minutes (Spataro, 2020).

2.1.4. Meeting functions

There are countless studies on meetings and researchers from various disciplines that have examined the characteristics of modern meetings. This has led to the lack of a universal theory of meetings; rather, many different concepts describe the role and dynamics of such business gatherings. Due to this large, fragmented stream of literature, Dittrich et al. (2011) conducted an extensive literature review in which they identify that meetings fulfill five purposes: coordination, symbolic, social, cognitive and political functions. Dittrich et al. (2011) call the first meeting function coordination. This relates to the administrative and organizational activities that occur during meetings, such as distributing information and planning the future of the organization. Second, meetings fulfill a symbolic function, which describes dimensions including rituals, social status and the legitimation of orders. Hence, this function is crucial for various actors to symbolically signal the established order within the organization. The third function describes meetings as a social practice that enables the establishment of relationships with colleagues and facilitates group affiliation. The fourth function is the cognitive function or the sense-making function because it relates to sense-making and critical reflection. Meetings are a sense-making device by providing a setting for the development of new idea and inputs. Finally, meetings can have a political function, as reviewed by Dittrich et al. (2011). This function describes the meeting participants' ability to take advantage of meetings by, for instance, asserting their own interests (Dittrich et al., 2011).

Dittrich et al. (2011) conclude that strategic work is influenced through these functions. Since the aim of this thesis is to analyze the relevance of power and politics in offline and online meetings, the political function is of particular interest and is discussed later in more detail.

2.1.5. Framework for studying meetings

To systematically study meetings as practices, Hendry and Seidl (2003) developed a conceptual framework by adapting Luhmann's social systems theory. From their viewpoint, strategy meetings and workshops are strategic episodes because they provide a "social mechanism by which reflective discourses can be pursued within the social system, but without necessarily disrupting the practices and routines by which that system is maintained" (Hendry & Seidl, 2003, 180). In other words, meetings are episodes that allow strategists to suspend and replace organizational structures for a limited period. The clearly specified beginning of the meeting enables them to switch off the context of the company while strategizing. The end of an episode can either be goal or time oriented in that the meeting ends when a specific goal or a predetermined time is reached. According to the framework, the distinct practices are be categorized into initiation, conduct and termination practices. The initiation phase describes the decoupling from the greater system of the organization. It must be decided who attends the meeting and which topics are included, such as which specific actors and issues are bracketed in or bracketed out (Boden, 1994). The conduct phase refers to the self-organization that is utilized during the meeting to conduct the meeting efficiently (Hendry & Seidl, 2003). Many studies have explored, for example, the phenomenon of turn-taking in meetings during the conduct phase (Angouri & Marra, 2010; Boden, 1994; Jarzabkowski & Seidl, 2008; Schwartzman, 1989). As a kind of organizational form in discourses and conversations, turn-taking ensures that the discussion contributions are distributed among the individual participants. The termination phase relates to the conclusion and the recoupling act at the end of the meeting. Everything discussed during the episode must be taken back to the wider system of the company when the episode ends (Hendry & Seidl, 2003). Figure 2 illustrates the three meeting phases according to Hendry and Seidl (2003).

Contrary to Hendry and Seidl (2003), Hoon (2007) finds that that informal interactions around meetings are not less important than the more formal ones during meetings. For this reason, this author argues that it is necessary to extend the framework with a phase before and after the meeting. Hoon's (2007) findings are supported by Mirivel and Tracy (2005), who highlight that pre-meeting talk, which includes preparatory and work talk, can significantly influence the shape of the actual meeting. Further, Jarzabkowski and Seidl (2008) mention the importance of observing preand post-meeting talks to catch relevant intentions and opinions of participants behind the scenes. Given the importance of such "behind-the-scene-discussions" (Hoon, 2007, 939), this work seeks to extend the aforementioned framework by adding fourth and fifth phases, called pre-meeting and postmeeting. While the three meeting practices highlighted by Hendry and Seidl (2003) refer to the episodes of the actual pre-planned business gathering with an agenda, these additional practices neither have an officially planned agenda nor are they officially scheduled. Based on Hoon's (2007) definition of informal interactions around meetings, this author refers to these informal practices in the sense of information exchange by phone, mail or face-to-face in hallways and offices. It is argued that strategists can deploy informal preand post-meeting practices to influence strategizing. For in-



Figure 2: Framework for studying meetings; Source: Author's creation, in accordance with Hendry and Seidl (2003).

stance, spontaneous coffee breaks in the corridor of the office provide an informal platform not only for exchanging ideas, but also for cultivating business relationships and building collegial support, which can have profound consequences for the later outcome of the meeting. However, in this author's opinion, Hoon (2007) neglects the role of artifacts in her analysis of informal strategic conversation. One could argue that not only informal conversations, but also the way in which documents are prepared before the meeting and processed after the meeting can impact strategic work. Therefore, pre- and post-meeting practices not only include social interactions, but also document preparation and follow-up.

In sum, it is argued that the distinct meeting practices can be categorized into five phases, as the slightly modified conceptual framework of Figure 3 displays. This framework for studying meetings is a point of reference for the further analysis of meetings in this thesis.

2.2. Power and politics

Within this section, the need to integrate power and politics in the analysis of meetings is outlined. This is performed by first critically reviewing definitions and concepts of power. Second, various research findings on power issues in strategizing are presented, and a micropolitical approach is introduced.

2.2.1. The concept of power

The nature of power in organizations is ambiguous and often arbitrarily defined. Even in the literature, a general definition of power does not exist. Since the concept of power is difficult to determine, various perspectives of different research fields are presented.

In the late 1950s, social psychologists French and Raven (1959) conducted a notable study in which they define *social power* as the ability to psychologically change the behavior, attitudes, values or beliefs of others through the mobilization of the following five power bases: *reward, coercive, legitimate, referent* and *expert powers*. Hereby, the power of individuals and thus the ability to influence others increases with the strength of the respective power bases. Reward power stems from a person's ability to reward others by, for example, complementing, offering training opportunities or raising wages. Conversely, coercive power refers to the capability of mediating punishment. A person capable of rewarding or punishing others is in a superior power position and can thus make

people perform tasks that they would not do otherwise. The third power base, legitimate power, is primarily based on an agent's hierarchical position within the organization. Basically, this type of power derives from an agent's perception that another agent is legitimized to exert influence over others due to an assigned or elected authority position. Consequently, this exertion of influence is often tacitly accepted by those whose behavior is indirectly determined. People with referent power tend to psychologically change others' attitudes and beliefs by respecting them and making them feel appreciated. Hence, referent power emphasizes identification, affiliation and similarity. The last base, expert power, originates from an actor's knowledge and expertise. An experienced person with considerable skills enjoys the respect and trust of others, which facilitates convincing them of certain ideas (French & Raven, 1959). A few years later, Raven (1965) added a sixth base to the power concept: informational power. This power base comes from possessing and controlling information that other actors need but only one actor has (Raven, 1965).

French and Raven's (1959) typology may be one of the most famous and most utilized power conceptualizations in research. Many power theories of mainstream management literature also assume that influence is exerted through the mobilization of power bases. Pfeffer and Salancik (1974, 1977), for instance, advance a model of organizational power by employing a strategic-contingency approach. They posit that power stems from the possession and control of "scarce critical resources" (Pfeffer & Salancik, 1977, 4). Such sources of power include the control of reward and punishment, legitimate authority, control of and access to information, domain-relevant expertise, creation of credibility, contacts with superiors and the control of uncertainty, as has been mentioned by various studies in organizational mainstream theory (Crozier & Friedberg, 1979; French & Raven, 1959; Mintzberg, 1983; Pettigrew, 1973; Pfeffer & Salancik, 1974, 1977; Raven, 1965). At this point, it must be emphasized that such lists of resources are far from complete since the inherent nature of power is not absolute but rather dependent on the context and its defined critical resources (Pfeffer & Salancik, 1977).

In social theory, however, power theories that conceptualize power as stemming from the possession and control of resources have been widely criticized. Foucault (1980, 1994), for instance, made a major contribution to power literature



Figure 3: Extended framework for studying meetings; Source: Author's creation, in accordance with Hendry and Seidl (2003), Hoon (2007).

by introducing an analytic of power rather than another theory of power, in which he focuses on the micro-techniques of power. According to Foucault, power is significantly linked to knowledge and circulates through discourses that can be seen as a cluster of organized and coordinated relations Foucault (1980, 1994). In an interview, the founder of the discourse analysis mentioned that "power in the substantive sense, le pouvoir doesn't exist" (Foucault, 1980, 198). According to Foucault, power is not rooted in the possession and control of resources and cannot be defined by certain qualities but is rather characterized by power-knowledge relations at a certain place at a given time (Foucault, 1980, 1994). Foucault's analytic of power influenced other sociologists such as Giddens (1984), whose conception of power is based on a theory of structuration, also called the duality of structure, in which power is not conceptualized as a resource, a quality, or a position of certain actors but rather as a social factor. Consequently, in social theory, power is not only seen as something negative in the sense of suppressing or influencing others, but also as something positive that makes the dynamics of development and change possible through social interactions and practices (Foucault, 1980, 1994; Giddens, 1984).

As mentioned, there is no universality to the definition of power due to the wide variety of concepts with either negative or positive connotations. This author does not desire to eliminate one at the expense of others, which is why this study focuses on a broad definition of power in neutral terms. Hence, power can be a negative as well as a positive force to achieve goals in the sense that it

concerns the ways that social relations shape capabilities, decisions, change; these social relations can do things and can block things unfolding. Power is ultimately about the choices that we make, the actions we take, the evils we tolerate, the goods we define, the privileges we bestow, the rights we claim, and the wrong we do. (Clegg et al., 2006, 3)

2.2.2. Power and politics in strategizing – A micropolitical approach

Authors Jarzabkowski et al. (2007) formulated in their introductory paper on strategizing five key questions that

are theoretically as well as practically important for SAP research. The fifth question, "How can existing organization and social theory inform an analysis of strategy-as-practice?" (Jarzabkowski et al., 2007, 7), is of particular relevance for this thesis. The recent turn in strategy research is considerably influenced by contemporary social scientists such as Giddens and Foucault Whittington (2006). To analyze issues of power in strategizing, many scholars employ Giddens' (1984) structuration theory and Foucault's (1980, 1994) epistemological discourse analysis theory, which have been briefly presented above. In particular, Foucault significantly influenced the SAP discipline with the introduction of the discourse analysis to study power-knowledge relations. For instance, Knights and Morgan (1991) utilized Foucault's work to identify strategic discourse and strategy itself as power mechanisms by characterizing strategy as a discourse, which in turn constitutes a body of power-knowledge relations. According to their seminal paper, strategic discourse allows upper managers to rationalize their activities and to legitimize and to enhance their managerial power positions in strategizing (Knights & Morgan, 1991). Subsequent studies (e.g., Laine & Vaara, 2007, Mantere & Vaara, 2008, Samra-Fredericks, 2005) built on the findings of Knights and Morgan (1991) to further analyze power issues in strategizing. Laine and Vaara (2007), for example, not only note that different types of employees utilize certain strategy discourses to find themselves with new levels of power, but also highlight the role of resistance to uncover power dynamics in organizations.

As pointed out, there exist various studies that are concerned with power in strategizing. Nevertheless, Clegg, Carter and Kornberger (Carter et al., 2008; Clegg et al., 2004) argue that the role of power in SAP research remains under-researched, positing that "studies of power and strategy would advance our understanding of the practice perspective" (Carter et al., 2008, 93). Other authors emphasize that the SAP perspective pushes politics and power mechanisms into the background by focusing primarily on routine practices and techniques. They criticize the implicit assumption that practices are shared by various strategists, which indirectly excludes political behavior (Ezzamel & Willmott, 2004). Motivated by this critique and referring to Jarzabkowski et al.'s (2007) fifth key question, Hansen

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and Küpper (2009) suggest integrating a micropolitical approach into the theoretical basis of the SAP perspective for a "power related contextualization of strategizing" (Hansen & Küpper, 2009, 24). From this perspective, it can be argued that organizations are influenced by politics, which can be described as "power in action" (Hardy, 1996, S3). According to Hardy (1996), influencing strategic work politically must encompass the following four power dimensions that integrate various aspects of the power theories mentioned above: power of resources, processes, meaning and the system. The first dimension integrates the mainstream approach (e.g., French & Raven, 1959, Mintzberg, 1983, Pettigrew, 1973, Pfeffer & Salancik, 1974, 1977), in which power stems from critical resources. By deploying critical resources, strategists influence the behavior of others, resist ideas and hence affect strategic action. Nevertheless, Hardy (1996) argues that power "restricted to the mobilization of resource dependencies" (Hardy, 1996, S6) provides an overly narrow conceptualization, so he suggests adding further power dimensions to analyze power and politics in strategizing. Therefore, the second dimension captures power that is rooted in decision-making processes and its underlying political tactics. For instance, individuals shape strategic work by indirect participation through the determination of participants and agendas. The third dimension incorporates power stemming from language, habits and symbols. In this dimension, strategists exert influence by legitimizing their own ideas and delegitimizing others (Hardy, 1996). This aligns with Pettigrew's (1977, 85) view that strategy formulation can be seen as a political process by defining "politics as the management of meaning." Later, Mueller, Whittle, Gilchrist, and Lenney (2013, 1191) contribute to the literature by indicating that sensemaking is a "political and power-laden process." Last, the fourth dimension resides in the power of the system, which can be traced to Foucault's work (1980, 1994) in which power is not considered to be an instrument of coercion and influence that individuals possess but rather as a positive, regularly embodied social phenomenon. In this sense, the fourth dimension excludes the idea that strategists mobilize the other three power dimensions to influence strategic work. The author of this thesis, however, agrees with Hardy's (1996) opinion that although managers may not be able to transform the system itself, they still deploy specific power dimensions to influence strategic work. Therefore, Hardy's (1996) fourth dimension - the power of the system - is put into the background and is not explicitly considered in this work. The three power dimensions in scope are summarized in Appendix 1.

Overall, this section has demonstrated that power conceptualizations do not necessarily exclude each other but can be utilized in combinations to study power and politics in strategic work. Strategic business gatherings are essential for shaping stability and change within an organization; therefore, *the exercise of power in meetings* deserves a closer examination. This is accomplished by comparing *political behavior in online and offline meetings*. According to the literature, it is necessary to dive deeper into the *political func-* *tion* of meetings as identified by Dittrich et al. (2011). Altogether, a micropolitical view is integrated into the analysis of strategy meetings by conceptualizing meeting practices as routinized political behavior applied by strategists who act as *micro-politicians*. This perspective is based on Hansen and Küpper's (2009) paper on power. Political activity can, therefore, be utilized to advance personal as well as organizational goals, which is well in line with the neutral power definition of this paper.

2.3. A power-related perspective of meetings

The final section of this literature review combines the theoretical background on meetings with the notions of power and politics. The first part discusses the political function of meetings for a more comprehensive understanding of power and politics in meetings. The second part presents various micropolitical practices that have been identified in the strategy literature and thus serve as a basis for the empirical part of this thesis.

2.3.1. The political function of meetings

As previously mentioned, meetings have an interorganizational political function which must be analyzed closely to capture the underlying power mechanisms in strategic work. Dittrich et al. (2011) reveal in their literature review that strategists politically utilize meetings to influence strategic work by *setting and advancing the agenda, building support and forming alliances, exerting influence, suppressing new ideas, keeping topics on the agenda* and *negotiating*. This section dives deeper into the concepts of power and politics by providing an overview of relevant research findings regarding these six dimensions of the political function of meetings. Therefore, it focuses on a wide range of papers outside the field of organizational research to illustrate comprehensibly how the political function of the meetings is identified.

Setting and advancing the agenda

Tepper (2004) analyzed the role of meetings as instruments of policymaking by determining whether strategic forums are important in "generating alternatives and setting agendas" (Tepper, 2004, 521). To answer this research question, he conducted an extensive literature review on nonroutine gatherings. Hereby, he identifies characteristics of meetings that serve a policy purpose, concluding that policymakers can utilize meetings as framing devices because they offer an opportunity to promote specific programs and alternatives (Tepper, 2004).

