



## **Online-Appendix zu**

# **„The Effect of Carbon Taxes on Directed Technological Innovation: A Case Study of Sweden“**

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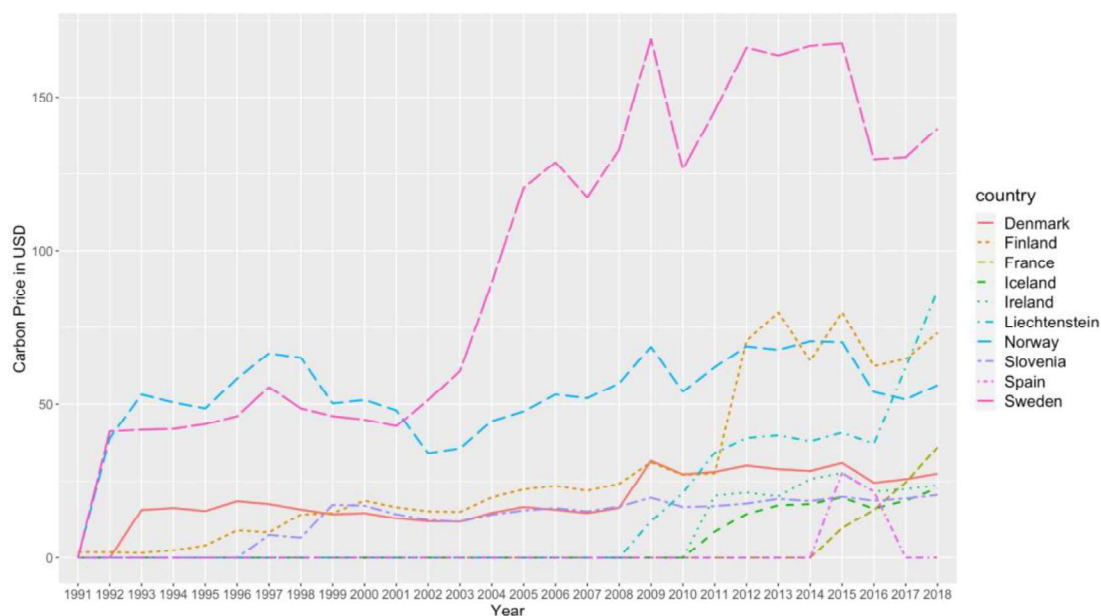
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## Appendix

### Appendix 1: Carbon Price among EU countries (Worldbank, 2022)

Appendix 1 depicts the carbon price for those EU countries that implemented one until 2018. Luxembourg and Netherlands are not plotted as they introduced a carbon tax after 2018. Estonia, Latvia, Portugal, Poland, and Ukraine are not included in the graph as their carbon tax rate is negligible with a rate of well below €10 until 2018. According to the OECD (2018b), the fuel tax in Poland is not classified as a carbon tax. The prices are in USD and represent the nominal prices as of April, 01 2022.



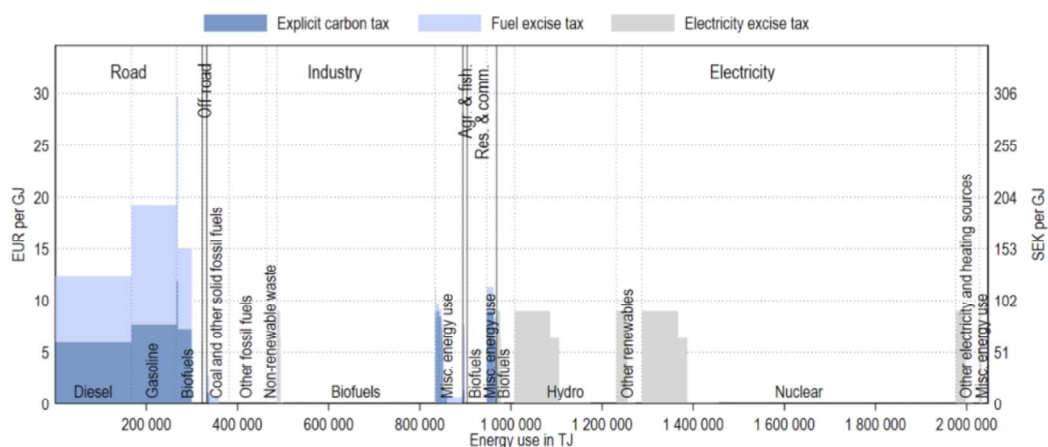
## Appendix 2: Share of GHG emissions priced and price signals from taxes & EU ETS in Sweden (OECD, 2016)

