JÖNKÖPING UNIVERSITY
International Business School

Synthetic Control Analysis: Impact of Sweden's Incentive Abolishment on Electric Vehicle Demand

Does the discontinuation of the bonus policy affect the demand of electrical vehicles in Sweden?

BACHELOR THESIS WITHIN: *Economics*
NUMBER OF CREDITS: *15*
PROGRAMME OF STUDY: *International Economics*
AUTHOR: *Julia Lundqvist and Pontus Hjort*
SUPERVISOR: *Andrea Schneider*
JÖNKÖPING *May 2024*

Bachelor Thesis in Economics

Title: Synthetic Control Analysis: Impact of Sweden's Incentive Abolishment on Electric Vehicle Demand

Authors: Julia Lundqvist and Pontus Hjort

Tutor: Andrea Schneider

Date: 2024-05-19

Key terms: EV, Incentive, Policy, Abolishment, Synthetic Control, Demand, Social Norms, Klimatbonus

---

Abstract

In November 2022, the Swedish government decided to abolish the electric vehicle (EV) policy incentive "Klimatbonus". We create a synthetic control group based on other countries with similar continuous policies to gauge the outcome of EV registration in Sweden had the abolishment not occurred. The purpose of this study was to estimate whether this decision has generated a significant post-abolishment impact on the demand for EVs in the Swedish car market. Our findings show that even though the demand has decreased, the result is statistically insignificant. We conclude the policymakers have correctly estimated that the effects on demand will be small. With this study, we contribute to evaluating the treatment effects of abolished EV policies.

Declaration

We hereby declare that this thesis represents my/our own work.

We have read and applied the current research ethics guidelines concerning the use of artificial intelligence (AI) tools in this work, as outlined in the General Course Information. In the preparation of this work, the authors utilized the following AI tools, specifying the purpose for their use.

In this paper, we have used ChatGPT as complementary to improve text quality. This includes suggestion for Thesis title as well as synonym generation. Furthermore, ChatGPT has also been assisting in certain STATA coding. We have also used typing assistant Grammarly to improve grammar structure.

As authors, we have reviewed and edited the content as needed and take full responsibility for the content of the thesis.

Signature: Julia Lundqvist

Date: 16th of May 2024

Signature: Pontus Hjort

Date: 16th of May 2024

Table of Contents

Figures

Tables

Appendix

1. Introduction

There are several climate goals in relation to greenhouse gas emission set up by the EU, where many member countries have introduced various policies to spur the sales of electrical vehicles (EVs). One common way to incentivise the usage of EVs is through bonus schemes where a person can apply for a financial subsidy after the purchase. In 2018, the Swedish Government introduced a bonus-malus scheme, "Klimatbonus", to incentivise EVs and disincentive high emission cars (The bonus malus system*,* 2023). In November 2022, the bonus part of the scheme was abolished with the arguments that the market share of EVs had reached a significant level and that the price of purchasing an EV was equal to the price of purchasing a high emission car, in other word, the bonus had achieved its goals (Frågor och svar, 2023).

The purpose of this study is to evaluate how the demand has changed as an effect of the abolishment. Previous literature has formerly gauged effects with regards to a potential abolishment (Kong et al., 2020) while others evaluate how the demand is affected when the abolishment is replaced by other subsidies (Lu et al., 2022). However, there is yet to evaluate the effect of the demand once the abolishment has occurred while still not offset by substituting incentives. From theory, we would expect a decline in demand as a result of the loss in incentive to purchase an EV (Schwager, 2017). On the other hand, it may not be certain due to other factors such as the social pressure that point individuals to accept the purchase terms of the EV after the abolishment to a greater extent in contrast prior to the enactment (Akerlof & Kranton, 2000). This would thus call for the EV to be integrated on the car market from both a price and social aspect.