These results align with the findings of Adams (2004), who analyzed the sense in which public meetings encourage citizens to participate in policymaking processes. Contrary to his expectations, citizens cannot utilize meetings to directly influence the decisions of the government. Nevertheless, meetings offer citizens an opportunity to raise important issues and thereby to enhance their political power. Overall, Adams (2004) argues that meetings are a "tool that citizens can use to achieve political objectives" (Adams, 2004, 43). Overall, Adams (2004) and Tepper's (2004) findings suggest that strategy meetings can additionally be utilized politically by advancing a certain agenda and promoting interests.

Building support and forming alliances

Adams (2004) further finds that public meetings provide a venue for politicians to acquire support from the nation. Kangasharju (1996, 2002) reports that meetings provide not only a means for demonstrating and receiving support, but also for forming alliances or coalitions. According to Kangasharju's (1996) first study, such alliances are based on external factors, such as friendships, and are not necessarily relevant for the conversation itself. However, associations are consequential for the discussion when they are made visible to other committee members when both parties act as a team. Utilizing data from videotaped meetings of an institutional committee, she finds that the underlying interactive nature of meetings enables the spontaneous emergence of so-called "interactional teams" (Kangasharju, 1996, 291). More precisely, interactional environments, such as conflicts that arise in multiparty conversations, tempt participants to choose sides, which often leads to opposing groups that both establish their identities (Kangasharju, 1996). In a subsequent study on committee meetings, Kangasharju (2002) reinforces the importance of disagreements in meetings and the associated formation of oppositional alliances by highlighting that they are a "potentially powerful device which can be utilized to pursue important goals" (Kangasharju, 2002, 1460). Based on these findings, this author argues that team building before, during and after meetings enables collective action and opposition, which can considerably influence the power position of certain actors in the strategy-making process.

Exerting influence

Other studies report that meetings exert influence through the usage of power (Clifton, 2009; van Praet, 2009; Wodak et al., 2011). For instance, Wodak et al. (2011) investigated to what extent CEOs influence meeting outcomes by building team consensus in strategy meetings. According to the findings, Chief Executive Officers (CEOs) positively as well as negatively affect the results of a meeting by deploying distinct discursive practices, as is further discussed below. On the one hand, leading managers hinder the formation of a general agreement. On the other hand, they are in the hierarchical position to control team interactions and foster team consensus (Wodak et al., 2011). Moreover, Clifton (2009) analyzed the extent to which not only managers, but also subordinates employ specific discursive practices to influence decision-making and thus the meeting outcome. In his study, influence is conceptualized as "a fluid process or set of potentials within teams" rather than a possession of certain meeting participants (Clifton, 2009, 60). It must be emphasized, however, that spontaneous and reflexive skills are necessary to exploit such potential and that certain resources are only available to superiors (Clifton, 2009). Finally, van Praet (2009) contributed to this dimension by exploring power relations at a British embassy. He analyzed to what extent ambassadors as political leaders utilize their central role in meetings to sensitize and legitimize the ideology they have developed. By following Goffman's interaction theory and applying a multiple data collection method, van Praet (2009) further finds that meetings are politically utilized by the central player to exert influence over other participants. According to the participants' perceptions, "contributing to the meeting is perceived as an act of obedience and commitment to the Ambassador's will and to the projected group norm of solidarity, participation and involvement" (van Praet, 2009, 93).

Suppressing new ideas

Another dimension of the political function of meetings is the opportunity to suppress new ideas from meeting members as outlined in Dittrich et al.'s (2011) literature review. Jarzabkowski and Seidl (2008), for instance, observed 51 meetings in a university context to address their research question of how meetings are utilized to influence the stability of strategic direction, such as the stabilization of existing strategies, as well as to promote changes, such as the destabilization of existing strategies. They report that the person who chaired the meeting was to some extent legitimized to determine who may attend the meeting and speak during the conduct phase. Hence, the chairperson who was in favor of stabilization rather than destabilization of existing structures suppressed new ideas utilizing certain discussion modes. Further, the authors add that the chair could further strengthen the structural authority by devaluing other participants' proposed variations (Jarzabkowski & Seidl, 2008). One year later, Schwarz (2009) contributed to the literature by conducting a longitudinal case study in which she also analyzed how strategy workshops are utilized to constrain strategy formulation. She concludes that workshop participants offer resistance and reject participation when they want to circumvent ideas developed by others (Schwarz, 2009).

Keeping topics on the agenda

Other studies find that meetings fulfill a political function in that they are utilized as a holding place. Tepper (2004) reveals that meetings offer an opportunity to keep certain items on the political agenda until a decision can be made (Tepper, 2004). These results align with the findings of Jarzabkowski and Seidl (2008).

Negotiating

Finally, meetings serve a political function in negotiating, as identified by Dittrich et al. (2011). According to Boden (1995), however, everyday negotiations in business gather-

ings are defined as "sequentially structured rather as determined by relations of power" (Boden, 1995, 84). In his view, negotiation is framed through everyday language and talk. Specifically, actors construct conflict and consensus environments by utilizing certain linguistic devices (Boden, 1995). Asmuss and Oshima (2012, 67) further highlight the negotiation dimension by stating that meetings provide a venue for employees to constantly negotiate their positions, which they call "the negotiation of entitlement." In their opinion, entitlement to make proposals and accept or reject them is not a predefined characteristic of meeting participants but is negotiated by interacting closely (Asmuss & Oshima, 2012).

Altogether, the six dimensions of the political function of meetings as identified by Dittrich et al. (2011) allow individuals to utilize meetings politically. At this point, it is important to mention that these dimensions do not exclude each other but are often combined.

2.3.2. Micropolitical practices in meetings

For a fuller understanding of how power is utilized to influence *strategic work*, this subchapter focuses closely on meeting practices that are applied by different *strategists*. Hereby, relevant research findings on meeting practices, referred to as *political tactics*, are outlined by dividing them into the five episodes according to the extended framework displayed in Figure 3. This method of analysis is motivated by Jarzabkowski and Seidl's (2008) study, who applied the original framework suggested by Hendry and Seidl (2003) to study meeting activities.

Pre-meeting phase

According to the modified framework for studying meetings, pre-meeting practices include social interactions as well as other practices, such as document preparation. Hoon (2007) highlights the importance of "strategic conversations" (Hoon, 2007, 927) between senior and middle managers around meetings. Referring to Balogun, Gleadle, Hope-Hailey, and Willmott (2005), Hoon (2007) notes that such "back-stage activity can be understood as a preparation for front-stage activity and it is used to manipulate these frontstage activities" (Hoon, 2007, 945). These practices entail creating understanding and alignments as wells a making pre-compromises; they align with the second dimension of the political function of meetings — building support and forming alliances.

Kaplan (2011) further highlights the usage of PowerPoint as a powerful technological communication device. She mentions that the "connections between cognition and politics are unavoidable" when analyzing PowerPoint usage in strategic work (Kaplan, 2011, 343). Furthermore, she finds that socalled PowerPoint affordances that are accessible to different strategists are utilized for different purposes, such as setting the boundaries around strategic work and facilitating the negotiation of meaning through collaboration. In her opinion, such boundary work or cartography is politically relevant in deciding which topics are addressed in the decision-making process during meetings. Hence, she emphasizes that strategists who control which slides are included or excluded in the document can promote their own interests by highlighting specific ideas and providing direction (Kaplan, 2011). Based on her findings, it can be argued that documents are a power mechanism when they embody certain ideas that are generated and selected by actors in the pre-meeting phase.

With regard to online meetings, it is unclear to what extent people utilize events before the meeting to influence strategic work. Especially if, as during COVID-19, companies rely entirely on home offices, informal talks in the hallways before the meeting are no longer possible. Additionally, the collaboration for the preparation of documents is more difficult if the responsible persons are not in the same office but have to coordinate virtually. Nevertheless, careful document preparation may become increasingly important to set boundaries in advance.

Initiation phase

Switching off the organizational context is the critical aspect of the initiation phase, as previously introduced (Hendry & Seidl, 2003). Jarzabkowski and Seidl (2008) highlight the deployment of orientation practices to decouple meeting structures from the greater system. Furthermore, they reveal that meeting practices such as "bracketing participants in central location," "setting the agenda" and "chairing" during the initiation phase can leverage the authority of upper management (Jarzabkowski & Seidl, 2008, 1401-1403). In other words, an upper manager's authority is physically as well as symbolically privileged if the meeting members assemble at a place chosen by the manager because upper managers are often situated at the central location while other participants are not. Furthermore, by setting and introducing the agenda, upper managers decide what will be discussed in the meeting, which significantly shapes the structure of the meeting (Jarzabkowski & Seidl, 2008). These findings align with insights from the political studies that have been introduced above (Adams, 2004; Tepper, 2004). Finally, the authors find that upper managers who are frequently responsible for chairing the meeting further increase their authority by determining the meeting procedure of the next meeting phase — the conduct phase (Jarzabkowski & Seidl, 2008). These results are supported by other meeting analyses outside the strategizing context (Angouri & Marra, 2010; van Praet, 2009) and especially express the first dimension of the political function of meetings - setting and advancing the agenda. In addition to the previously mentioned findings, the entrance of the ambassador — the political leader — as well as a potentially lengthy monologue to open a meeting are highlighted as power demonstrations. The leader's powerful appearance and speech at the beginning of the meeting remind other participants of the manager's superior position, which keeps other participants from speaking (van Praet, 2009).

With the increasing trend toward online meetings, the question arises whether power stemming from physical and

symbolic authority vanishes when people no longer gather within the organization. If meetings are conducted online from home, then upper managers no longer determine the location. Conversely, participants are in their familiar surroundings, which may make them feel more comfortable. Furthermore, the opportunity to demonstrate authority through a powerful entrance and appearance at the beginning of the meeting is removed when meetings are held online. According to the author's view, online meetings could, therefore, leverage the power of other employees to politically utilize meetings while decreasing the power of upper management due to the loss of physical and symbolic authority. Therefore, it is important to closely investigate the power of orientation practices in the context of online meetings.

Conduct phase

Conduct practices are likely the most important meeting practices because they define the effectiveness of business gatherings, which significantly depends on self-organization (Hendry & Seidl, 2003). As mentioned previously, turntaking as a type of organization in discourses is utilized by actors to determine which participant is allowed to speak at a given time. The author of this thesis argues that an actor who regulates the granting of the right to speak thus politically utilizes meetings. Especially in formal meetings, chairpersons are often granted the power to control the flow of the discussion by utilizing specific linguistic devices (Angouri & Marra, 2010). Jarzabkowski and Seidl (2008), for instance, find that the chairperson can hinder the emergence of a new strategic orientation in meetings by appointing the speakers in different discussion modes, such as restricted discussion, restricted-free discussion and administrative discussion. Such meeting practices are political tactics and are represented by the suppressing new ideas dimension. Furthermore, van Praet (2009) concludes that leaders are likely to control turn-taking to enhance their central position during meetings. The author of this thesis questions to what extent meeting participants other than the chairperson are endowed with the authority and power to control turn-taking in conversations.

Wodak et al. (2011) offer similar findings by analyzing how CEOs politically utilize meetings by controlling team interactions and fostering team consensus. They describe five specific discursive practices that are likely to be employed by leadership to influence decision-making in meetings: *bonding, encouraging, directing, modulating* and *re/committing* (Wodak et al., 2011). Bonding refers to constructing identity and building consensus during team meetings. By utilizing sentences starting with *we* instead of *I*, chairpersons, on the one hand, accept and, on the other hand, avoid personal responsibility. Furthermore, those meeting members who have different opinions are often excluded from group thinking that could further weaken the leader's relational power position. Encouraging describes the chairpersons' relaxation of power insofar as they support the participation of other meeting members (Wodak et al., 2011). This author questions to what extent leaders indirectly exercise power by encouraging only selected participants to speak while discriminating against those with different opinions. Gathering selected opinions could thus strengthen the power position of leaders in a rather subtle and vague way. Directing is the practice of closing a discussion. For instance, chairpersons can utilize their authority to promote personal interests by not inviting other participants to more dialogue. Finally, modulating and re/committing are identified as practices utilized to invite other meeting participants to action. However, while modulating is utilized to stress the urgency to react, re/committing is more likely to remind others of their personal obligations to take appropriate measures (Wodak et al., 2011). Wodak et al.'s (2011) identified practices align with the political dimensions labeled as suppressing new ideas and exerting influence. Therefore, it is important to mention that the exercise of power can have negative as well as positive consequences on the meeting outcome depending on the combination of these five discursive practices. In a subsequent study, Kwon et al. (2014) identify the following discursive practices that leaders utilize to develop a shared view in team meetings: equalizing, re/defining, simplifying, legitimating and reconciling. In the context of power and politics in strategy meetings, it is necessary to emphasize the fourth practice — legitimating — as a potential micropolitical practice. In strategic discussions, strategists gain control through highlighting the relevance of their beliefs and underlying assumptions.

Further, Clifton (2009) identifies that specific *formulations* are a powerful mechanism for managers to close topics. As an implicative for the end of a discussion, managers can stop the emergence of further arguments that could threaten their decision. Such deletion of other voices and the related reduction of decision-making conversations, as identified by Clifton (2009), are exploited by upper managers to utilize meetings politically during the conduct episode in which decisions are made. Subordinates, however, can gain influence over decision-making conversation by "maneuvering the decision-maker into alignment" (Clifton, 2009, 68). Hence, meeting participants at lower hierarchy levels steer the discussion outcome into a preferred direction by gaining the vote and support of the chairperson or superior person by creating alignment (Clifton, 2009).

Fewer studies analyze the role of specific linguistic devices and bodily activities that underlie discursive practices during the conduct phase. Nevertheless, the display of emotions through tone or facial expression is a powerful political tactic because it generates different interpretations (Liu & Maitlis, 2014). Kangasharju (1996, 2002), for instance, finds that various devices are utilized to indicate affiliation or disaffiliation with other participants. *Repeating and paraphrasing* another speaker's arguments are employed to signal team alliances. Moreover, nonverbal behavior such as *eye contact, posture* and *gestures* not only indicate agreement or mutual understanding, but also disagreement and distance. Finally, the author mentions *smiling and laughter* as means of

demonstrating affiliation (Kangasharju, 1996, 2002).

Clifton (2009) additionally finds that laughter can be utilized to exert influence. Liu and Maitlis' (2014) study is one of the first that uncovers the underlying emotional dynamics in executive management meetings and their indirect effects on strategic work. Thereby, they distinguish between the display of positive and negative emotions; positive emotions, such as energetic exchanges and amused encounters, strengthened team relationships, which in turn, led to more collaborative strategic work. Contrarily, the display of negative emotions, such as discord interactions, recurrent confrontations and depleting barrages, forced team members apart, which resulted in decision postponement and prevention of strategic actions due to missing commitment and consensus. Altogether, these systematic ways of signaling proximity and alliance or distance and opposition in meetings are interpreted as political practices.

Again, the question arises regarding the extent to political tactics change if meetings are online. For instance, turntaking becomes a more powerful tactic in online meetings if the chairperson mutes and unmutes individual participants during the meeting. Furthermore, it is unclear to what extent it is possible to control team interactions by utilizing specific discursive practices. Finally, if the cameras are switched off, then it is no longer possible to have eye contact and observe facial expressions of other participants. Kangasharju (1996) finds that alliances must be made visible to other members to be relevant for the meeting outcome; therefore, it can be claimed that it is no longer possible to form alliances during online meetings. Even if the cameras are on, reading facial expressions of other meeting members may become an issue and change the political usage of meetings.

Termination phase

As mentioned, termination practices refer to the dissolvement act of specific meeting structures by recoupling the process with the wider system of the organization. Jarzabkowski and Seidl (2008) identify various practices that are regarded as political when terminating a meeting: rescheduling, setting- up working groups, voting and stage managing. Rescheduling and creating working groups that carry topics from meeting to meeting are tools utilized to keep certain topics on the agenda until a suitable time. These practices express the fifth dimension of the political function of meetings — keeping topics on the agenda. Furthermore, voting is likely to be associated with the deselection of proposed strategic alternatives and could therefore be utilized by powerful strategists to eliminate them. In contrast to voting, stage managing is likely to be utilized to destabilize existing strategic orientations by increasing acceptability and legitimacy of new strategic initiatives (Jarzabkowski & Seidl, 2008).

When meetings occur online, it does not seem to have a particular impact on these identified micropolitical practices. Nevertheless, it is worthwhile to examine this in more detail in the empirical part of this paper.