Appendix 2 depicts the share of GHG emissions priced and price signals from taxes and the EU ETS as well as the share of emissions priced by these instruments. Not all taxes depicted refer to the carbon tax. The electricity sector is subject to a tax, which however is not a carbon tax. The sector with the highest carbon tax coverage is road transport (91%), whereas the sector with the highest overall tax coverage is electricity (100%). The sectors with the highest ETS price coverage are offroad transport (68%) and electricity (24%) (OECD, 2016).

| Sector                   | Emissions by sector (in t CO <sub>2</sub> ) | Carbon tax                               |                                 | EU ETS                                   |                                 | Overlap of tax and ETS <sup>1</sup> | Emissions not covered by carbon tax or ETS |
|--------------------------|---|--|---------------------------------|--|---------------------------------|-------------------------------------|--|
|                          |   | Mean price (in EUR / t CO <sub>2</sub> ) | Emissions covered (in % priced) | Mean price (in EUR / t CO <sub>2</sub> ) | Emissions covered (in % priced) |                                     |  |
| Agriculture & Fishing    | 1,501                                       | 77.40                                    | 33%                             | 0.00                                     | 0%                              | 0%                                  | 67%  |
| Electricity              | 5,246                                       | 193.08                                   | 100%                            | 7.24                                     | 24%                             | 24%                                 | 0%   |
| Industry                 | 60,176                                      | 62.19                                    | 24%                             | 7.24                                     | 23%                             | 14%                                 | 67%  |
| Offroad transport        | 719   | 112.42                                   | 10%                             | 7.24                                     | 68%                             | 7%                                  | 29%  |
| Residential & Commercial | 7,484                                       | 159.36                                   | 21%                             | 7.24                                     | 0%                              | 0%                                  | 79%  |
| Road transport           | 21,241                                      | 226.62                                   | 91%                             | 0.00                                     | 0%                              | 0%                                  | 9%   |
| Total                    | 96,367                                      | 68.25                                    | 42%                             | 1.16                                     | 16%                             | 10%                                 | 51%  |

### Appendix 3: Effective tax rates in EUR per GJ on energy usage by sector and energy category (OECD, 2019)

This figure shows that energy and CO<sub>2</sub> tax rates in Sweden differ across energy use by sector and category. The CO<sub>2</sub> tax applies to fossil fuel use and low blends of biofuels in gasoline and diesel at a rate of SEK 1200 (EUR 111) per tonne of CO<sub>2</sub>. The tax rates shown are applicable on 1 July 2018. The energy usage data reflect data in 2016 (OECD, 2019)