In order to examine the effects of the discontinuation of the bonus policy in terms of registrations of EVs, we will create a synthetic twin of Sweden through a synthetic control group consisting of OECD countries with similar policies. The synthetic twin will then serve as a comparison unit, where it estimates the amount of EV registrations had Sweden not abolished its policy. Comparing the EV registrations in Sweden after the abolishment with the estimated EV registrations of the synthetic twin will show the overall effect of the abolishment.

One important aspect of the synthetic control method is the inclusion of countries in the donor pool where we have based the inclusion on two criteria. First, being a member of the OECD, which is standard in the literature when evaluating a OECD member (e.g., Born et al., 2019; Abadie et al., 2015; and Hope, 2016). Second, having similar characteristics as Sweden (Abadie 2021), which in this case is an ongoing financial incentive on EV purchases. With these two criterias in mind, the final analysis is made on monthly data with 12 OECD countries in the donor pool. To obtain a homogeneous comparison independent of country size, all data on EV registrations has been recalculated as total registration per 100.000 working age inhabitants.

The structure of the paper is as follows: We start with the Institutional Background in Section 2, where we focus on the introduction, regulations, and abolishment of the Swedish Klimatbonus. We will also shortly describe the Swedish climate goals, historical EV market share, and some of the countries included in the donor pool. This is followed by a Literature Review and Theoretical Framework in Sections 3 and 4 respectively. Section 5 contains the Data and Methodology, where we describe the variables used, argue for the choice of method, describe the rationale behind the method, discuss its requirements in terms of both data requirements and contextual requirements, and end with a description and argumentation for the countries included in the donor pool.

The Results and Analysis in Section 6 is where we present and describe our main result as well as check the robustness of this result. Our results show no significant effect on demand in neither the main result nor the robustness checks. We then discuss this result and the study's limitations in Section 7 and, lastly, describe and discuss the conclusions of the study in Section 8.

2. Institutional Background

In 2017, Sweden set a long term target for their greenhouse gas emissions, whereby 2045 their net emissions of greenhouse gas should be at zero, meaning that they capture more greenhouse gases than they emit. This entails that the emission in 2045 must be 85% lower than what they were in 1990. The last 15% will be accounted for through capturing measures such as increasing the absorption of carbon dioxide from the atmosphere and storage of carbon dioxide from burnt biofuels. In terms of greenhouse gas emissions from domestic transportation, the target is set at 70% lower emissions in 2030 compared to 2010 which goes along with the EU goals Agenda 2030 (Mål för transportpolitiken, n.d.).

In 2012, newly registered EVs were counted to 922, compared to 301.335 of the total registered vehicles that year. Over time, the absolute number of newly registered EVs has increased. For example, by 2014, it had an increase of 3755 while the total newly registered car market only increased by 22 702 from 2012. The total share of these types of vehicles thus had increased from 0.3% to 16.54%. This have then stabilized with 13.45% of changes in newly registered vehicles between 2014-2016, thus a reduction of approximately 3 percentage points. However, from the first half of 2016 to the first half of 2018, the change in newly registered EVs in comparison to the change of total newly registered cars in Sweden has increased by 20.41% (SCB trafikanalys[1]).

In order to reach the climate goals and increase the market share of low emission cars, the Swedish Government announced a bonus-malus system on vehicles on December 21st 2017. The bonus is an incentive scheme to attract electric car sales, and the malus is a scheme to disincentivize purchases and usage of high emission cars, adding up to the Klimatbonus scheme (The bonus malus system, 2023).

The bonus policy's implication regards a price discount of at most 25% of the car's acquisition price, or at most €4265 [2], as long as its CO_2 emission fulfils the policy requirement. The regulation was enacted on July 1st 2018, where the maximum CO_2 to be emitted was set at 70 grams per kilometre (Sveriges Riksdag 2017). Since then, there have been several amendments to the requirements on maximum CO_2 emission. In April 2021, the CO_2 emission requirement was lowered to 60 grams per kilometre and in July 2022 to 50 grams. In the beginning of 2023, the Swedish Government austered emission to 30 grams while also reduced payout compensation (Bonus - for low emission vehicles*,* 2024).