Post-meeting phase

Post-meeting practices extend the framework of Hendry and Seidl (2003) by adding practices after meetings end; however, they are worth consideration for the analysis of how meetings are utilized politically. Accordingly, these types of practices are similar to pre-meeting practices, which have been discussed previously.

Overall, based on the existing literature, micropolitical practices in strategy meetings are categorized as discursive and orientation practices (e.g., Jarzabkowski & Seidl, 2008, Kwon et al., 2014, Wodak et al., 2011) that are underscored and supported by linguistic and technological devices (e.g., Kaplan, 2011) as well as bodily actions (e.g., Liu & Maitlis, 2014). According to Seidl and Guérard (2015, 11), discursive practices are defined as the "patterns of saying and the discursive devices that people use," whereas orientation practices refer to logistic facilities necessary for successfully holding a meeting (Seidl & Guérard, 2015, 11). Additionally, meeting practices are constantly shaped by factors such as different cultures, values, beliefs, leadership styles, individual characteristics and personal skills as well as formal positions. Furthermore, the literature review of potential micropolitical practices in meetings provides clear indications that different power dimensions, as introduced by Hardy (1996), are active when analyzing political behavior in meetings. Hence, the relationship of different factors and power dimensions is analyzed in more detail in the empirical part of this thesis. In this sense, the purpose of this work is to close the research gap between power and meetings in strategizing by integrating existing organizational and social theory into the analysis of SAP.

Moreover, the analysis of political tactics has revealed that few studies in SAP research address the usage of technology in meetings. Similar to Whittington (2006), Orlikowski (2000) suggests, therefore, a "practice-oriented understanding of the recursive interaction between people, technologies, and social action" (Orlikowski, 2000, 405). According to Orlikowski and Scott (2008), approximately 95% of organizational research does not consider the role of technology while conceptualizing social and technological aspects separately and thus neglects the importance of technology in organizations themselves. Vaara and Whittington (2012) built on this argument by highlighting that SAP research must address the role of materiality systematically to capture the importance of material technologies, such as virtual meetings, in strategic work. Consequently, the way in which technology that is fundamental to contemporary organizations is utilized is not sufficiently explored from a practice-based perspective (Vaara & Whittington, 2012).

Given the theoretical background of meetings, power and politics as well as the need for future research, this thesis poses the following research question:

How do strategists politically utilize offline and online meetings to influence strategic work?

Specifically, this thesis focuses on two aspects: On the one side, it examines how strategists mobilize different dimensions of power and rely on different power mechanisms to promote their ideas and gain control over meeting discussions. On the other side, it explores how strategists' political tactics are changing due to the increasing trend toward online meetings, as has been outlined. By comparing applied political tactics in virtual meetings to those in physical meetings, this thesis stresses the importance of focusing closely on the political function of online meetings from an activitybased view. To answer the research question, a case study based on PCIs is conducted, as is outlined in the next chapter.

3. Empirical Setting and Method

The previous chapter explored existing literature on power and politics in meetings; this chapter focuses on the empirical setting and method necessary to answer the research question. The first part discusses the motivations behind the chosen research design. The second part focuses on the data collection method by introducing PCIs. The last part outlines in detail how the data was analyzed, utilizing first- and second-order concepts based on a grounded theory approach.

3.1. Research design

This section provides an overview of the chosen research design. It highlights that political behavior in meetings must be analyzed from various perspectives, and justifies the determination of an appropriate research strategy. Finally, it discusses the selection of cases by presenting an overview of the research setting and sample.

3.1.1. Beginning phases of research

The focus of this empirical work is on strategists, also called practitioners, who utilize meetings politically to influence strategic work. Practitioners are the actors who perform and execute strategy. The practitioners' origins, their personal identities and the actions as well as practices that they choose are crucial to strategic work. The two primary groups of actors are upper and middle managers, as they are the prime movers of strategy. Since SAP research attempts to avoid the typical view of top-down strategy processes, various studies additionally focus on the importance of middle managers in strategizing (Jarzabkowski et al., 2007). Balogun and Johnson (2004) note that middle managers guide other employees toward new strategic ideas by making sense of strategic changes. Hope (2010) builds on this study and finds that middle managers employ specific power resources, such as special expertise, to politically influence the strategy change outcome. Nevertheless, there exists a rising criticism that practice-based research on strategy as well as power literature conceptualizes power as a commodity of upper managers while neglecting the potential abilities of middle-level employees to influence strategic work (Hansen & Küpper,

2009; McCabe, 2010). According to Hansen and Küpper (2009, 9), "strategies evolve in a micropolitical context and are the result of a negotiating process of micropolitical interested actors on all levels of the hierarchy." Hence, especially with regard to power in meetings, the role of middle managers has not yet been examined to the same extent as that of upper managers. Therefore, various researchers indicate that meeting practices should not only be analyzed from the perspective of upper managers, but also from the view of middle managers and other employees (e.g., Dittrich et al., 2011, Seidl & Guérard, 2015). Seidl and Guérard (2015) expect that specific meeting functions - here, the political function — differ significantly between higher and lower organizational levels because all meeting participants have distinct cognitive skills and resources that they utilize, which allow them to steer discussions and influence meeting outcomes (Asmuss & Oshima, 2012). Building on these findings, this author argues that it is important to analyze political behavior in offline and online meetings from various angles. Consequently, capturing different perspectives of upper and middle managers is crucial to investigate how strategists politically utilize meetings to influence strategic work.

3.1.2. Determination of the research strategy

To define a suitable research strategy that properly answers the research question, various methods were considered. The different research approaches, such as the analysis of archival information, histories, experiments, surveys and case studies, have their own advantages and disadvantages (Yin, 2003). According to Yin (2003), the following three key conditions determine the appropriate strategy: (1) the formulation of the research question, (2) the degree of control that the researcher has over behavior and events and (3) the focus on contemporary or historical issues.¹ This thesis seeks to answer a how question by aiming to analyze how strategists politically utilize meetings. Further, no control of the investigator over behavioral events is required to analyze and answer this research question, which eliminated the usage of experiments. Finally, the study of physical and online meetings is based on a set of contemporary events as opposed to historical events. Based on these conditions, the author considered a case study, which is defined as "an empirical inquiry that investigates a contemporary phenomenon within its reallife context" (Yin, 2003, 13) to be the appropriate research strategy for this paper. Yin (2003) distinguishes between four case study designs, depending on how many units of analysis and how many contexts are studied. This study covers the analysis of people's perspectives about the political function of meetings from several companies, whereas each company is the subject of an individual case. Consequently, a holistic multiple case study design was applied. The motivation behind the application of this case study type is further outlined in Section 3.1.3.

 $^{^1{\}rm A}$ clear presentation of the different possible research strategies according to Yin (2003) is found in Appendix 2.

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Moreover, a qualitative research approach seemed to be suitable for the following reasons. In contrast to quantitative approaches, which objectively assess reality on the basis of considerable datasets, qualitative approaches analyze the complexity of a phenomenon more deeply from the perspective of the researcher by purposefully collecting, analyzing and interpreting data. Furthermore, qualitative research enables the researcher to formulate and build new theories rather than testing pre-existing theories (Williams, 2007). Since this work is about analyzing the political tactics of employees in the context of offline and online meetings, it makes sense to utilize a qualitative research approach so that the social phenomenon can be examined from the researcher's perspective (Williams, 2007), which allows deep insight into the individual case (Flick et al., 2000). In the literature that focuses on the political function of meetings, a wide variety of qualitative methodologies are applied. For instance, van Praet (2009) and Jarzabkowski and Seidl (2008) report results from ethnography, while Tepper (2004) conducted a case study. To study meeting practices, the majority of studies in SAP research utilize critical discourse analysis to analyze the written and spoken language in strategy meetings (e.g., Kwon et al., 2014, Wodak et al., 2011).

3.1.3. Selection of cases

To provide an overview of the selected cases, the following three parts present how access to the case study sites was gained and highlight relevant characteristics of the research setting and sampling.

Research access

Access to the case study sites was obtained primarily via accessibility to key persons, also called gatekeepers, as is likely to occur in qualitative research investigations (Merkens, 2000). According to Merkens (2000), gatekeepers are persons within an organization who are accessible to the researcher. Hence, the author contacted various acquaintances working in different companies that regularly hold online and offline meetings. At this point, it must be stressed that the researcher deliberately decided against conducting an in-depth case due to the following reason. If the selection of study participants is based on accessibility instead of selection criteria, then there is a risk that the research investigation will strongly depend on the accessibility to a single case and thus on the perceptions, motives and attitudes of the people working in the respective company (Merkens, 2000). Hence, the findings of this work would have been significantly influenced by the meeting culture and the workforce of a single company. To supplement and complete the findings, Merkens (2000) suggests extending the single case to a case group. Therefore, a holistic multiple case study design instead of a single case study design was chosen.

The selection of additional participants from each company was initially based on the snowball principle, a sampling technique in which the primary data source names other potential interview partners who possess researchrelevant characteristics (Biernacki & Waldorf, 1981). The gatekeepers of the respective companies thus were central because they were able to recommend and motivate people for interviews. However, the author carefully selected suitable candidates from these referrals based on the ongoing analysis of the existing data. More precisely, subsequent sampling was integrated with data collection and analysis, as suggested by Glaser and Strauss's (1967) concept of theoretical sampling, which is an established method of case selection in explorative-qualitative research design and contrasts representative random sampling methods. Thereby, case selection decisions are based on pre-developed categories and concepts rather than on preconceived assumptions and frameworks (Glaser & Strauss, 1967). Consequently, no pre-determined sample of interview partners existed at the beginning of the empirical process. Conversely, interview partners were further selected according to the criteria of theoretical relevance, which states that the researcher only chooses comparison groups that enable the development of emerging categories and concepts. Thereby, the control over differences and similarities is a predominant factor (Glaser & Strauss, 1967). Since the goal of the thesis is the general exploration of political behavior in online and offline meetings, the most heterogeneous cases were considered. Hence, by maximizing the differences between the companies and the interview partners in the same group, the aim was to detect basic patterns to the greatest extent possible (Glaser & Strauss, 1967). In theoretical sampling, researchers usually stop adding cases when no new insights can be gained, which means that the list of categories is theoretically saturated (Glaser & Strauss, 1967). In the context of this master thesis, however, time constraints made the usage of theoretical saturation possible only to a limited extent. The next two sections provide a detailed overview of the companies - the research setting — as well as the interview partners — the research sample.

Research setting

Utilizing the snowball method, which started with gatekeepers, it was possible to gain access to eight companies. Five of these eight companies were finally selected for the study. The selection criteria that emerged in the course of the research process can be summarized as follows:

- Online versus offline meetings. For a careful comparison of online and offline meetings, it was necessary to choose only those companies that were already experiencing the usage of offline *and* online meetings.²
- Camera policy. To analyze the importance of physical and virtual presence, a setting consisting of firms with different camera policies was chosen.

²The usage of online meetings is not just temporary due to COVID-19.

• Company characteristics. Throughout the analysis, it became clear that there exist significant differences in the evaluation of power in meetings depending on environmental as well as organizational factors. Therefore, considerable care was taken to select companies that are as heterogeneous as possible to generalize the findings on political behavior in meetings. The selected companies differ in the economic and business sectors they operate in, the location of the headquarters, their annual revenues, the number of employees and their organizational structure. In particular, the different structures of the companies ensured that the results were not limited to firms having a certain hierarchical order.

Further detailed characteristics of the five case companies are provided in the table displayed in Appendix 3. It is important to stress that the role of companies is secondary in this work, as the focus of the analysis is on the perspective of upper and middle managers rather than the differences between companies. Therefore, the author refrains from significant elaboration on company characteristics.

Research sampling

As previously mentioned, the subsequent sampling was based on the principles of grounded theory. In the sense of multi-perspectivity, care was taken that only those people were chosen who were useful for the development of the theory. Hence, the sampling group within the same company consistently came from *two* different hierarchical levels. Specifically, each company's sampling group included one person having a *higher* position (*upper management*) and one person having a *lower* (*middle management*) position relative to the other. In all five companies, the relatively lower person directly reported to the superior person. Furthermore, the respondents regularly participated together in virtual and physical meetings. This allowed a direct comparison of the participants' perspectives on the political function of meetings.

At the end of the research process, five upper and five middle managers from five companies were interviewed to capture employees' perspectives about the exercise of power in meetings. The respondents differed not only with respect to their position in the company, but also with respect to their experience, age and gender. The number of persons either directly or indirectly subordinate to the respondents varied between two and 300 persons. Two women and eight men were interviewed; all were between 34 and 65 years of age and had between 1 and 30 years of experience in their respective companies. The research sample is presented in Table 1 and further documented in Appendix 4.

As portrayed, the interview partners comprised a wide range of employees working in companies with different organizational structures. Such a heterogeneous sample offered the opportunity to acquire an understanding of how different types of individuals politically utilize meetings and how actors from different hierarchical levels perceive the political function of meetings. Furthermore, the diverse sample enabled the researcher to make comparisons between two hierarchical levels within the same company as well as between different hierarchical levels across companies.

3.2. Data collection

According to Yin (2003), a carefully conducted case study should include several sources of information because each source has its own advantages and disadvantages. Therefore, Yin (2003) suggests triangulating data. The approach to multiple sources of evidence can be based on data collection methods such as documentation, interviews, archival records and direct observation (Yin, 2003). However, due to time constraints and COVID-19, which required personal contacts to be kept to a minimum, triangulating data was possible only to a limited extent. Hence, the main sources of evidence were interviews complemented by constantly writing notes regarding respondents' behavior as well researching company characteristics on websites and in annual reports.

3.2.1. Data collection method

Since this work investigates the political behavior in offline and online meetings, interviews were well suited as a primary data collection method because they enabled the researcher to inquire regarding motives for action and situational interpretations in a generally open form. Furthermore, interviews are utilized to capture and reconstruct the subjective perspectives of the respondents (Hopf, 1978). When deciding on the appropriate interview form, Hopf (1978) names three relevant factors: (1) the openness of the questions and the respect of their sequence, (2) the concentration on specific constellations of topics, situations and questions and (3) the narration of the interviewed person. Considering these three questions, this author chose a compromise between semistructured and narrative interviews, also called PCIs. Hereby, the researcher follows an interview guideline although the questions are open, and the sequence of questions is freely selectable (Hopf, 1978). The methodology of PCIs is widely utilized in qualitative social research and is traced to Andreas Witzel. It focuses on respondents' individual reflections, perceptions and experiences on a certain problem or topic - here, the exercise of power in online and offline meetings. PCIs combine inductive and deductive procedures. On the one hand, the researcher acquires a theoretical, scientific understanding via a literature review. On the other hand, a so-called principle of openness is realized by utilizing respondents' narratives to modify the more theoretical concepts (Witzel, 2000).

3.2.2. PCI instruments

Usually, four instruments are utilized to conduct such PCI: (1) a *short questionnaire*, (2) an *interview guide*, (3) the *interview recording* and (4) *postscripts*. In the following section, these four instruments are briefly introduced.

Interviewee*	Position of interview partner	Number of subordi- nate persons	Corporate structure of the company
I.1A	Upper management	Direct: 25; indirect: unknown	Typical matrix organization
I.1B	Middle management	Direct: 7-9	
I.2A	Upper management	Direct: 7; indirect: 30	Decentralized organization
I.2B	Middle management	Direct: 5	
I.3A	Upper management	Direct: 6; indirect: 47	Matrix organization
I.3B	Middle management	Direct: 1	
I.4A	Upper management	Direct: 20; indirect: 300	Centralized organization (hi- erarchical)
I.4B	Middle management	Direct: 9	
I.5A	Upper management	Direct: 12; indirect: 230	Decentralized organization
I.5B	Middle management	Direct: 2	

Table 1: Overview of interview partners; Source: Author's creation

*For each company, the person having a higher position is marked in dark grey and the person having a lower position is marked in light grey. For reasons of anonymity, no more detailed information is given.

Short questionnaire

The first instrument utilized for PCIs is the short questionnaire, which has two functions. It collects sociodemographic data from the interviewees (Witzel, 2000), and as Witzel (2000) highlights, a short questionnaire at the beginning of the interview avoids interrupting the flow of the conversation. According to Witzel, a question-answer structure during the interview itself can disturb the subjective views of the respondents (Witzel, 2000).