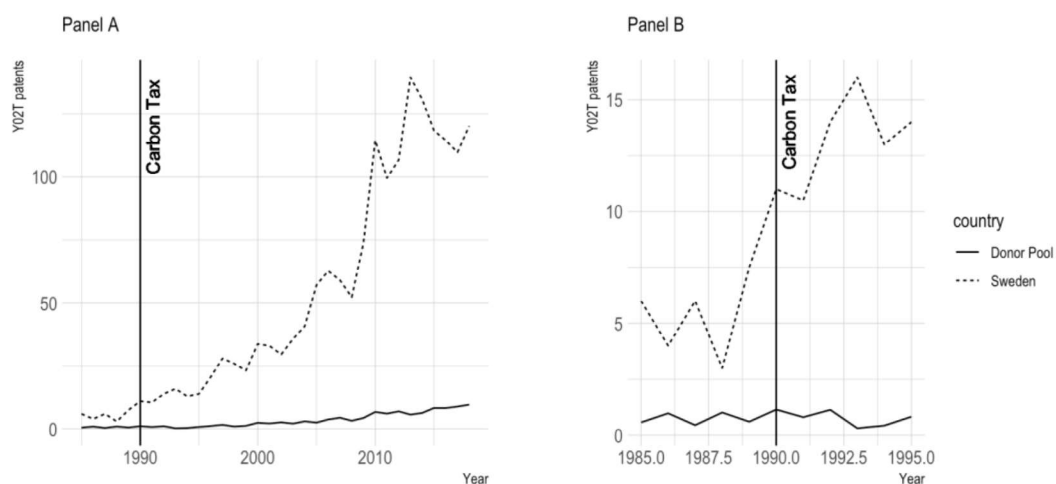
#### Appendix 4: Y02T subcategories and their frequency

Y02T subcategories, excluding aeronautics or air transport (Y02T 50/00) and Maritime or waterways transport (Y02T 70/00), with the participation of Swedish inventors between 1978 and 2018. The descriptions are taken from the USPTO (2022).

| CPC Class Symbol | Definition   | Swedish Patent Families |
|------------------|--|-------------------------|
| Y02T 10/12       | Improving ICE efficiencies   | 166.964                 |
| Y02T 10/40       | Engine management systems  | 23.917                  |
| Y02T 10/70       | Energy storage systems for electromobility, e.g. batteries   | 20.5                    |
| Y02T 10/62       | Hybrid vehicles  | 14.5                    |
| Y02T 10/30       | Use of alternative fuels, e.g. biofuels  | 11.75                   |
| Y02T 10/7072     | Electromobility specific charging systems or methods for batteries, ultracapacitors, supercapacitors or double-layer capacitors                            | 11.5                    |
| Y02T 10/72       | Electric energy management in electromobility  | 8                       |
| Y02T 10/64       | Electric machine technologies in electromobility   | 8                       |
| Y02T 10/88       | Optimized components or subsystems, e.g. lighting, actively controlled glasses   | 4                       |
| Y02T 90/12       | Electric charging stations   | 3                       |
| Y02T 90/40       | Application of hydrogen technology to transportation, e.g. using fuel cells  | 2.333                   |
| Y02T 10/84       | Data processing systems or methods, management, administration   | 2.167                   |
| Y02T 90/14       | Plug-in electric vehicles  | 2                       |
| Y02T 90/167      | Technologies related to the interoperability of electric or hybrid vehicles  | 2                       |
| Y02T 90/169      | Aspects supporting the interoperability of electric or hybrid vehicles, e.g. recognition, authentication, identification or billing                        | 2                       |
| Y02T 90/16       | Information or communication technologies improving the operation of electric vehicles   | 2                       |
| Y02T 10/92       | Energy efficient charging or discharging systems for batteries, ultracapacitors, supercapacitors or double-layer capacitors specially adapted for vehicles | 1                       |
| Y02T 10/86       | Optimization of rolling resistance, e.g. weight reduction  | 1                       |
| Y02T 10/82       | Elements for improving aerodynamics  | 1                       |

