

Oppelt, Paolo

Article

The Effect of Carbon Taxes on Directed Technological Innovation: A Case Study of Sweden

Junior Management Science (JUMS)

Provided in Cooperation with:
Junior Management Science e. V.

Suggested Citation: Oppelt, Paolo (2024) : The Effect of Carbon Taxes on Directed Technological Innovation: A Case Study of Sweden, Junior Management Science (JUMS), ISSN 2942-1861, Junior Management Science e. V., Planegg, Vol. 9, Iss. 1, pp. 1286-1305, <https://doi.org/10.5282/jums/v9i1pp1286-1305>

This Version is available at:
<https://hdl.handle.net/10419/290636>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by/4.0/>



Online-Appendix zu

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

Paolo Oppelt

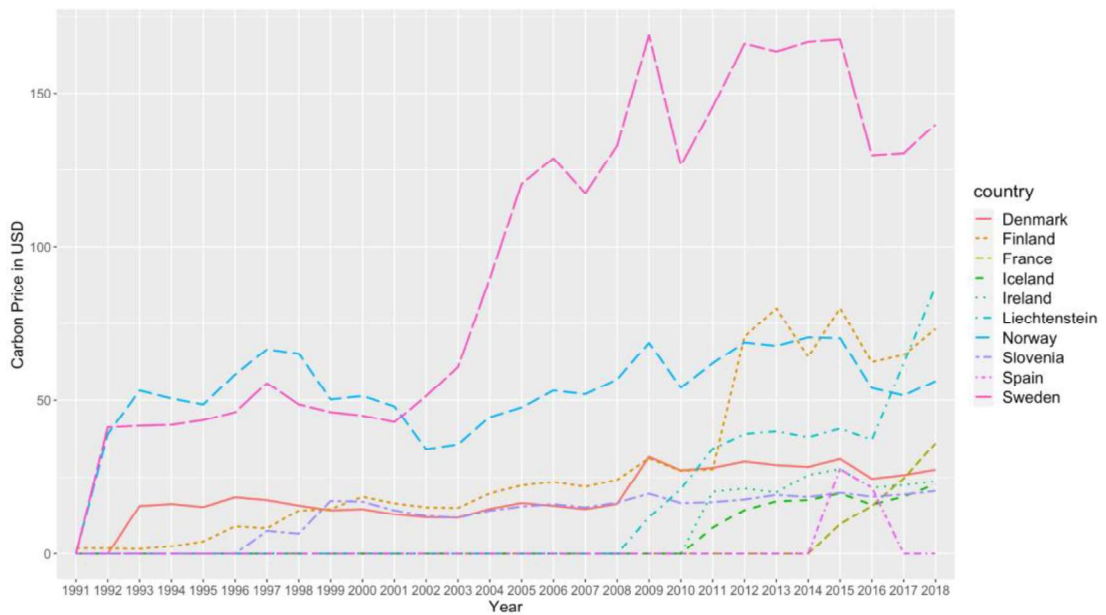
Technical University of Munich

Junior Management Science 9(1) (2024) 1286-1305

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.



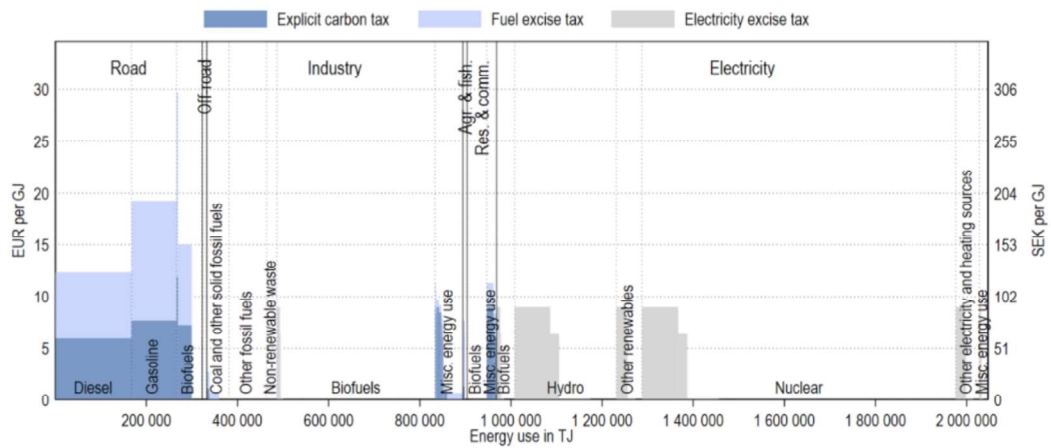
Appendix 2: Share of GHG emissions priced and price signals from taxes & EU ETS in Sweden (OECD, 2016)