Interview guide

The second instrument, the PCI guide, enables the researcher to cover important topics by encouraging storytelling through certain communication strategies. The following four communication strategies are applied to stimulate a free narrative and concurrently structure the interview: (1) preformulated introductory question, (2) general explorations, (3) specific explorations and (4) ad-hoc questions. A preformulated introductory question opens the interview. This question should be as open as possible and cover a broad spectrum without focusing on specific problems. Therefore, particular attention must be paid to avoid a predefined direction in the conversation that could occur in a traditional question-answer game (Witzel, 2000). According to Witzel (2000), general explorations allow the interviewer to further explore the subjective perspectives of the respondents and to elaborate on the actual research question by requesting examples and prompting details. Specific explorations examine in detail what has already been said. The statements of the interviewees are reflected, questions of understanding are posed, and further perspectives are promoted through confrontation (Witzel, 2000). Finally, ad-hoc questions supplement the interview answers with the missing aspects that are important for the study. These are preformulated questions from the interview guide rather than spontaneous questions. Such preformulated questions ensure that the findings of the various interviews can be compared (Witzel, 2000).

The interview guideline utilized the SPSS method, as suggested by Helfferich (2011). These four letters stand for the German terms *sammeln* (English: collect), *prüfen* (English: check), *sortieren* (English: sort) and *subsummieren* (English: subsume). In a first step, the potential interview questions relevant for answering the research question are collected and compiled. In a second step, the questions are checked for suitability. Hence, unsuitable questions, such as suggestive and closed questions, are deleted from the list. In a third step, the remaining questions are sorted by topics and question types, such as open questions, questions for maintaining a topic and further as well as detailed questions. Finally, the questions are subsumed by placing them in the appropriate place in the interview guide (Helfferich, 2011).

Altogether, the interview guide for this thesis reflects the PCI type proposed by Witzel (2000) and the principle for guideline construction as recommended by Helfferich (2011).

Interview recording

Interview recording is the third instrument of PCIs. According to Witzel (2000), the interviewer focuses precisely on the conversation by recording the interview rather than writing notes. Moreover, it is common practice to transcribe the recording completely after the interview to facilitate the later data analysis (Witzel, 2000).

Transcripts complement the audio recordings by graphically depicting the different aspects of people's behavior (Kowal & O'Connell, 1995). Kowal and O'Connell (1995) distinguish between four types of transcriptions, which depend on the accuracy of the representation of these aspects. For this work, a standard orthography was chosen because this type is closest to the written language and thus facilitates the transcription of the interviews (Kowal & O'Connell, 1995).

Postscripts

Immediately after the interviews, postscripts are utilized to complement the recordings. Thereby, any comments on individual answers and on the atmosphere are composed to better capture respondents' subjective views. Furthermore, spontaneous ideas and first attempts at interpretation by the researcher are the basis for the later analysis and comparison of the interviews (Witzel, 2000).

3.2.3. Interview procedure

The procedure of PCIs compromises all four instruments that have been described above. Through the aforementioned SPSS principle, an interview guide consisting of four sections with predefined keys and further questions was developed. Section 1 welcomed the interview partners, clarified organizational matters and introduced the master thesis topic as well as the style of the interview.³ Additionally, questions regarding sociodemographic and individual characteristics from the short questionnaire were posed at the beginning of the interview (see Appendix 6). The short questionnaire was important for reporting the heterogeneity of the research sample group. In other words, the interview partners were asked about their origin, their mother tongue, their age, their length of employment in their respective company and their current position as well as the number of directly and indirectly subordinate persons within the company. Section 2 built the core unit of the interview by inviting the participants to tell how they perceived the exercise of power in online and offline meetings. The following four open questions guided the interview:

- 1. How would you define power in meetings (positive, negative or neutral)?
- 2. What kind of power do you consider particularly important in meetings?
- 3. What are political practices that are utilized to influence the outcome of meetings?
- 4. What influence do contingent factors have on the exercise of power in meetings?

Furthermore, respondents were asked how their answers to these questions changed with the trend from physical to virtual meetings. These introductory questions began a narrative sequence in which the participants reported their experiences on power in online and offline meetings. This communication strategy, as suggested by Witzel (2000), was central due to the research gap regarding the exercise of power in online meetings. Furthermore, questions promoting details were asked, and examples were explicitly requested to explore the statements. By generating storytelling as well as requesting details and clarifications, new important insights regarding the political behavior in offline as well as online meetings were gained. Section 3 ensured that all important topics were covered and that the findings could be compared. As recommended by Witzel (2000) and Helfferich (2011), various thematic areas were added by writing key points or specific questions on certain topics, such as the meeting setting, different meeting episodes, power mechanisms and meeting types. These questions were only asked if the interviewee had not already answered them during the interview. At this point, it must be mentioned that the interview questions were adapted and expanded during the data collection process to include emergent and important topics, as recommended by Yin (2003). In particular, detailed further questions that were based on the statements of the preceding interview partners were added continuously. The final version of the interview guide, containing all further and detailed questions, is displayed in Appendix 7. In Section 4, the insights were summarized by the interviewer. Furthermore, the participants were provided with the opportunity to raise any important but not yet mentioned topics before concluding the interview. The interviews lasted approximately 50-60 minutes and were, in the majority of cases, conducted in German, which is the native language of the researcher as well as of the majority of the interview partners. Speaking German facilitated the flow of speech and understanding. Furthermore, 20 minutes were utilized immediately after each interview to write the aforementioned postscripts (see Appendix 8), as suggested by Witzel (2000). The noted inputs and ideas from the postscripts were consistently added to further interviews to obtain as many and comparable results as possible.

Due to the extraordinary situation of COVID-19, the interviews were primarily conducted utilizing Microsoft Teams or Zoom. This interview setting complicated the observation of nonverbal aspects for the interpretation of the answers, as proposed by Witzel (2000). Nevertheless, this interview procedure further underscored the importance of virtual meetings in today's business and research society.

During the subsequent transcription of the interviews (see Appendix 8), conversations during introduction sections as well as characteristics of the interviewees' behavior that were irrelevant for answering the research question were not transcribed. Furthermore, linguistic and paralinguistic peculiarities were omitted, as is usual for standard orthography, according to Kowal and O'Connell (1995). However, care was taken to ensure that no changes in content were made.

³Furthermore, all interviewees were made aware of the confidentiality agreement which was sent to them a few days before the conduct of the interview. The template of the agreement cais displayed in Appendix 5.

Moreover, linguistic and paralinguistic peculiarities central for further data analysis were reported in the postscripts. This procedure aligns with the recommendations of Flick et al. (2000) to transcribe only research-relevant data, as is the suggestion not to report subjective perceptions as objective measurements in the transcripts themselves.

3.2.4. Pretest

Before the interviews with the sample group were conducted, the interview guide was pretested for comprehensibility, logic in the sequence of questions, duration and recording possibilities (Meulemann, 2002). Particular attention was paid to whether the questions were formulated in a sufficiently open fashion to introduce new ideas that the researcher had not yet identified in the literature research. Furthermore, it was possible to test whether the majority of the questions in the interview guide could be answered within one hour and whether the quality of the recordings met all requirements. Finally, the pretest offered the author an opportunity to practice the interview in a familiar environment before speaking to businesspeople formally about the political function of meetings. The first version of the interview guide utilized for the pretest is found in Appendix 9.

The pretest revealed that some key questions in Section 3 were overly detailed. According to the test persons, narrowly formulated questions could prevent the emergence of new inputs that the researcher may not have considered before the interview. Consequently, the interview guide was revised. The key questions in Section 3 were formulated more openly, and the detailed questions were retained as backup in case the respondents did not provide sufficiently detailed information. Furthermore, questions such as "How does this political behavior differ between online and offline meetings?" were added to the majority of the sections to secure an explicit comparison of the political behavior in online and offline meetings.

Additionally, both test persons stated that it would make little sense to send the whole interview catalog to the participants in advance, especially as people from higher levels would not have the time to prepare proactively for questions before an hour-long interview. Moreover, both test persons considered a free narrative to be considerably important to gain interesting research findings. Therefore, a shortened list of questions was designed, which contained only the topic introduction and the key questions relevant for the thesis. The abridged list of questions sent to the interviewees two days before the respective interview is displayed in Appendix 10.

3.3. Data analysis

This section provides a detailed overview of the data analysis. It discusses the grounded theory approach and introduces the usage of first- and second order concepts. Further, it presents the different stages of the theory development of this work.

3.3.1. A grounded theory approach

Qualitative research has often been criticized for its lack of rigor because theory development is often based on the expansion of existing knowledge to gain new insights (Gioia et al., 2013). Gioia et al. (2013, 16), however, highlight that "advances in knowledge that are too strongly rooted in what we already know delimit what we can know." On the one hand, scientific standards must be met for theory advancement. On the other hand, more inductive approaches are necessary to gain new, valuable insights. To address both requirements, Gioia et al. (2013, 16) devised a "systematic inductive approach to concept development" by presenting data systematically in first- and second-order analyses, as recommended by Gioia and Chittipeddi (1991). This thesis also utilizes first- and second-order concepts to categorize and interpret collected data; "first-order concepts are the facts" while "second-order concepts are the *theories* an analyst uses to organize and explain these facts" (van Maanen, 1979, 2). In SAP research, these concepts have widely been applied by various researchers (e.g., Balogun & Johnson, 2004, Hope, 2010).

The evaluation technique utilized in the interviews depends on the objective, the question and the methodological approach. Qualitative content analysis (Mayring, 2015) and coding in grounded theory (Glaser & Strauss, 1967; Miles & Huberman, 1984; Strauss & Corbin, 1990) are thereby two frequently utilized methods. The latter, qualitative analysis in grounded theory as developed by Glaser and Strauss (1967), is an open methodology in which data collection and evaluation are intertwined. In contrast to content analysis, there is no "royal road" to data categorization. This significantly complicates the procedure. Nevertheless, this thesis applied an open analysis due to the rather explorative character of the study. A general category definition, according to Mayring (2015), would have been overly restrictive for an insightful evaluation of the material and would not have been theoretically conclusive.

3.3.2. The constant comparative method

In grounded theory, the analyst can either code all relevant data before analyzing and constituting proofs for hypothetical propositions or generate theory by constantly redesigning the analysis without explicitly coding data (Glaser & Strauss, 1967). A combination of these two forms of analyses, called the *constant comparative method*, was utilized for this thesis (Glaser & Strauss, 1967, 101). Hereby, theory is developed more systematically "by using explicit coding and analytic procedures" (Glaser & Strauss, 1967, 102). Furthermore, the constant comparative method involves a continuous comparison of data, codes, categories and concepts to build new theory.

In accordance with Glaser and Strauss's (1967) constant comparative method, the following outlines in detail how the transcribed interviews were coded and analyzed utilizing first- and second-order concepts. This author relied on specific coding techniques for qualitative data analysis, as introduced by Miles and Huberman (1984) as well as Strauss and Corbin (1990). For the sake of clarity, the procedure is presented in four stages, which, however, occurred in parallel. The data analysis process described below is graphically illustrated in Figure 4 and further documented in Appendix 11. All final coded interviews are in Appendix 12.

Stage 1: Provisional start list of codes

In the first-order analysis, raw interview material was reviewed by coding and categorizing the data. According to Miles and Huberman (1984, 56), codes are "tags or labels for assigning units of meaning to the descriptive or inferential information during a study." As suggested by Miles and Huberman (1984, 58), data was precoded by creating a "provisional start list" of codes with preliminary definitions to speed analysis.⁴ In this process, the extended framework of Hendry and Seidl (2003) with the five meeting phases was a guideline. Further, the list was supplemented by codes and subcodes that related to a particular topic, such as contextual factors and power dimensions, or particular settings, such as online and offline or strategic and operational meetings. The list of abbreviations of the predefined codes was then imported into the MAXQDA software, which considerably facilitated the coding procedure that followed.

Stage 2: Comparison within a single company

By attaching the preliminary defined codes of the start list to chunks, such as words, sentences or paragraphs, each interview was first organized utilizing MAXQDA.5 Furthermore, new codes were attached to interview statements that pointed toward political behavior in online and offline meetings. This rather inductive coding technique, despite the provisional start list of codes, allowed an open-minded analysis, which is in accordance with the grounded theory approach of Glaser and Strauss (1967). Moreover, the actual words of the interview partners, which are referred to as in-vivo codes (Strauss & Corbin, 1990), were particularly fruitful to gain insights into people's perceptions of power and politics in meetings. Throughout the analysis, particular attention was paid to the comparison of statements from the two hierarchical levels within the same company. Hence, the coded segments of the interviews within the same company were constantly compared to each other to reduce redundancies and to combine similar codes into one overarching code.⁶ This coding technique aligns with Miles and Huberman (1984), who recommend constant redefining, adding and discarding of codes. Further, detailed codes that related to a particular theme or construct were clustered into broader categories. In the literature, this process of "breaking down, examining,

comparing, conceptualizing, and categorizing data" is called *open coding* (Strauss & Corbin, 1990, 61).

Stage 3: Comparison between companies

Once interviews from more than one company were coded, the constant comparison between the interviews from different companies began.⁷ Hence, previously coded interviews were periodically reread and recoded to uncover differences and similarities. Glaser and Strauss (1967, 106) define an initial rule for the constant comparative method that describes this process: "While coding an incident for a category, compare it with the previous incidents in the same and different groups coded in the same category." The comparisons within as well as between the different hierarchical levels and companies allowed networks of connections to be made, which is similar to Strauss and Corbin's (1990, 96) notion of *axial coding*.

As the analysis progressed, the constant comparison of incidents allowed the researcher not only to reduce the number of categories to a manageable quantity, but also to develop specific characteristics of categories to generate theoretical properties, also called *higher-level concepts* (Glaser & Strauss, 1967).⁸ These concepts became increasingly integrated through further comparisons and thus provided the basis for the abstract second-order analysis (Glaser & Strauss, 1967). Finally, the wide variety of interrelated topics that were identified during the process were summarized in so-called memos, as Glaser and Strauss' (1967, 107) second rule highlights: "Stop coding and record a memo on your ideas." Hence, memo writing of interpretation ideas considerably assisted further comparisons as well as the *theory* development during the analysis.⁹

Stage 4: Delimiting and writing the theory

According to Glaser and Strauss (1967, 113), "delimiting a universe of collected data" forces the researcher to spend effort only on the data relevant for the main theoretical categories and concepts. Hence, delimiting features were applied as the theory solidified and focused categories and concepts emerged. As recommended by Glaser and Strauss (1967), the first level for delimiting occurred at the theory level by reducing and generalizing the terminology. This was performed by referencing the concept of power, which was introduced in Chapter 2.2.2. Specifically, the identified patterns and relationships were analyzed at an abstract level by referencing Hardy's (1996) power dimensions — the powers of resources, processes and meaning. This process was simplified by the provisional start list of codes, which differentiated

⁴The provisional start list of codes is found in Appendix 11 (see excel tap: provisional start list).

⁵The comparison between the two different levels within the same company is found in Appendix 11 (see excel tap: within).

⁶The final list of codes is found in Appendix 13 (see also excel tap of Appendix 11: final list of codes).

 $^{^7 {\}rm The}$ comparison between the different levels and companies is found in Appendix 11 (see excel tap: between).

⁸The final list of core categories as well as the higher-level concepts is found in Appendix 11 (see excel taps: core categories and concepts).

⁹The memos on the author's ideas are found in Appendix 11 (see excel tap: memos)



Figure 4: Overview of qualitative data analysis; Source: Author's creation, in accordance with Glaser and Strauss (1967), Miles and Huberman (1984), Strauss and Corbin (1990).

these power dimensions. The second level for delimiting concerned the reduction of the list of categories to eight main categories which allowed the researcher to dive deeper into the constant comparison of coded segments within these core categories (Glaser & Strauss, 1967). This approach can be compared to Strauss and Corbin's (1990, 116) selective coding technique. Under the terms of grounded theory, coding for categories is further delimited when theoretical saturation is accomplished (Glaser & Strauss, 1967). Therefore, only incidents that offered new insights were coded and compared as the interview analysis progressed. Furthermore, if new categories emerged over time that were not theoretically saturated, then the author recontacted the respective interview partner with specific queries.¹⁰ Nevertheless, some questions remained open in the end, as the timeframe of this work limited the usage of theoretical saturation.