The malus policy refers to higher vehicle tax burdens on cars emitting higher levels of CO_2 for three years after the date the vehicle becomes taxable. This regulation was also

[1] https://www.scb.se/hitta-statistik/statistik-efter-amne/transporter-och-kommunikationer/vagtrafik/fordon/
[2] Exchange rate assumed approx EUR/SEK = 0.085 as of May 9th 2024

enacted on July 1st 2018, with a charge of €7 per gram of CO_2 for all cars emitting more than 95 grams per kilometer and a charge of approximately €9 per gram of CO_2 for all cars emitting more than 140 grams per kilometer. The emission limit and the tax-rate on the malus policy has been changed several times since the first day of introduction. In April 2021, a charge of €9 per gram of CO_2 applied to all cars emitting more than 90 grams per kilometer and a charge of €11.25 per gram of CO_2 applied to all cars emitting more than 130 grams per kilometer. In June 2022, a charge of €9 per gram of CO_2 applied to all cars emitting more than 75 grams per kilometer and a charge of €11.25 per gram of CO_2 applied to all cars emitting more than 125 grams per kilometer (Malus - for high emission vehicles*,* 2023).

On November 7th 2022, the Swedish government came to the decision that the bonus part of the policy had achieved the goal it was intended to: increase the market share of environmentally friendly cars on the market. This decision was not only based on the market shares but also on the cost effects they had evaluated of the policy, the cost of driving and owning an environmentally friendly car was fairly equivalent to that of other cars. The discontinuation of the Klimatbonus came into effect the day after the announcement was made, the malus part was however kept. One important distinction with regards to the cut-off date, is the time it might take for consumers to receive a new car from the purchasing day. The government therefore decided that anyone who had ordered a low-emission car before November 8th could still register the car for the bonus up until March 31th 2024, with proof of the day of purchase (Frågor och svar, 2023).

In order to properly estimate only the effect of abolishment, we limit our dataset to start in July 2018, after the policy was first introduced. As of the abolishment of the policy, November 2022 will then be the treatment date for our analysis.

Aside from Sweden, there are several other countries that have implemented similar policies. As mentioned, we found 12 OECD countries with financial incentives on EV purchases. However, only four of them are included in the synthetic twin. Therefore, we will briefly explain their policy enactments in this paragraph. Norway's current enactment tells exemption of purchase taxes and VAT for EVs priced below €42 647[3] (Moms, 2024). In addition, until 2023, Norway also held a 75% registration fee discount (Norway, n.d.). Ireland, on the other hand, offers a progressive purchase grant of a maximum €3500 of the EV if the full price ranges between €14 000-€60 000 (Grant amounts, n.d.). The German Environmental Bonus has a related structure as a purchase grant between €3000-€4000 is paid out to newly registered EVs for full prices up to €60 000 as well as improved charging infrastructure (Regulatory environment, n.d.). On December 17th 2023, the Environmental Bonus was abolished with immediate effect (Manthey, 2023). Luxembourg, however, still has an active purchase subsidy with a grant to a maximum of €8000 if all requirements are met. Otherwise, the subsidy gets reduced to €3000 (Luxembourg, n.d.).

3. Literature Review

Over the years, there have been several articles published that studies the impact of financial incentives across the world. The topics vary from direct financial purchase subsidies and taxation to indirect subsidies such as charging station infrastructure. There are, however, few studies that focus on the impact from an abolishment of such policies. Since findings may be partially explained by social or cultural differences between countries or regions, we will sort our literature review based on geographical location to make each section as homogeneous as possible. We will start with China as it is the only place where studies have been made on abolished policies by this point in time. Thereafter, we work through the review by studying the general impact of financial incentives on EVs in the United States, Europe, and finally Sweden.