## Appendix 5: Trend of the number of Y02T patent families annually.

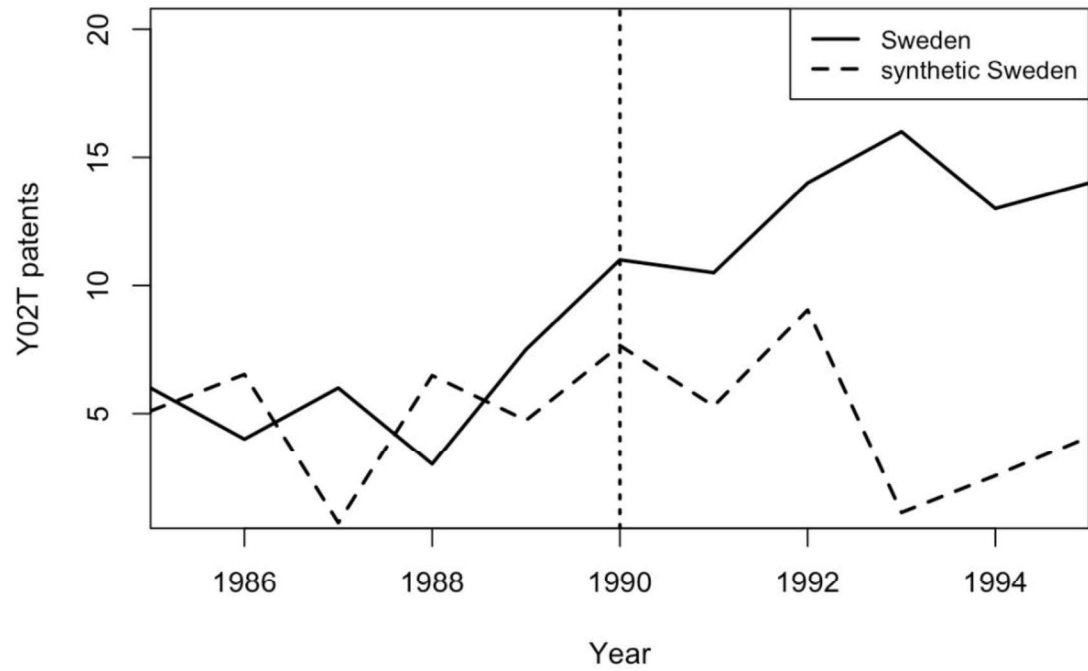
Panel (A) shows the years 1985 until 2018, while panel (B) zooms into the time timeframe 1985 until 1995.



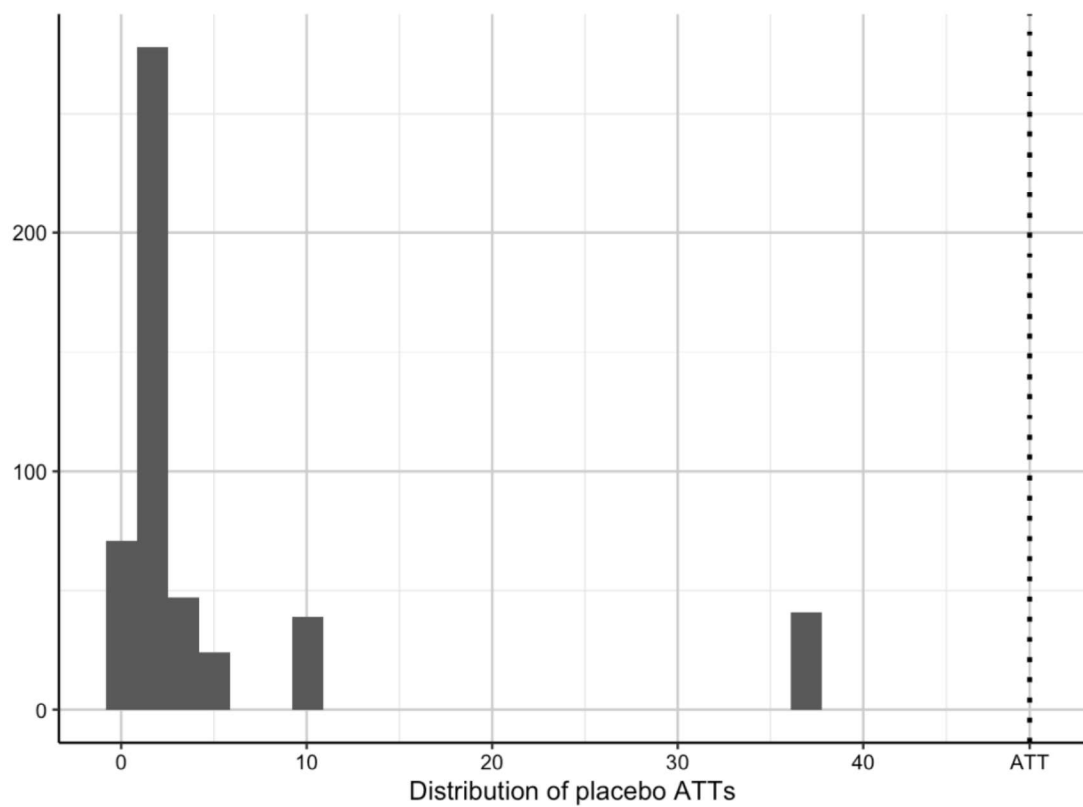
## Appendix 6: Country Weights in Synthetic Sweden