Finally, the grounded theory data was written on the basis of the reduced list of categories and concepts as well as the memos that were collected throughout the interview analysis.

4. Research Findings

As mentioned, collected data was organized utilizing first- and second-order analyses (Gioia & Chittipeddi, 1991; Gioia et al., 2013; van Maanen, 1979). In the following two sections, the findings are discussed in considerable detail. Due to the fact that the interview partners had different views on strategy meetings, the next two sections first explain the exercise of power in meetings generally. Subchapters 4.1.3 and 4.2.3 are specifically dedicated to the exercise of power in strategy meetings.

4.1. First-order findings

The objective of the first-order analysis is to document and replicate the story of the interviewees as truthfully as possible (van Maanen, 1979). In this thesis, this is performed by quoting important statements from the interviews.¹¹ Although care has been taken to ensure that the analysis is as objective as possible, it should be noted that the first-order results contain relatively subjective elements, as they are based on the perceptions of only 10 interviewed individuals.

4.1.1. The evaluation of power

All interview partners were asked at the beginning of the interview how they would define power and what kind of power they considered to be particularly important in meetings. Overall, the analysis of the interviews reveals that individuals from different levels and companies perceive power as neutral, which aligns with the power definition of this paper. Power is utilized to lead and motivate a team as well as to make efficient decisions in the interests of the stake-holders and for the benefit of the company. However, power concentrated in one person — primarily due to a superior hierarchical position — can be utilized negatively by enforcing one's own interests.

Es kann beides sein. Es kommt immer drauf an, wird sie benutzt, um persönliche Interessen vielleicht durchzubringen oder wird sie benutzt, um die Ziele des Unternehmens zu erreichen. (I.2B, Pos. 7)

It can be both. It always depends whether it is used to push through personal interests or to achieve the goals of the company.

¹⁰For instance, people were asked about the organizational culture, as the analysis showed that the exercise of power in meetings is strongly related to the culture of the company.

¹¹The quotes are presented in the language in which the interviews were conducted (black). For German quotes, the English translation is added in grey.

Of note is that the interview partners commonly identified various contextual factors as crucial for the meeting culture. It has been reported that contextual factors on different levels, such as the country and the company, significantly influence the political function of meetings. For instance, the interview partners of the two multinational companies headquartered in France (Comp. 1 and Comp. 2) stated that the rather steep French hierarchical structure, known for its topdown instructions, is also reflected in the meeting rooms of Swiss branches. In contrast, interviewees from Company 5 stated that the hierarchical "pyramid is disappearing more and more" since they "have clear proof that a hierarchical way of working doesn't work" (I.5B, Pos. 161). Hereby, it has been suggested that the corporate culture is particularly important for large and international companies to create a common basis among employees. Moreover, individual values and backgrounds further shape political behavior in meetings.

Das ist eine französische Firma. Da ist vom Grundsatz her viel mehr Politics als bei anderen Firmen. Das ist einfach so. Das ist nicht einfach dahergeredet, sondern das ist so. Das heißt, Politics im Sinne von Top-down. (I.2A, Pos. 15)

This is a French company. There is a lot more politics than with other companies. That is simply the case. That's not just talking out of turn, that's just the way it is. That is, politics in the sense of topdown.

Und dort spielt dann die Firmenkultur eine riesige Rolle, weil das ist quasi dann der Konsens für diese 35 Repräsentanten und 35 Länder und 50 Sprachen und 19 weiß nicht was, um miteinander zusammen zu arbeiten. (I.5A, Pos. 17)

The corporate culture plays a huge role, because that is the consensus for these 35 representatives and 35 countries and 50 languages, and 19 don't know what to do to work together.

Aber ich glaube, es hat schon auch mit der Funktion, der Kultur, Headquarter, Nicht-Headquarter, auch ...mit dem Charakter eines jeden Menschen zu tun, inwieweit es der Person auch wichtig ist, Macht auszuleben. (I3B, Pos. 43)

But I think it also has to do with the function, the culture, headquarters, non-headquarters, [and] also ... with the character of each person, to what extent it is important for the person to live out power.

As these quotes illustrate, the rather open interview style allowed the researcher to gain important insights not yet examined in the literature.

4.1.2. Applied political tactics

The following five sections, which are based on the five phases of the extended framework (Hendry & Seidl, 2003), outline in detail the reported applied political tactics in meetings. Thereby, the practices are discussed in the settings of offline as well as online meetings. Figure 5 provides an overview of the general identified political tactics in the five meeting phases.

Pre-meeting phase

Offline meetings:

During the interview process, it became clear that the premeeting phase is a central factor for utilizing meetings politically. Interview partners from both levels stated that selfmanagement techniques are the lifeblood for successfully exerting power during meetings by causing one to prepare a personal set of arguments and written documents as well as answers to potential questions from other meeting participants.

Man sollte ... gut vorbereitet sein und vielleicht auch einen roten Faden haben, eine Argumentationskette, mit der man da durchkommen möchte. Und hat dann so auf diesem Wege einen Vorsprung, der einen dazu befähigt, diese Macht durchzusetzen, das als Machtmechanismus einzusetzen. (I.1A, Pos. 19)

You should ... be well prepared and perhaps also have a red thread, a chain of arguments that you want to get through. And in this way, you have a head start, which enables you to enforce this power, to use it as a power mechanism.

...dass die Vorbereitung auch ein Element ist, dass jemand, der bewusst steuern will, sich besser vorbereitet. (I.4B, Pos. 49)

Preparation is also an element ... someone who wants to steer consciously is better prepared.

Additionally, people chairing the meeting can influence the meeting outcome by making key decisions in advance. Interviewees claimed that they make a conscious decision to set the strategic course of action prior to the meeting. Hence, by setting the agenda, selecting the participants and defining the intended objectives and outcomes of the meeting, they steer the subsequent discussion in their preferred direction and thus limit the exercise of power by other meeting participants.

> Man hat seine eigene Agenda und sagt: 'Ich möchte jetzt ein Meeting und das ist die Agenda.' Man fragt den anderen nicht Also da schränkt man schon mal den Meeting Scope, die Ziele, schon mal sehr stark ein. (I.2A, Pos. 19)

> You have your own agenda, and you say, 'I want a meeting now, and this is the agenda.' You don't ask the other person So, you cut down the meeting scope and the goals.



Figure 5: Overview of applied political tactics in different meeting phases; Source: Author's creation.

...Berufung von Experten oder Einberufung von Experten ins Meeting, wenn man in einem meritokratischen Umfeld arbeitet, ist es nämlich auch wirkungsvoll, wenn man einen Technokraten, jemand, der das Thema voll durchdringt, reinbringt, der hat eine hohe Believability und kann möglicherweise den Kurs, ohne eine Stimme zu haben in der Abstimmung, gänzlich steuern. (I.5A, Pos. 33)

If you are working in a meritocratic environment, it is also effective to bring in a technocrat, someone who is fully engaged in the subject, who has a high degree of credibility and can possibly steer the course without having a voice in the vote.

Moreover, interview partners from upper management levels especially saw the prior assessment of other meeting participants as important. According to these managers, a so-called key stakeholder matrix is crucial to anticipate the positions, interests, values and cultures of others. Doing this allows them to neutralize potential opponents in advance and to adapt accordingly during the meeting.

Du musst dir sehr klar Gedanken machen, wenn du Widerstand hast vor einem Meeting, wo du ein Ziel erreichen möchtest, wie teilst du die Key Stakeholder ein? Also sind das Unterstützer, sind das eher Neutrale oder sind das Gegner? Das ist das klassische Schema. (I.2A, Pos. 74)

You have to think clearly: if you have resistance before a meeting where you want to achieve a goal, how do you divide the key stakeholders? So, are they supporters, are they rather neutral or are they opponents? It's the classic pattern.

Position und Interesse, wenn wir das jetzt so sagen wollen. Auf jeden Fall, dass man vorher antizipiert, was denn die anderen tun werden in dem Meeting und sich darauf ein paar eigene Argumente zurechtlegt. (I.1A, Pos. 27)

You have to know their positions and interests. In any case, anticipate what the others will do in the meeting and make your own arguments.

Of note is that interview partners from the relatively lower level reported that the predominantly important political tactic is to acquire allies by starting a convincing process before the scheduled meeting occurs.

> There's always a preparation phase, where you make sure that all the people in the room will be in agreement with you in advance, and there will be no surprises or discussions. So, this is one of the most used tactics. (I.5B, Pos. 13)

> Mehrheiten zu gewinnen, dass man sich vielleicht vor dem Meeting bereits abstimmt mit den Parteien, die daran teilnehmen, damit man mit Sicherheit weiß, dass im Meeting selber die eigene Meinung unterstützt wird. (I.2B, Pos. 11)

> To win majorities, ... perhaps before the meeting, you coordinate with the parties that are participating, so that you know for sure that your own opinion is supported during the meeting itself.

It is important to mention that middle and upper managers influence and motivate people to form alliances, generate support and align interests differently across companies. For instance, while interview partners from one company (e.g., Comp. 1) stated that they neutralize opponents in informal discussions over lunch or coffee breaks, others stated that they conduct convincing work in more formal, one-on-one meetings before the actual meeting occurs (e.g., Comp. 4 and Comp. 5).

Online meetings:

If meetings are held online, then the aforementioned political practices of the pre-meeting phase are utilized differently. Due to the setting and a greater social distance between meeting participants, some tactics become ineffective while other tactics become more important. As expected, both assessing the interests of key stakeholders and getting people on board by generating support and forming alliances becomes more difficult with an online setting.

Diese berühmte Unterscheidung zwischen Position und Interesse finde ich online viel schwieriger ... (I.1A, Pos. 163)

I find this famous distinction between position and interest much more difficult online.

Weil alles was so informell läuft in der Firma, also nicht öffentlich, was nicht über Kommunikation weitergegeben wird, das hörst du an der Kaffeeecke, beim Mittagessen. Und das fehlt natürlich. Die sozialen Kontakte fehlen auf jeden Fall. (I.1B, Pos. 31)

Because everything that happens so informally in the company, i.e., not in public, that is not passed on through communication; you can hear that at the coffee corner, at lunch. And that's missing, of course. Social contacts are definitely missing.

Additionally, if pre-meetings for online meetings are not explicitly and officially scheduled, then participants consciously avoid the convincing process by not being available prior to the meeting. This tactic limits the exercise of power by other participants.

You need to schedule the meeting and make sure that the time slot is available. It's not that you cross someone in the office now. (I.5B, Pos. 29)

Unsere Kommunikation findet eher über E-Mails oder ein zusätzliches Meeting in dem Sinn statt. Wenn jetzt die Person physisch im gleichen Office wäre, dann wäre es vielleicht einfacher, man trifft sich einfach auf einen Kaffee und geht gemeinsam Essen. (I.2B, Pos. 57)

Our communication is more likely to take place via email or an additional meeting in that sense. Now, if the person was physically in the same office, it might be easier to just meet for coffee and have lunch together.

They do not engage in this [type of] chat; it's a quick chat about personal things. Because they want to keep the distance so they do not show their weaknesses, I would say. Showing your personal things is . . . showing your weaknesses. And I've seen many people putting this big distance in the meetings to be perceived as more powerful. (I.5B, Pos. 121)

Thus, during the interviews, it became clear that power mechanisms based on the exploitation of social relationships and contacts must be compensated with better selfpreparation if one aims to utilize meetings politically.

> Ich kann mich auf ein Online-Meeting mehr schriftlich vorbereiten und das auch ausnutzen. Ich glaube aber, dass es das auch braucht ... (I.1A, Pos. 37)

> I can prepare for an online meeting more in writing and take advantage of that. But I believe that it needs this.

Comparing the aforementioned political practices in the pre-meeting phase of offline and online meetings, it can be concluded that the trend toward online meetings implies a shift from acquiring allies to better self-management techniques and preparation practices to utilize meetings politically.

Initiation phase

Offline meetings:

During the initiation phase, in which the organizational context is switched off, various political practices are applied to demonstrate power relations and highlight role allocations. First, upper managers from different companies reported that they may deliberately choose their own office as a meeting location to make a statement and signal that they are in a higher position. Furthermore, interviewees who are not part of upper management teams stated that the seating arrangement in the physical room is utilized to visualize power relations.

Aber es ist schon noch sehr klassisch, dass am Kopfende eigentlich der Chef sitzt. Und das hat man eben im virtuellen Raum nicht. (I.3B, Pos. 25)

But it is still classic that the boss is actually sitting at the head end. And you don't have that in virtual space.

Nevertheless, even if the choice of the meeting place as well as the seating arrangement are important tactics for employees in upper management positions, it is important to highlight that this political tactic considerably depends on ones' personality, as the following quote states.

> Die Sitzung findet beim Mächtigeren statt ..., das findet man in den meisten Unternehmen als Ausgangslage, Basis. Jetzt gibt es Gründe, um von dem abzuweichen Und das hängt etwas mit den persönlichen Präferenzen zusammen. Es gibt solche Autoritätspersonen, die sagen: 'Ich gehe zum Tiefergestellten, um eben dieses Machtgefälle etwas zu nivelliere.' (I.5A, Pos. 73)

The meeting takes place where the more powerful person is ..., which is in most companies a starting point, a basis. Now there are reasons to deviate from that... And that has something to do with personal preferences. There are such authority persons who say, 1'm going to the lower level, to level out the power difference.'

Second, the impression that strategists provide at the beginning of the meeting by having a strong appearance or a powerful speech is significantly important to secure one's position and to gain other meeting participants' support. This political tactic is typically applied by people from the upper management level because they want to signal their hierarchical position and legitimate authority to exercise power.

Was auch recht häufig kommt, ist das plakativ gleich am Anfang mal reinkommen und sagen: 'Wir müssen da und da hinkommen.' Sowieso die Formulierung 'wir MÜSSEN irgendwas.' (I.1A, Pos. 107)

What also happens quite often is the bold way of coming in right at the beginning and saying, 'We have to get there and there.' Anyway, the phrase 'we HAVE to do something.'

Das ist auch Machtausübung, dass man nicht in Time ist, sondern ganz bewusst, fünf, sieben Minuten später kommt. Ja, ich bin der Stärkere, ich bin der Chef, ich darf das. (I.2A, Pos. 23)

That's also exercising power, that you're consciously not on time, but you come five, seven minutes later. Yes, I'm the strongest, I'm the boss, I'm allowed to do it.

Third, participants identified that not only are setting the agenda and defining objectives in the pre-meeting phase crucial to limit the power of others, but also essential are communicating the agenda and the goal of the meeting at the beginning. No matter which hierarchical level the person belongs to, introducing the agenda and chairing the meeting provide an opportunity to lead. Hence, if one's agenda is to suppress the ideas of others and reach a specific goal, then this becomes clear by stating the intended outcomes and not inviting other participants to raise their opinions throughout the meeting.

... was ist die Zielsetzung und ich gebe den Rahmen, in welchem ich über Strategie ... sprechen will und bereit bin dazu. Und das ist wichtig, das ist nämlich eine Machtausübung meinerseits, indem ich hingehe und sage: 'Das ist der Rahmen.' (I.5A, Pos. 23)

What is the objective, and I give the framework in which I want to talk about strategy ... and I am prepared to do so. And that is important because that is an exercise of power on my part, by going and saying, 'That is the framework.'

Online meetings:

In virtual meetings, the aforementioned political tactic of introducing the agenda in one's interests is the same. However, the exercise of power by utilizing certain symbols loses much of its importance. On the one hand, superiors no longer have the ability to choose the meeting location, which may lessen the appearance of their authority. On the other hand, one's physical appearance no longer implicitly symbolizes power over the conduct of the meeting.

> And when you had to go to an important meeting ... having a bright color or the way you were wearing the clothes was super important. Now with the trend toward online meetings, this has completely disappeared...It's not important anymore. Why? Before it was an important symbol of power. (I.5B, Pos. 57)

Generally, it was found that exercising power in the initiation phase is more challenging in online than in offline meetings because symbols of power cannot be deployed to the same extent.

Conduct phase

Offline meetings:

During this phase, power can be exercised by following one's own agenda strictly. Hence, the person who sets and introduces the agenda controls the flow of the discussion according to personal interests by following the pre-defined agenda.