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 ₂)	Carbon tax		EU ETS		Overlap of tax and ETS ¹	Emissions not covered by carbon tax or ETS
		Mean price (in EUR / t CO ₂)	Emissions covered (in % priced)	Mean price (in EUR / t CO ₂)	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 use by sector and energy category (OECD, 2019)

This figure shows that energy and CO₂ tax rates in Sweden differ across energy use by sector and category. The CO₂ 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 CO₂. The tax rates shown are applicable on 1 July 2018. The energy usage data reflect data in 2016 (OECD, 2019)



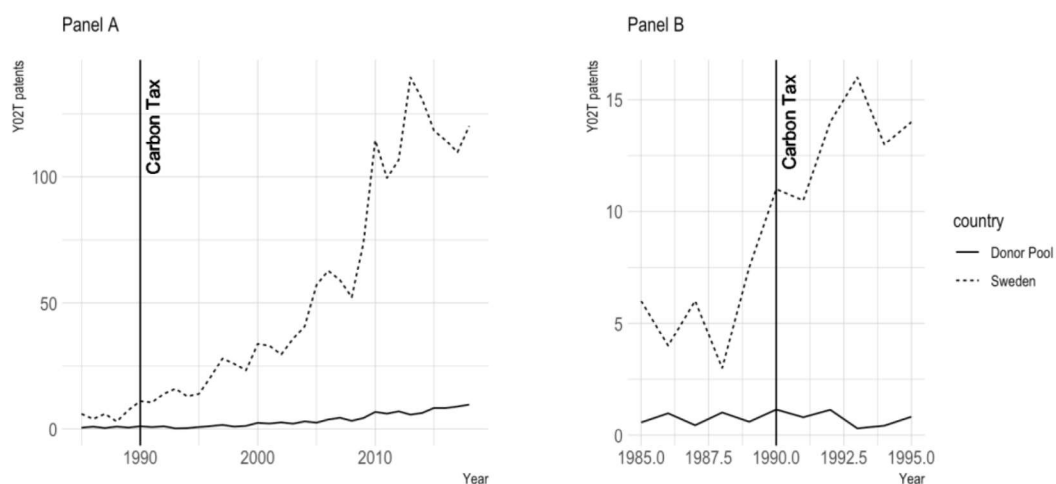
Appendix 4: Y02T subcategories and their frequency

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.

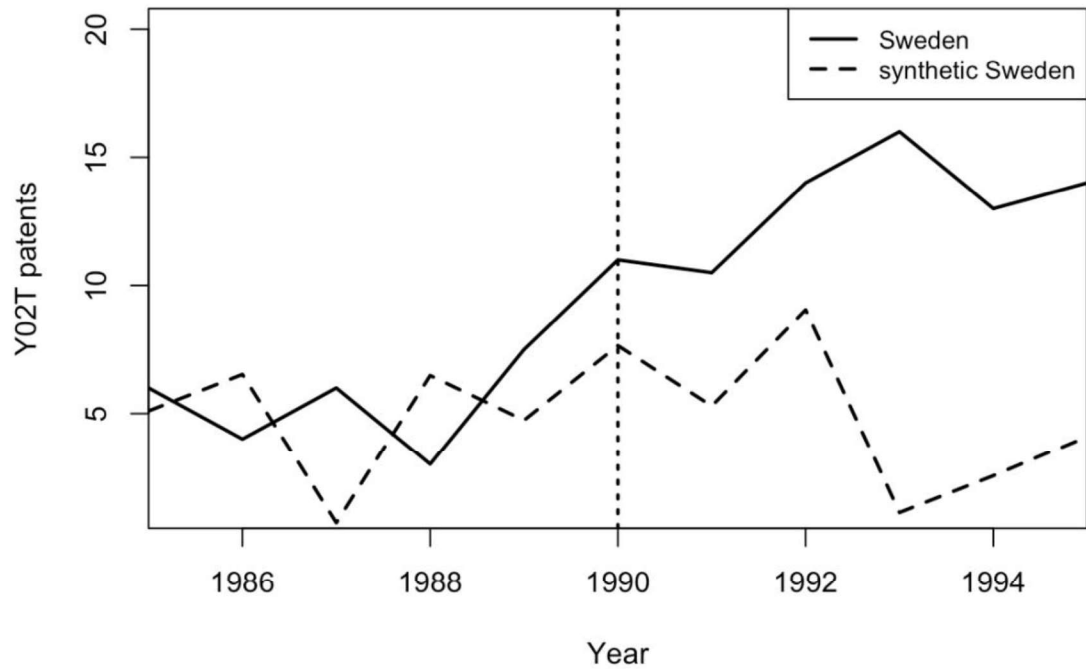
Panel (A) shows the years 1985 until 2018, while panel (B) zooms into the time timeframe 1985 until 1995.