| Countries      | Weights | Sequential Numbering |
|----------------|---------|----------------------|
| Austria        | 0.638   | 1                    |
| Belgium        | 0.362   | 2                    |
| Bulgaria       | 0       | 3                    |
| Croatia        | 0       | 4                    |
| Cyprus         | 0       | 5                    |
| Czech Republic | 0       | 6                    |
| Greece         | 0       | 7                    |
| Hungary        | 0       | 8                    |
| Lithuania      | 0       | 9                    |
| Luxembourg     | 0       | 10                   |
| Malta          | 0       | 11                   |
| Poland         | 0       | 12                   |
| Romania        | 0       | 13                   |
| Slovakia       | 0       | 14                   |

### Appendix 7: Trends in Y02T family patents: Sweden vs. synthetic Sweden (1985-1995)



### Appendix 8: Bootstrapping

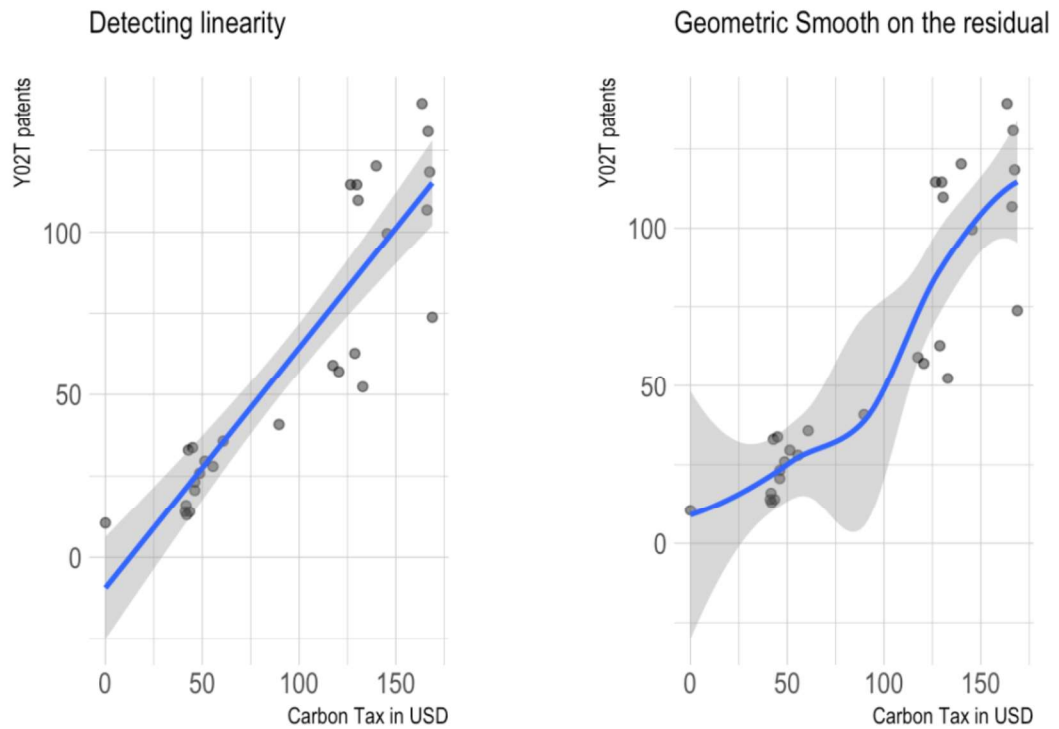