> Wenn ich persönlich irgendeine eigene Agenda habe und ich muss sie durchbekommen, dann würden wir das sicher auch als politisches Handeln bezeichnen, wenn ich dann meine Macht nutze, um Leute zu überstimmen oder mit verschiedensten Mitteln ... zu beeinflussen. (I.1A, Pos. 13)

> If I have a personal agenda, and I have to get it through, then we would certainly call it political action when I use my power to outvote people or influence them by various means.

> Dann das Meeting relativ straff führen in dem Sinne, dass jeder eine kurze Sprechzeit hat. (I.2A, Pos. 45)

> Then [I would run] the meeting relatively tightly in the sense that everyone has a short speaking time.

It is important to mention that turn-taking is not utilized to the extent expected. In particular, upper managers stated that the implicit exercise of power through skillful and strategic maneuvering is more central to following a personal agenda. Specifically, asking clever questions, encouraging certain people to state their opinions and interrupting others advances one's own interests. One person from a relatively higher position further claimed to consciously allow another person to lead the meeting, knowing that this person is well accepted by the opponents and has already neutralized them in advance.

Was aber auch vorkommt ... dass jemanden nicht aussprechen lassen oder nicht zu Wort kommen lassen, unterbrechen, in das Wort fallen. (I.1A, Pos. 113)

What also happens is that you don't let someone speak, or don't let them speak, interrupt, fall into the word.

So sometimes you show power in the way you ask [for] reactions from them; you're not asking them for feedback, you're just asking them, [and] their action is to embrace it. And you close the opportunity to give feedback if it's what you want. (I.5B, Pos. 171)

Und ich überlasse ihm die Diskussion mit diesem Gegner, den er hoffentlich schon vorher getroffen hat, dass er schon gar nicht mehr Gegner ist. (I.2A, Pos. 76)

And I leave him to discuss with this opponent, whom I hope he has met before, [so] that he is no longer an opponent at all.

Interestingly, writing the meeting minutes in one's interests to utilize meetings politically is not a common tactic in the majority of the companies because meeting minutes are usually reviewed and double-checked. However, both upper and middle managers from Company 4 were of a different opinion.

Und weil ja meistens der Meeting Chair oder Prozess Manager die Meeting Minutes schreibt, kann man dort relativ stark noch beeinflussen, was dort steht. (I.4A, Pos. 113)

And because it is usually the meeting chair or process manager who writes the meeting minutes, you can still influence what is written there.

Die Machtausübung kommt eigentlich mit dem Protokoll, weil das Protokoll am Schluss maßgeblich ist. (I.4B, Pos. 99)

The exercise of power actually comes with the protocol, because the protocol is decisive in the end.

Skillful political maneuvering by utilizing certain formulations and tactics is underscored by linguistic and bodily signals. By consciously choosing the tone of voice and being in command of the meeting language — being a native speaker — certain persons can maneuver others into alignment. Additionally, sending bodily signals is often utilized by various practitioners to influence the behavior of others.

> ... dann gibt es jemanden, der sich sehr eloquent im Englischen ausdrücken kann, macht natürlich

auch etwas aus. Dann hört man eher der Person zu, so dass sie eben steuern kann, wenn sie will. (I.4B, Pos. 31)

Then there is someone who can express himself eloquently in English; of course it makes a difference. Then you listen more to the person, so that he or she can steer when they want to.

... dann sind da sehr viele körpersprachliche Signale, die da auch natürlich mitspielen, die physisch im gleichen Raum sehr viel steuern können bei den Leuten. (I.4B, Pos. 23)

There are a lot of bodily signals that naturally play a part in this, which can physically control a lot of people in the same room.

A further political tactic that is commonly applied by upper managers is to exploit the hierarchically superior position to make decisions alone or to deliberately block certain decisions. However, it is important to mention that the power that stems from decision-making processes is often perceived as a positive form of power since greater efficiency is achieved when a specific person is in charge of deciding.

> Wenn er einfach keine Lust hat, aus hierarchischer Sicht entscheidet er. (I.2B, Pos. 17)

> If he just doesn't feel like it, he decides from a hierarchical standpoint.

> Natürlich, wenn es einen Entscheid braucht, dann muss klar sein, dann habe ich die Macht. Ich entscheide schlussendlich. Es gibt keinen Konsensentscheid ... (I.2A, Pos. 33)

> Of course, if it needs a decision, it must be clear, then I have the power. I make the final decision. There is no consensus decision.

Finally, meetings are utilized politically by politicizing during breaks. According to upper and middle managers, breaks are often employed to form alliances, obtain support, negotiate meeting topics as well as approach and gently admonish participants to back off when they are overly confident in expressing their personal opinions during the meeting.

> Und wiederum andere verziehen sich kurz und begegnen sich 'zufällig' dann, um kurz bilateral abzusprechen. Und eben versuchen, so Allianzen zu bilden. (I.3A, Pos. 101)

> And others again leave for a short time and meet 'by chance' to discuss things bilaterally. This way they try to form alliances.

Online meetings:

When meetings are conducted online, physical aspects are completely lost if cameras are switched off and to some extent are lost when cameras are switched on. Wenn ich an einen Kollegen denke, der es liebt, sich ausbreiten, seine Sachen zu positionieren und sein neues Mobiltelefon hinzulegen, all solche Signale sendet man ... im Kopfausschnitt weniger, als wenn man sich seinen Raum nimmt, sich ausbreitet und auch etwas demonstriert. (I.3B, Pos. 25)

When I think of a colleague who loves to spread out, arrange his things and put his new cell phone down, all such signals are sent less with online meetings where you can only see the face than when you take your space in a physical room, spread out and also demonstrate something.

You can easily see across a screen with 20 people if they are happy with what you're commenting, or they are not happy, or they have a comment, they have a question, they want to talk. It's easier to manage. (I.5B, Pos. 87)

Therefore, all interview partners agreed that the exercise of power now occurs primarily through appropriately choosing arguments and utilizing conscious formulations.

So now everything comes down to the conversation, and what ... you bring to the conversation. You need to think more about the verbal part of the meeting, rather than all the other aspects, like position, clothing, ... so attitude and the verbal expression gets more important. (I.5B, Pos. 59)

Die Wahl der Worte im Online-Meeting ist sogar noch wichtiger, weil einfach durch die Technik der Klang der Stimme sowieso verfälscht wird. (I.2B, Pos. 105)

The choice of words in an online meeting is even more important because simply by the technology the sound of the voice is distorted anyway.

Das spürt man schon auch bei Leuten, die sprachlich gewandt sind, dass denen von Vorherein mehr Macht gegeben wird, weil der Ausdruck sehr viel Bedeutung hat . . . Vor allem die klare Aussprache, also die Deutlichkeit ist im virtuellen Raum von Wichtigkeit. (I.3B, Pos. 43-45)

You can feel that more power is given to people who are linguistically adept, because the expression has a great deal of meaning... Above all, clear pronunciation, i.e., clarity, is important in virtual space.

Interview partners further stated that meeting participants are less attentive in online meetings. In particular, the lack of a visual image decreases people's awareness, which can be exploited by certain actors and enhances their decision-making power.

Und das ist sehr gefährlich, weil die Leute sind nicht wirklich hundert Prozent anwesend, es werden Entscheidungen getroffen und plötzlich merkt man, ups, da hätte ich etwas anders machen sollen. (I.2B, Pos. 39)

And that's dangerous, because people aren't really 100% there. Decisions are being made, and suddenly you realize, oops, I should have done something different.

Nevertheless, the interview partners commonly thought that exercising power is more difficult in online meetings when people are inattentive because the virtual setting implies a distance between the meeting participants, which in turn, decreases the control over the flow of discussion and people. Consequently, interview partners from different levels perceived that encouraging a structured conversation by following the agenda is a promising tactic to further exercise power in online meetings.

> There's a lot of chance that they are not listening to what you're saying. And you cannot control that. (I.5B, Pos. 157)

> Das Klügste wäre, ich würde sagen: 'So, jetzt hören wir uns mal den an, dann die.' (I.1A, Pos. 49)

> The smartest thing to do would be to say, 'Let's hear this person, then this person.'

Furthermore, the majority stated that online meetings are more strenuous and tedious than physical meetings, which is why inserted breaks are utilized to relax rather than to politicize. Nevertheless, the invisible background chat compensates for the political purpose of breaks. However, the extent to which the chat is utilized in meetings significantly depends on the person's position and other individual factors. While interviewees from the relatively lower level said that they utilize the group chat for comprehension questions and background information, interviewees from the relatively higher level reported that they occasionally utilize personal chats to signal colleagues that they expect a statement that supports their opinion.

> So kannst du Background Informationen sammeln. Das ist extrem wichtig. (I.1B, Pos. 41)

> You can gather background information. This is extremely important.

Also wenn ich beispielsweise feststelle, dass ein Thema in der Diskussion sich nicht in die richtige Richtung entwickelt, dann kann ich per Chat den einen oder anderen darauf aufmerksam machen: 'Ich wäre doch froh, wenn wieder mal ein Statement käme, das in meine Richtung zeigt.' (I.3A, Pos. 79)

For example, if I notice that a topic in the discussion is not developing in the right direction, I can use chat to draw the attention of some people to it, 'I would be happy if a statement could be made that points in my direction.' In addition to the background chat, other technical tools are utilized to gain power throughout the discussion by gaining a knowledge or informational advantage. For instance, this advantage can be acquired by relying on specific background applications.

Ich kann ...Dinge googeln oder auf Youtube suchen, die ich direkt in die Diskussion einbringe, ohne dass die das merken. (I.5A, Pos. 111)

I can google things or search on YouTube, which I can bring directly into the discussion without them noticing it.

Furthermore, younger people who are keen on influencing other meeting participants and courageous to shape the meeting outcome are especially able to strengthen their position in online meetings as opposed to offline meetings.

Und ich muss schon sagen, gefühlt ist das ein Generationsthema. Ich denke, ältere Generationen tun sich nach wie vor schwerer mit diesem virtuellen Raum. Ich persönlich zähle mich mit 34 Jahren noch eher zum jüngeren Semester und finde, dass es eher von großem Vorteil ist. (I.3B, Pos. 15)

And I have to say, it feels like an issue of generations. I think older generations still find it harder to deal with this virtual space. Personally, at 34 years of age, I still tend to count myself with the younger generation and think that it is a great advantage.

Consequently, interviewees from different firms felt that online meetings allow participants to start from a more equal basis, in which both younger and subordinate participants become more courageous to ask critical questions and express their ideas.

Ich finde schon, das Virtuelle unterstützt es, alle mit der gleichen Basis starten zu lassen. (I.3B, Pos. 27)

I think that virtual meetings support letting everyone start at the same base.

Die machen alle irgendwie etwa ein bisschen gleicher. (I.4A, Pos. 25)

They all kind of make everyone a little bit more alike.

Overall, the analysis reveals that while in offline meetings, power is often exercised by physically demonstrating authority, in online meetings, verbal expression and skillful argumentation become more important. Moreover, personal attitudes as well as generational differences impact the political usage of technological devices.

Termination phase

Offline and online meetings:

Termination practices refer to the dissolvement act of specific meeting structures by recoupling the process with the wider system of the organization. Thereby, actors exploit the situation when people become impatient and inattentive at the end of the meeting by summarizing different opinions in a desired form and not asking for further input and feedback.

> Der Abschluss des Meetings kann natürlich auch eine Möglichkeit sein, Macht auszuüben, weil man dann zusammenfassen kann ... die gewünschte eigene Version zusammenfassen, so dass die Leute dann in dem Moment nicht mehr reagieren. (I.4B, Pos. 85)

> The conclusion of the meeting can, of course, also be a way to exercise power, because then you can summarize ... your desired version so that people do not react.

> Ich versuche das Gesamtbild zu machen, zusammenzufassen und dann mache ich aber kein Voting. (I.2A, Pos. 50)

> I'm trying to get the big picture, summarize it, and then I'm not letting people vote.

Additionally, a commonly utilized tactic is to reschedule meetings and delay decisions in one's interests to keep certain topics on the agenda until decisions can be made.

> Andere Formen von Macht, da denke ich an Verzögerungstaktik, dass man einfach auf gewisse Dinge nicht eingeht, sodass die Zeit des Meetings abläuft und man hat noch nichts entschieden dazu. (I.2B, Pos. 11)

Other forms of power, I think of delaying tactics, [are] that you just don't go into certain things so that the time of the meeting runs out, and you haven't decided anything yet.

Aber viele Meetings sind dann halt so: Man geht auseinander und nichts wird richtig dokumentiert und dann hat der eine andere Position als ich oder ein anderes Verständnis. Man kann das auch gut beeinflussen, indem man bewusst keine Klarheit schaffen will am Ende eines Meetings. (I.4A, Pos. 105)

But many meetings are like this: You go apart, and nothing is documented properly, and then the person has a different position than I do or a different understanding. You can also influence this by deliberately not wanting to create clarity at the end of a meeting.

In contrast to the other meeting phases, neither differences in political behaviors of upper and middle managers nor in offline and online meetings were identified throughout the analysis.

Post-meeting phase

Offline meetings:

As hypothesized, the political behavior in the phase after the meeting is significantly similar to the exercise of power before the meeting since numerous informal activities occur. Interview partners, especially those from relatively lower positions, stated that they occasionally utilize the walk back to the office or business lunches to reflect on issues and build support for subsequent meetings.

Mittagessen. Und dort wird über Kreti und Pleti diskutiert oder was war jetzt wichtig. Also viel so informell wird sich dann ausgetauscht: 'Wie machen wir jetzt das? Hat noch jemand eine bessere Lösung?' (I.1B, Pos. 111)

Lunch. And there we discuss different things. So, there is a lot of informal exchange, 'How do we do this now? Does anyone else have a better solution?'

Conversely, actors at relatively higher levels perform more educational work by approaching certain people to resolve disagreements and avoid potential frustration that could negatively affect people's credibility about their capability to make decisions.

Also die Klärung, die Zeit zu nehmen, auch Aufklärungsarbeit zu leisten ...nach dem Meeting, scheint mir ganz wichtig. (I.2A, Pos. 78)

So, the clarification, to take the time, also to do educational work...after the meeting seems to me to be important.

Und einfach so auch respektiert und also Respekt und Wertschätzung der Person gegenüber bringt. Ansonsten könnte das natürlich Frust auslösen. (I.3A, Pos. 113)

And, therefore, show respect and appreciation to the person. Otherwise, of course, it could cause frustration.

A further micropolitical practice that is more likely to be applied at higher levels is to make decisions after adjourned meetings in a smaller setting.

Oder wenn es heißt hinterher dann: 'Es wird vertagt.' Und dann klären wir das so. (I.1A, Pos. 69)

Or it is said, 'We postpone the meeting.' And then we decide afterward.

Das heisst eigentlich: Man schliesst den Rest der Gruppe aus und macht dann One-to-One einen Follow-Up und entscheidet dann etwas, was man der Gruppe zurückspielt. Das ist ein relativ gutes Instrument, um die Leute auszuschliessen, die sich nicht in dem Moment melden, wenn man sagt, man mache einen Follow-Up. (I.3A, Pos. 127)

That actually means [that] you exclude the rest of the group and then do a one-on-one follow-up and then decide something to give back to the group. This is a relatively good way to exclude people who don't come forward the moment you say you're doing a follow-up.

Online meetings:

If the meeting occurred online, then the communication after the meeting is more consciously chosen as a tool to influence the meeting. According to the interviewees, the telephone is only utilized when major issues still need to be reflected upon and discussed.

> Es fällt deutlich schwerer, dann wieder den Telefonhörer in die Hand zu nehmen . . . (I.3B, Pos. 35)

> It is much more difficult to pick up the phone again.

According to one upper manager, however, the willingness to make decisions in online meetings is lower than in offline meetings, which increases the tendency of making follow-up decisions in a more informal setting.

> Das ist meine subjektive Empfindung, dass man in Online-Meetings ein bisschen vorsichtiger herangeht und eher noch ein Folgeveranstaltung braucht oder den eben besprochenen Mechanismus nutzt, um es hinterher offline zu klären. (I.1A, Pos. 83)

> That is my subjective feeling — that in online meetings, one approaches things a bit more cautiously and rather needs a follow-up event or uses the mechanism just mentioned to clarify things offline afterward.