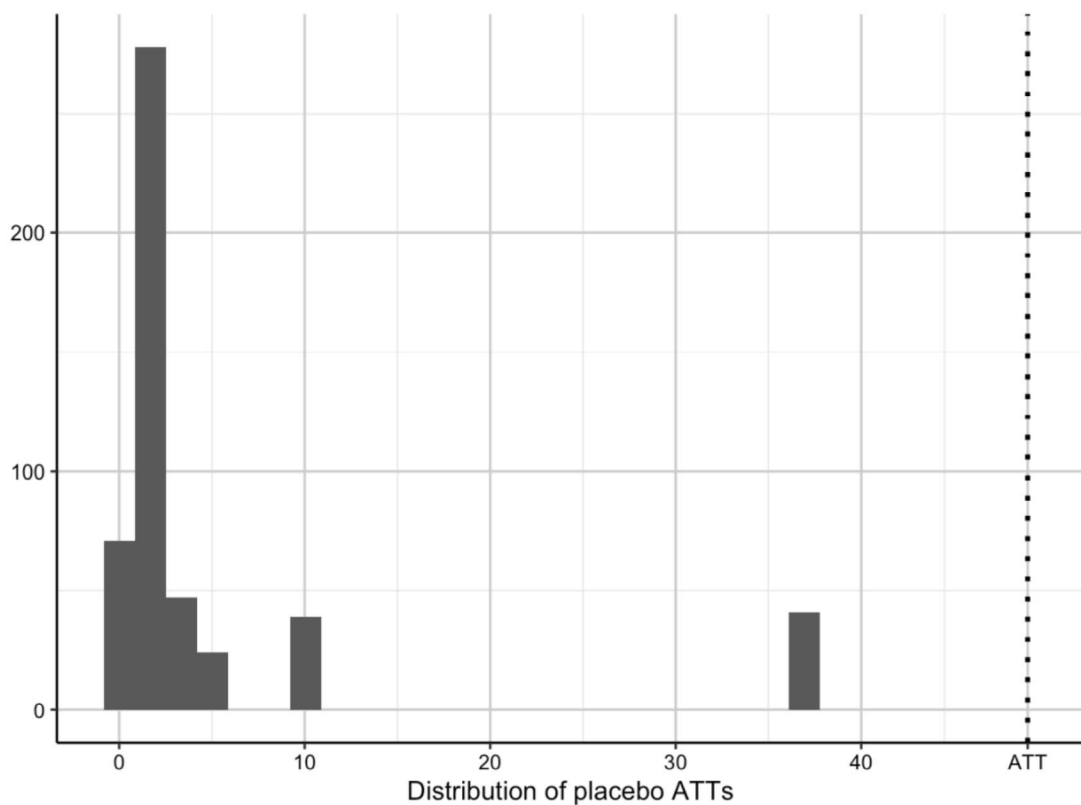
Appendix 6: Country Weights in Synthetic Sweden