## Appendix 9: OLS Regression on the carbon price and Y02T patents

| <i>Dependent variable:</i>  |                         |
|-----------------------------|-------------------------|
|                             | y02t                    |
| usd_t_carbon                | 0.715***<br>(0.067)     |
| Constant                    | -6.610<br>(7.081)       |
| Observations                | 29                      |
| R <sup>2</sup>              | 0.810                   |
| Adjusted R <sup>2</sup>     | 0.803                   |
| Residual Std. Error         | 19.226 (df = 27)        |
| F Statistic                 | 114.780*** (df = 1; 27) |
| <i>Note:</i>                |                         |
| *p<0.1; **p<0.05; ***p<0.01 |                         |

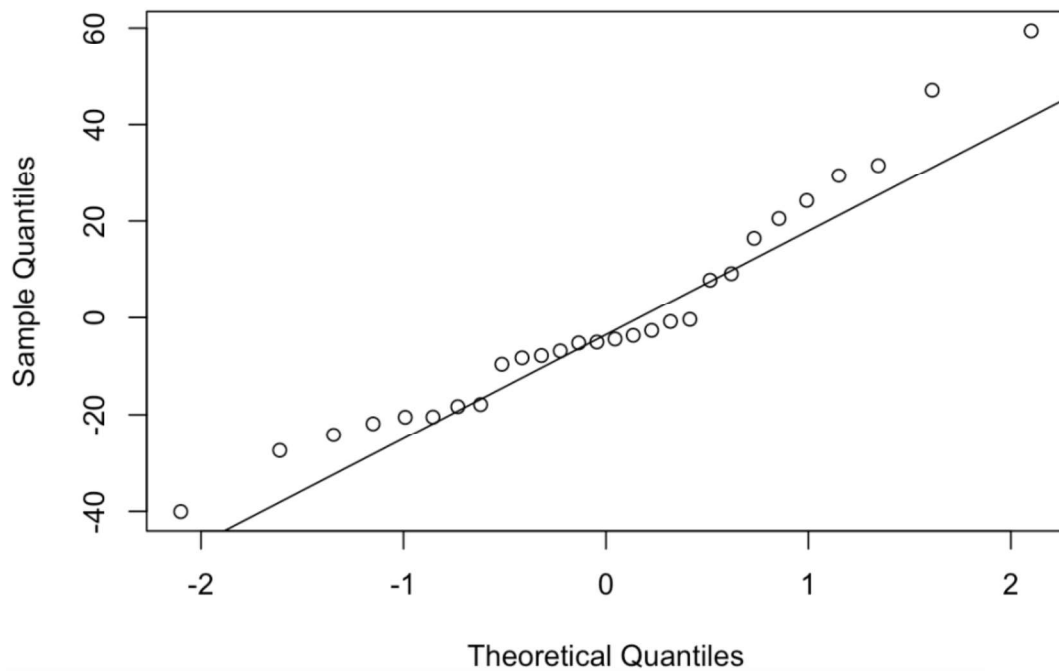


## Appendix 10: Assessing linearity with a residual plot



## Appendix 11: Normal Q-Q Plot

### Normal Q-Q Plot



## Appendix 12: Diagnostic plot: Heteroscedasticity