4.1.3. Evaluation of strategy meetings

In the course of the interviews, the researcher learned that it is difficult to understand the term *strategy*. The definition of strategy meetings thus varied significantly between companies, hierarchical levels and, generally, between the individual interview partners. While some stated that strategic work is part of a process with many iterations and small meetings, others stated that sizable strategy meetings usually occur outside the office over several days. Nevertheless, it was jointly agreed that collaboration and social interaction are more central to strategic meetings than to operational meetings. Operational meetings aim at making quick and pragmatic decisions in order to move day-to-day businesses forward while strategy meetings aim to discuss key strategic issues of a department or the entire company and to make medium- to long-term decisions. To develop a strategy together, it is therefore important to listen to the arguments of all participants and to create space for creativity and innovative ideas.

In strategischen Meetings liegt der Fokus viel mehr in der Kollaboration, in der Diskussion und im gemeinsamen Austausch von Ideen, wo auch weniger Struktur dann gegeben ist. (I.4B, Pos. 107)

In strategic meetings, the focus is much more on collaboration, discussion and the exchange of ideas, and there is less structure.

Es sollte viel mehr Raum da sein für die Reflektion. Jeder sollte da angehört werden, jeder sollte auch einen Stake haben. Man sollte auch sich selbst viel mehr challengen. (I.2A, Pos. 80)

There should be much more room for reflection. Everyone should be listened to; everyone should have a stake. You should also challenge yourself much more.

Da ist das Zusammenspiel der Einzelteile wichtig. Und dann muss sich am Schluss irgendwas herauskristallisieren. (I.1A, Pos. 135)

The interaction of the individual parts is important. And then something must crystallize in the end.

Nevertheless, when examining respondents' evaluations of power in meetings, it is important to mention that power structures are considered to be stronger and clearer in strategic than in operational meetings.

Strategie-Meetings sind ja in der Regel sehr Top-Down. (I.3B, Pos. 47)

Strategy meetings are usually top-down.

...showing power and using these mechanisms will be more important in strategic meetings. (I.5B, Pos. 141)

Das heißt, der Chef, der muss nicht nur den Rahmen setzen, er muss auch Ordnungshinweise geben. (I.4A, Pos. 25)

That is, the boss, he must not only set the framework, he must also give instructions for order.

Within this circle of employees, which is part of strategic work, careful preparation and skillful argumentation are the predominantly important political practices. In contrast to operational meetings, power is not significantly generated by physical aspects but rather by objective persuasion both during and outside meetings.

...in einem Strategie-Meeting ist dann jeder auch vorbereitet und weiß, was er für richtig hält. Und damit kommt dieses Argumentieren und sachliche Beeinflussen mehr als Machtmechanismus zum Tragen. Aber weniger die anderen genannten, die nicht auf Argumentation basieren, sondern mehr emotional, körperlich sind. (I.2A, Pos. 139)

In a strategy meeting, everyone is prepared and knows what they think is right. And thus this argumentation and factual influencing is more of a power mechanism. But not so much the others mentioned, which are not based on argumentation but more emotional, physical aspects.

Strategische Meetings sollten sehr viel mehr Vorbereitung haben, Nachbereitung. (I.2A, Pos. 80)

Strategic meetings should have much more preparation [and] follow-up.

Oft werden wichtige Entscheidungen dann gefällt beim Mittagessen oder beim Abendessen oder entscheidend beeinflusst, dass am anderen Tag dann viel einfacher eine Entscheidung gemacht werden kann. (I.2A, Pos. 82)

Often, important decisions are made over lunch or dinner or are so influenced that a decision can be made much more easily the next day.

Regarding online strategy meetings, the interview partners were rather critical, as the exchange of information before and after the meetings as well as the joint development of the strategic orientation is central. The majority of respondents criticized online meetings for the lack of social interaction, preventing the generation of innovative ideas.

> Strategische Meetings, ausgenommen jetzt in der aktuellen Situation, in der man einfach nicht zusammenkommen konnte, finden eher weniger online statt. Meiner Meinung nach passiert das aus gutem Grund, weil eben doch sehr viel Körpersprache mitspielt, weil man zusammenarbeiten muss und weil man auch die Gelegenheit benötigt, in den Pausen individuelle Gespräche zu führen. Das ist ein bisschen ähnlich wie politisieren. (I.4B, Pos. 117)

> Strategic meetings, except now in the current situation where you simply couldn't get together, tend to take place less online. In my opinion, this happens for a good reason — because a lot of body language is involved, because you have to work together and because you also need the opportunity to have individual conversations during the breaks. That's a bit like politicizing.

> ...diese Strategie Offsites sind ja meistens so, dass man auch Zeit weg vom Büro hat. Und man hat dann eben auch den Abend, das Nachtessen oder die Bar...Ich glaube, das ist qualitativ etwas ganz anderes, was man mit Online-Meetings nicht fertigbringt. (I.4A, Pos. 171)

These strategy offsites are usually constructed in such a way that you have time away from the office. And then you also have the evening, dinner or the bar... I believe that this is qualitatively something completely different, which you can't achieve with online meetings.

However, participants revealed that the attitude toward online strategy meetings depends considerably on the experience the company already has with virtual tools. The interview partners from Company 5 emphasized how efficiently online meetings can be conducted in the strategic area. The majority of the respondents additionally stated that a mix of online and physical meetings would make sense to take advantage of the benefits of online meetings without having to completely forego physical interaction.

Also alles, was man zur Verfügung haben muss, kann man elektronisch aus meiner Sicht besser abbilden als in physischen Meetings. (I.5A, Pos. 99)

So everything you need to have at your disposal can, in my opinion, be better represented electronically than in physical meetings.

Aber gerade so in der Phase der Findung und der Auslegung braucht es immer wieder die physischen Meetings. (I.3A, Pos. 173)

But it's in the phase of finding and interpreting that physical meetings are needed again and again.

Overall, the reported findings of the first-order analysis were grouped and summarized in eight core categories. The full list of categories with evidence are in Appendix 14.

4.2. Second-order findings

The first-order analysis has identified various political tactics in online and offline meetings. The objective of this second-order analysis is to explore and explain the identified patterns of the first-order analysis and to arrange them in a theoretical context (van Maanen, 1979) without explicitly referring to the five meeting phases. According to van Maanen (1979, 3), such insights are called "interpretations".

4.2.1. Differences between upper and middle managers

Following the reasoning set forth by Seidl and Guérard (2015) and Asmuss and Oshima (2012), it was hypothesized that the political behavior in meetings differs significantly between upper and middle managers. Based on the first-order analysis, several noteworthy results are revealed regarding political behavior of employees on different hierarchical levels. First, the role of upper managers is anchored on a solid foundation that allows the direct exercise of power by relying on physical signals and making key decisions without the consensus of other meeting participants. Second, from the interviews, it is apparent that upper managers are more

likely to apply self-management techniques and assess potential opponents in advance, while middle managers build support and form alliances by informally talking to other meeting participants in pre- and post-meeting phases. Nevertheless, the results regarding differences between the political behaviors of upper and middle managers are objectively inconclusive for several reasons. First, the way in which certain power resources are mobilized, how meetings are moderated and how phases before and after meetings are utilized depends more on individual preferences and personal attitudes than on relative positions. Accordingly, it is important to distinguish whether one wants to exercise power over or with other meeting participants. Moreover, interview partners had different perspectives on their relative positions in the respective companies. For example, while some middle managers highlighted their superior positions (e.g., I.1B and I.2B) in meetings, others reported from the perspective of subordinates and highlighted the political behaviors of their superiors (e.g., I.4B). Finally, it is identified that middle managers have a secondary role in strategy meetings and only have the lead in operational-type meetings, which restricts their exercise of power in strategic meetings. Overall, it is summarized that while these reasons make it difficult to distinguish the political behaviors at different hierarchical levels, they also make it possible to generalize the exercise of power in meetings by treating personality as a crucial factor. This significantly simplifies the development of the theoretical framework mentioned below.

4.2.2. Framework

This subchapter is dedicated to the developed theory. It demonstrates how power is generally exercised in meetings, and it focuses closely on the comparison between online and offline meetings.

Emergent framework

The core categories of political tactics identified above align with the findings of Dittrich et al.'s (2011) six dimensions of the political function of meetings: setting and advancing the agenda (Adams, 2004; Tepper, 2004), building support and forming alliances (Adams, 2004; Kangasharju, 1996, 2002), exerting influence (Clifton, 2009; van Praet, 2009; Wodak et al., 2011), suppressing new ideas (Jarzabkowski & Seidl, 2008; Schwarz, 2009), keeping topics on the agenda (Jarzabkowski & Seidl, 2008; Tepper, 2004) and negotiating (Asmuss & Oshima, 2012; Boden, 1995). These six dimensions have, however, been supplemented with further dimensions, as among other things, both pre- and post-meeting phases and physical aspects have been considered. Nevertheless, to find a theoretical explanation for this political behavior, it is necessary to dive deeper by considering power concepts of social science. Therefore, in this thesis, the core categories are analyzed at an abstract level by referring to Hardy's (1996) power dimensions: power of resources, power of processes and power of meaning to determine a theoretical explanation for the findings outlined above. The secondorder analysis reveals an explanatory framework, which is displayed below. Figure 6 illustrates that power dimensions are shaped by the contextual factors that were identified throughout the analysis. These are related to each other as signaled by the arrows.

First, the analysis of the interviews reveals that power in meetings is understood as either positive or negative depending on the context. Hereby, (1) *environmental factors*, (2) organizational factors and (3) individual factors play central roles. First, environmental factors refer, in this thesis, to national and regional cultures. It has been identified that both the degree of internationalization and the culture of the country where the company is headquartered significantly influence the extent of certain power relations within the company (e.g., Comp. 1 and Comp. 2). Because cultural differences are actively pursued during meetings, it is important to know the environment and adapt accordingly. Second, organizational factors, such as the historical background of the company, firm values and beliefs as well as company experiences, are a direct outflow of environmental factors. In other words, the national culture shapes the power relations of the organizational culture in both positive and negative senses. Consequently, it has been argued that the more international the company is, the more important the corporate culture is in laying common ground for the meeting culture and its power relations. Third, individual factors determine the subjective perception of power and the extent of one's political behavior. The analysis reveals that the extent to which a person is driven by power depends on individual values and sociodemographic characteristics, domain-relevant expertise and the perception of the legitimized authority to exercise power due to an appointed position, as summarized in the previous section. For instance, although a company may be hierarchical, such as Company 4, it is up to the individual person to decide on the degree to which this hierarchical order is lived. This means that the personality of each individual has an especially significant influence on power relations and dynamics in meetings. This insight further justifies the reason that no particular level- or company-specific differences in the political behavior in meetings were found.

Overall, it is important to study in greater detail the whole picture to understand the exercise of power in strategy meetings. In other words, short-, medium- and long-term dimensions display additional elements that must be considered to analyze political behavior in online and offline meetings. These identified results can be compared to the literature review by Dittrich et al. (2011), which concludes that the way meetings are conducted is considerably influenced by contingent factors on environmental, organizational and individual levels. In the context of power, it is additionally derived that Hardy's (1996) three power dimensions are shaped by such contextual factors (see Arrow 1 in Figure 6). Specifically, contextual factors have a direct influence on Hardy's (1996) first power dimension, called the power of resources. Depending on the context, different individuals from different companies attributed different weighting factors to the importance of critical resources. Consequently, the evalua-

tion of power is ambiguous. Most importantly, nearly all interview partners reported that power stems from the hierarchical order within the company or from an elected authority position that legitimizes certain actors to exert influence over the meeting process. For instance, the meeting chair is, by virtue of the assigned role, automatically legitimated to exercise power in establishing and performing the agenda. This perception of power is similar to French and Raven's (1959) power base, which is called legitimate power. Power that is solely rooted in a superior hierarchal position, however, was primarily perceived as a rather negative force, which aligns with the traditional power perspective of Pfeffer (1992, 30), who defines power as "the potential ability . . . to get people to do things that they would not otherwise do." In the context of meetings, this power source is an overarching power relationship anchored within the company. Furthermore, power that stems from contacts compensates and complements legitimate power. Employees, especially those in middle management positions, rely on political practices based on discourse with other meeting participants to build support, align interests and form alliances. However, employees in upper management positions depend rather on certain contacts to anticipate and assess the interests of other meeting participants. Hence, power stemming from contacts is crucial for formal and informal convincing processes in pre- and post-meeting phases. The finding that personal power is exercised within interpersonal relationships by psychologically changing people's attitudes rather than exerting control through superior position aligns with the referent power base (French & Raven, 1959). Moreover, power originates in domain-relevant expertise, knowledge and individual skills, as the analysis of the interviews from Company 5 reveals. In their opinions, power that is based on technological knowledge and expertise, also called *expert power* by French and Raven (1959), is independent of the hierarchical order within the company. Hence, it can be derived that knowledge advantages impact the majority of the identified political actions by causing the one who possesses them to be better prepared and more confident and decisive. This power base is also closely linked to informational power (Raven, 1965) because people who possess relevant information are in powerful positions.

Overall, the analysis reveals that various power resources, such as hierarchy, legitimized authority, information, domain-relevant expertise and contacts lay the foundation for the exercise of power in meetings. Hence, Hardy's (1996) first power dimension, which unites these resources, is a pre-condition for Hardy's (1996) other two dimensions: the power of processes and the power of meaning (see Arrows 2a and 2b in Figure 6). To have the power of processes, actors must draw on their hierarchical positions and legitimized authority as power resources (see Arrow 3a in Figure 6). Defining the four Ps of a meeting — determining the purpose, inviting selected participants, managing the process and planning the *product* — and thus limiting the meeting scope are not possible without access to these resources. Furthermore, if power is viewed as influence and an ability to make decisions, then it is important to build a network



Figure 6: Overview of developed theory regarding the exercise of power in meetings; Source: Author's creation.

of contacts to gain trust and support. According to I.5B, the employees "give you this power to decide because they have trust in you." However, the power of meaning, which is created through the conscious control of language and the usage of certain symbols, is only possible by employing resources, such as information, expertise or hierarchy (see Arrow 3b in Figure 6). Specifically, it has been identified that linguistic devices politically maneuver other meeting participants into alignment by utilizing specific formulations and changing one's tone of voice. In this respect, intelligent participants who are eloquent and thus steer others have a clear advantage in being able to utilize meetings politically.

The first-order analysis further indicates that upper managers in particular utilize political practices based on physical aspects, such as the location, the seating arrangement and the convincing appearance at the beginning of the meeting, to demonstrate power relations and dynamics. Hence, especially by utilizing certain symbols, relative superiors exercise power in meetings. Finally, a relationship between the power of processes and the power of meaning is identified, in that controlling language and utilizing symbols underscores political tactics related to the agenda as well as to decisionmaking practices (see Arrow 4 in Figure 6).

It has been revealed that Hardy's (1996) three power dimensions, which capture various power conceptualizations, are interdependent. Hence, when analyzing how individuals exert influence by utilizing meetings politically, these power dimensions cannot be considered in isolation. This is because Dittrich et al.'s (2011) five meeting functions are not mutually exclusive but are related to each other (Seidl & Guérard, 2015). For instance, former studies have identified how sense-making (Weick, 1995) or social ties in meetings (Hodgkinson, Whittington, Johnson, & Schwarz, 2006) have profound consequences for strategic work.

Extended framework

By comparing political behavior in physical and virtual settings, the author understood that the importance of certain elements of the three power dimensions increase or decrease when meetings are conducted online. Based on the framework displayed previously, Figure 7 illustrates with symbols, such as arrows pointing up or down as well as equals signs, how the weight of individual subdimensions is changing in online settings.

Most importantly, a shift in the power sources that employees utilize is occurring. When meetings are conducted online, power is mainly dependent on information and domain-relevant expertise because power that stems from a superior hierarchical or appointed authority position as well as from contacts becomes more difficult to demonstrate and exercise in an online setting. It has been identified that political practices based on the usage of symbols, such as choosing the location, sitting at the head of the table or utilizing bodily activities to signal a superior power position, are to a considerable extent, lost in web conferences. However, political tactics, such as forming alliances and building support as well as anticipating the interests of opponents, are not equally efficient when there is no opportunity to meet personally and exploit interpersonal relationships or social interactions. Because these power resources are becoming less important, strategists control other power resources in online meetings to a greater extent than in offline meetings. For further clarification, individuals from different hierarchical levels stated that the possession of information as well as knowledge advantages, such as domain-relevant expertise,



Figure 7: Overview of changes in the power dimensions due to the trend toward online meetings; Source: Author's creation.

are crucial to utilize online meetings politically. Some individuals mentioned that they can better exploit a prepared chain of arguments in online meetings to appear confident. Others stated that digital tools, such as the background chat and applications, are utilized to gather information that is brought into the discussion without others noticing. Power in online meetings is thus concentrated in experienced people who possess and control relevant information and skills. Consequently, the verbal part of meetings gains considerably in importance. Hence, the power of meaning is primarily created through the control of language rather than the usage of symbols in an online setting. By paying particular attention to careful formulations and the appropriate tone of voice, meeting participants from different levels gain respect and enforce their ideas to influence the meeting outcome.