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



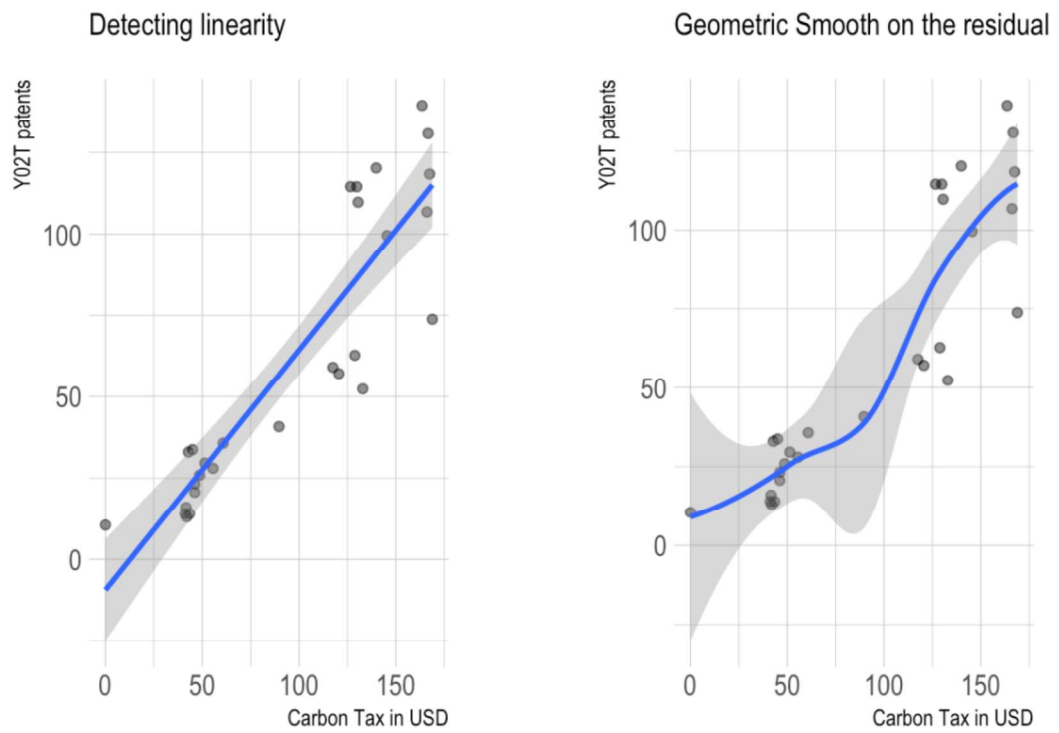
Appendix 9: OLS Regression on the carbon price and Y02T patents

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

Note:

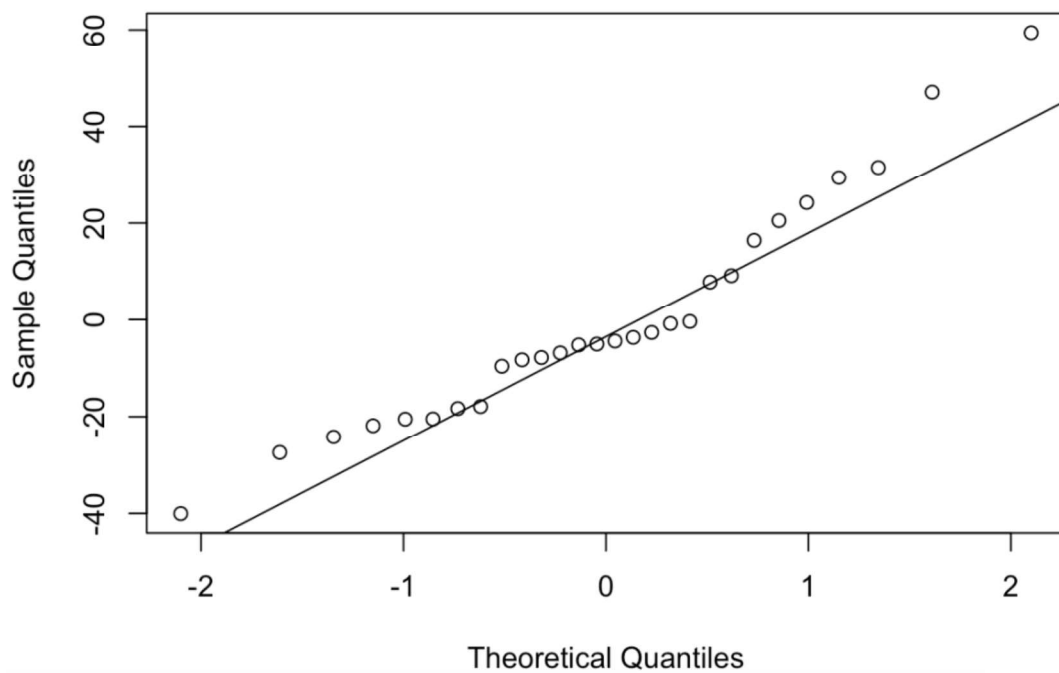
* p<0.1; ** p<0.05; *** p<0.01

Appendix 10: Assessing linearity with a residual plot



Appendix 11: Normal Q-Q Plot

Normal Q-Q Plot



Appendix 12: Diagnostic plot: Heteroscedasticity