Regarding the power of processes, the findings of the interviews are less straightforward. While it is true that the power of processes is primarily rooted in a superior hierarchical or appointed authority position, the fact remains that certain issues, such as technical problems, participants' inattention and background noises, complicate this way of exercising power. For instance, it has been argued that it is more difficult to strictly follow one's agenda in one's interests. However, based on the interviews, it is still unclear how exactly the online setting affects the political tactics based on participant determination and decision-making processes.

Finally, the influence of contextual factors on the interrelation of the power dimensions and the respective subdimensions must be discussed. In particular, organizational and individual factors are crucial. Political action in online meetings depends on the technical possibilities and gathered experiences of each organization. Eloquent expressions are becoming increasingly important in online meetings regardless of the company's camera policy; nevertheless, it is clear that the usage of cameras promotes self-staging activities and the assessment of other reactions (e.g., Comp. 5). Hence, it is deduced that the usage of symbols is more important in companies in which cameras are switched on during meetings. Further, employees who have considerable experience with online meetings over the last few years are more confident and thus in stronger positions. However, based on the interviews, younger generations who have grown up with technological devices have an advantage over older generations (e.g., Comp. 3). Suddenly, the younger age group, who has more affinity to digitality, is more present and secure, while the older age group has difficulties in finding their way around in virtual space.

To summarize, virtual meetings allow meeting participants to start from a more equal basis due to a redistribution of power. While those who mainly refer to their hierarchical positions or utilize personal relationships are losing importance, those who possess information and domain-relevant expertise are gaining importance. Consequently, those employees who create meaning not only through symbols, but also through the control of language by utilizing appropriate formulations are better prepared to utilize meetings politically in the future.

4.2.3. Evaluation of strategy meetings

According to the framework developed above, it is assumed that a shift from offline to online meetings will accordingly result in a shift of power resources in strategic areas and thus in a redistribution of power. However, this will only be the case if employees outside the upper management team are allowed to participate in strategy meetings. Furthermore, the first-order analysis reveals that not all power dimensions and mechanisms mentioned can be applied to the same extent in strategic matters. For instance, political tactics based on informational and knowledge advantages as well as on domain-relevant skills are more important in strategic meetings than in operational meetings. Power is thus mainly exercised by those who possess the credibility for the thematic framework. Consequently, such a trend would have a positive effect on the way meetings are utilized politically to influence strategic work.

Nevertheless, the first-order analysis additionally demonstrates that the conduct of online meetings in the strategic area is viewed rather critically. Although there exist clear power relations in strategy meetings, the joint development of strategic orientations is important. In contrast to operational meetings, the primary goal of strategy meetings is not to push and rush through topics to make quick decisions for everyday business life but rather to jointly develop new ideas and drive innovation to be prepared for the future. This view from the interview partners is consistent with Jarzabkowksi and Seidl's (2008, 392) and Seidl and Guérard's (2015, 5) definition of strategy meetings as "social practices" and "communicative events," respectively. In virtual space, however, collective work was judged to be difficult by the majority. As long as such work is possible during COVID-19, employees from both levels, therefore, favor a mix of online and physical meetings to promote collaboration and innovation.

Whether strategy meetings are increasingly being held online depends not only on the current situation caused by COVID-19, but also on the overall experience of the companies, as the discussions revealed. On the one hand, respondents from those companies that already utilize video conferences and virtual tools for brainstorming and generating ideas were more confident regarding the conduct of online strategy meetings (e.g., Comp. 5). On the other hand, interview partners from companies that do not utilize cameras saw the virtual implementation of strategy meetings as problematic (e.g., Comp. 1). However, the meeting situation as it was observed before COVID-19 hardly seems likely to return to its precrisis state in the foreseeable future, and the majority agreed that companies now must learn to utilize a combination of digital tools and virtual forms of collaboration to efficiently conduct strategy meetings not only physically, but also virtually. If companies succeed in this, then it is assumed that the usage of online meetings will additionally contribute to a democratization of opinion formation in strategic work, as is already observed in Comp. 5 (I.5A and I.5B). In this company, the political usage of meetings is a rather positive phenomenon for strategy because it emphasizes the usage of informational and expert power bases.

However, it is not yet clear to what extent this paradigm shift from hierarchical gravitation toward expert knowledge and credibility is anchored in strategy meetings. Since the personalities of the strategists has been identified as one of the most important factors influencing the exercise of power in meetings, it is assumed that power-driven people will in the future learn to assert themselves, to orchestrate and thus to influence strategic work not only in positive, but also in negative ways. Furthermore, how efficiently strategic online meetings can be utilized politically will probably only become apparent in the near future. Nevertheless, based on the firstand second-order analyses, it is concluded that only those strategists who know how to manage digitization and technological developments are well prepared to utilize meetings for political purposes.

4.3. Discussion

This chapter critically discusses the thesis. It reveals how the study enhances academic and practical understandings of the exercise of power. Advantages and disadvantages are highlighted and avenues for future research are presented.

4.4. Contributions and implications

By analyzing power in offline and online meetings, this thesis not only reveals the micropolitical dimension of the SAP literature, but also raises important issues relevant for firms. Hence, the following two sections discuss the extent to which this thesis contributes to theory and implicates praxis.

4.4.1. Theoretical contributions

The SAP stream of literature has gained considerable importance over the past 15 years by emphasizing the many micro-actions that strategists utilize to shape strategic work (Jarzabkowski et al., 2007; Johnson et al., 2007, 2003; Whittington, 2006). However, according to Clegg et al. (2004, 25), the "understanding of strategy necessitates an engagement with power and politics." Hence, this thesis contributes to the existing meeting literature by integrating a micropolitical approach into the analysis of strategy meetings. In particular, the behavioral activities of strategists are placed in the context of power and politics by conceptualizing meeting practices as routinized types of political behavior, as has been suggested by Hansen and Küpper (2009). Such a micropolitical approach illuminates the exercise of power in meetings not only as a negative, but also as a positive force. Moreover, the extension of Hendry and Seidl's (2003) framework with pre- and post-meeting phases elucidates the importance of political practices around meetings. Thus, it is demonstrated that the theoretical analysis of meetings should extend beyond the actual planned meeting time.

Additionally, this thesis addresses the research gap of online meetings in SAP research. Although this study is far from closing this gap, it indicates the importance of integrating the trend toward virtual meetings into the micro-perspective of strategy. Altogether, this thesis paves the way for further studies in SAP to analyze the development of power mechanisms due to arising possibilities and tools in technology.

4.4.2. Practical implications

The study of the political function of offline and online meetings provides useful insights for managers' everyday interactions in business gatherings. The practical implications of this thesis are summarized as follows. First, many interview partners mentioned that they had not previously actively considered the exercise of power in meetings. Therefore, this study raises employees' awareness concerning the mobilization of power mechanisms in meetings to shape strategic work. On the one hand, strategists can learn to consciously utilize certain resources not only to demonstrate power and authority, but also to gain recognition, respect and appreciation. On the other hand, strategists are made more aware of micropolitical practices deployed by other meeting participants. It is important that employees learn to assess and classify other meeting participants' political tactics to predict consequences for strategic work. Second, by incorporating power into the analysis of strategy meetings, various power games and political dynamics are made visible. If such mechanisms are visible, then potential abuses of power in and around meetings can be detected, identified and, if necessary, suppressed. Third, a broader knowledge of power and politics in meetings provides a company with the opportunity to train workers to learn to manage the three dimensions of power and to utilize the underlying power mechanisms to have a positive influence on strategic work in meetings. Moreover, employees should not only be trained to utilize physical meetings efficiently, as may have been the case so far, but they should also become familiar with new challenges and opportunities of virtual meetings. In other words, the paradigm shift should, in addition to the organization level, be aimed at the career level to ensure power relations and dynamics in meetings with positive consequences for strategy outcomes.

4.5. Limitations

Like all other studies, this thesis has strengths and weaknesses. The following two sections provide an overview and highlight that the results and their external validity should be interpreted cautiously.

4.5.1. Strengths of the study

The first strength of this study is that it builds on interviews as its primary data collection method. Interviews offer several advantages over other methods because they enable the researcher to focus directly on the unit of analysis - here, meetings — and to reveal insightful findings through causal inference (Yin, 2003). Moreover, the chosen methodology of PCIs based on Witzel's (2000) work combined inductive and deductive procedures, which considerably encouraged an open-minded analysis of power without the constraints of theoretical concepts. Another strength of this study is that multiple companies from different sectors were considered. Therefore, it was possible to identify that power relations and dynamics in meetings depend to a significant extent on environmental and organizational factors, such as organizational culture, historical background and degree of internationalization. Finally, the interview partners formed a heterogeneous sample group with regard to position, experience, background and age. Hence, incorporating different perspectives and experiences led to interesting research results and highlighted the importance of individual factors when analyzing the exercise of power in meetings.

4.5.2. Weaknesses of the study

There exist some concerns regarding the external validity of the conducted study, which are worthy of being discussed. External validity refers to the extent to which the insights of this thesis are generalizable to other firms and individuals holding meetings in physical and virtual forms. Hereafter, research design and data collection are critically analyzed (Yin, 2003).

Regarding the empirical context of the research design, it was not possible to capture the political function of meetings in different countries and cultures to the fullest extent. Nevertheless, the companies of interest were sufficiently diverse regarding environmental factors to identify that there exist significant differences in the applied tactics depending on the country and the degree of internationalization.

Regarding the data collection method and referring to Yin (2003), several weaknesses must be highlighted. First, interviews are subject to potential biases from the interviewer as well the interviewees. There is a risk that the interview questions have been poorly constructed by the interviewer, which may limit the answers from interviewees. Furthermore, it is difficult to verify whether the interviewee is simply providing answers that the interviewer expects. Second, a poor recall of the interview answers can confound the research results (Yin, 2003). This problem was mitigated in this thesis by recording and transcribing the interviews, although it would have been reasonable to complement the information from the interviews with participant observations and documentations. Observing actual interactions in offline as well as online meetings and collecting documents, such as minutes and presentations utilized or developed in meetings to steer discussions, could have been useful second and third data sources for triangulation purposes and a more rounded analysis of the research question (Yin, 2003).

Finally, interpersonal relations between the researcher and some key persons initiated the snowball access. According to Merkens (2000), a group selection based on accessibility indicates that the investigation is conducted within some self-determined limits. Nonetheless, since the participants referred by the gatekeepers met inclusion criteria based on the research progress, this problem was circumvented to a certain extent.

4.6. Avenues for future research

Although the findings of this thesis are indicative and provide some initial insights regarding the differences between the political function of offline and online meetings, further analysis must be conducted. Based on the findings, the author is of the opinion that meeting functions in addition to the political function should not be completely neglected for the analysis of power in meetings. This finding aligns with Seidl and Guérard (2015), who argue that more research must be conducted to understand how different meeting functions are combined and relate to each other. Hence, by focusing systematically on the interrelation of the *coordination, symbolic, social* and *cognitive* functions of meetings rather than relegating them to the background, one may capture the *political* function and its power mechanisms to the fullest extent.

Another promising direction for future research could be personal and direct observation of micropolitical practices in physical and virtual meetings. Conducting an ethnographic study would enable greater depth (Creswell, 2003) by allowing the researcher to analyze the political function of offline and online meetings not only from the perspective of a researcher, but also from the perspective of a participant. In physical meetings, the researcher could mingle with employees to identify key persons whose verbal as well as nonverbal behavior in strategy meetings is worth analysis. Furthermore, being personally present would enable the researcher to observe informal talks before and after the meeting.

Referring to Cornelissen and Cienki (2010), who recorded interactions among individuals on videotape, Seidl and Guérard (2015, 29) suggest conducting video ethnography as a method to "capture more effectively how body, materiality and discourse interact in meetings and how they relate to strategy formulation." In web conferences, on the contrary, it would make sense to participate virtually and to record strategy meetings to identify differences from in-person meetings. Additionally, it would be advisable to support the researcher's onsite observations with self-reporting methods (Balogun, Huff, & Johnson, 2003). Careful evaluation of political behavior via the computer could prove difficult and lead to misinterpretations; therefore, reflection and perception diaries of online meeting participants could serve as a complementary data collection method when applying an ethnographic approach. Furthermore, it would be exciting to empirically test the extent to which the exercise of power affects the efficiency of meetings. As the analysis of efficiency would extend beyond the scope of this work, it is all the more important to draw the attention of future researchers to it. According to the results of this study, the question then arises whether the redistribution of power resources caused by the online meeting trend should be assessed positively or negatively in terms of efficiency. However, since SAP literature on power and politics in online meetings barely exists, it is worth first analyzing power mechanisms of online meetings at a theoretical level. This could be performed by developing solid frameworks that study the politics of online meetings from an activity-based view.

To summarize, many companies have recently started to offer employees the option to work from home and virtually participate in meetings on a regular basis, although the majority of the companies analyzed stated that the trend toward online meetings, which was accelerated by COVID-19, will continue to grow for several reasons including work-life balance and costs. Therefore, future research must capture the underlying political function of online meetings and its related tactics to draw conclusions about the overall development and consequences of politics in strategy meetings.

4.7. Conclusion

Macht ist wie Energie. Und ohne Energie passiert überhaupt nichts. (I.5A, Pos. 57)

Power is like energy. And without energy nothing happens at all.

This master thesis opened with a quote that describes meetings as the heart of a successful company and is closed by a respondent's statement that indicates that power, like energy, is a required strength to put activities in motion. The aim of this thesis was to engage with the analysis of power in meetings by uncovering how strategists utilize online and offline meetings politically to influence strategic work.

The first part of this thesis comprehensively illustrated that past research identifies various political practices in physical meetings. Moreover, the need for investigating power issues in depth by focusing not only on physical, but also on virtual meetings was outlined. Therefore, the second part of this thesis conducted a holistic multiple case study to compare political behavior in offline and online meetings. In doing so, it focused on a wide range of strategists working in diverse companies. The primary discoveries of the empirical study are summarized as follows: First, environmental, organizational and individual factors influence power dimensions in meetings. In particular, personal attitudes that are, to a significant extent, independent of the formal position determine the way that meetings are utilized politically. Individual preferences are more important than appointed power positions; therefore, it further explains why, generally, no fundamental differences between upper and middle managers were found. Second, the comparison of the political behavior in offline and online meetings reveals that employees utilize specific power resources depending on the setting. Hereby, power that stems from hierarchy, legitimate authority and contacts loses importance in virtual meetings, while power rooted in information and domain-relevant expertise gains importance. Consequently, applying eloquent expressions and careful wording become more relevant than utilizing symbols to employ online meetings politically. Third, businesspeople are rather critical of developments toward virtual business gatherings in strategic areas to the disadvantage of innovation and collaboration possibilities. However, as video meetings become more userfriendly and closer to real-life scenarios, their popularity will continue to grow even among strategists. Hence, it is of utmost importance that they learn to manage new digital collaboration tools to produce positive power dynamics and capacity to effectively conduct virtual strategy meetings. Altogether, it is concluded that the way power is exercised in meetings is changing with the trend from offline to online meetings. However, the extent to which this will influence strategic work will only become clear in the near future. These three key findings have important implications for theory and practice but should nevertheless be treated with considerable caution due to the absence of literature regarding online meetings and the aforementioned weaknesses of the designed study.

Finally, after having analyzed the political behavior in meetings, it is concluded that power is indeed conceptualized as the fuel that runs today's companies by providing the nec-
essary strength to make decisions and reach efficient meeting outcomes. Consequently, it is important to note that energy levels and thus power dynamics in physical and increasingly in virtual meetings must be actively managed to ensure positive consequences for strategic work.

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