As we start with abolishment effects, Kong et al. (2020) tries to simulate the effect on the EV market and its diffusion if the abolishment of several policies such as product subsidy, carbon emission trading, and license plate restriction occurred. Kong et al. (2020) find that by that point in time, China was at the rapid development stage which would cause major fluctuation if abolishment took place at that stage. The outcome was estimated to cause a decline of 40.39% in market share. This is complemented by Lu et al. (2022) which is contending that once the subsidy disappears, the EV choice rate declines from

[3] Exchange rate assumed approx EUR/NOK = 0.085 as of May 9th 2024

47.52% to 12.43%. However, this could be offset by substitute policies to mitigate or fully cope with the decline. Lu et al. (2022) propose alternative substitutional policies such as mileage subsidies and parking fee discounts which do not need to match the total amount of the original policy to compensate for the decline in demand. In comparison to our study, Sweden did not intervene in its abolishment by substitution which rationally would give us clearer results based on the drop in demand explained by the abolishment.

Aside from studies on abolishment impact, a handful of studies on financial incentives on China has also been conducted. In Qiu et al. (2019), the effectiveness of EV incentive policies is tested based on 88 Chinese pilot cities. They conclude that the demand side of the policy is effective as opposed to the supply side. Therefore, there is an emphasis on continued focus on charging discounts as well as subsidies on the charging infrastructure. On the one hand, purchase subsidies are found to be ineffective. This is supported by Liu et al. (2021) where the financial incentives have no significant effect on EV sales in China while the construction of charging stations and convenience in non-purchase orders drive demand and thus make the EV incentive policy effective. On the other hand, Zheng et al. (2022) investigates the Chinese EV incentive policy based on panel data and the difference-in-differences method. By using this method, they measure both the control and the treatment group before and after the intervention. In their paper, EV purchase subsidy incentives were found to be the contributor to one-quarter of EV sales from 2009-2018. There are thus mixed results of financial incentive impact on the EV market in China.

Recently, Shang et al. (2024) find further evidence of the mixed result. This study is experimented on a quasi-natural level as a result of financial constraints from the Chinese government and based on panel data from 224 cities in China. Even though the EV incentive policies are found to be most effective in the most populous and economically developed cities, their findings contend that a 1% increase in purchase subsidies will increase EV sales by 1.36% and sale shares of EVs by 2.31%. In particular, parking benefits and a number of vehicle restrictions stand as the most effective incentive policies. We could thus speculate whether the mixed result on the incentive effect is based on the setting between rural and urban areas from the other studies mentioned. However, aligned with the findings of Qiu et al. (2019), the supply side shows no significant benefits to these incentive policies. This is probably due to manufacturers' aim to maximize their profits rather than increase social welfare.

The United States showed more cohesive results with regard to the effect of EV policy incentives. In 2005, the Federal government implemented the Energy Policy Act. This was enacted as an incentive to increase sales of alternative fuel vehicles, such as EVs, by providing a $2000 taxable income deduction. Jenn et al. (2013) measure the effectiveness of this policy. By use of econometric dummy variables, Jenn et al. (2013) find that hybrid electric vehicle sales increased by 0.0046% per dollar when the incentive was $1000 or higher in incentive. This aligns with Sierzhula et al. (2014) who find that for each $1000 increase in incentive would generate an average increase in EV market share of 0.06%. For example, if a policy was enacted that increased EV incentives by $2000, this would thus lead to a 0.12% increase in EV market share within that country. Furthermore, Sierzhula et al. (2014) also claim another important factor for efficient policy incentives: charging stations. The author contends that for each additional charging station per 100.000 residents, the EV market share would increase by 0.12%, thus generating twice as high an effect as that of the financial incentive.

Similar to Shang et al. (2024), incentive policies in the United States are also dependent on the population setting. Slowik & Lutsey (2017) discovers that consumer incentives have had an effect on EV sales. His findings shows that over 80% of the top metropolitan cities in the United States in terms of EV sales offer incentives varying between $2000-$5000. Wee et al. (2018) followed up on this research by gauging the effectiveness of the EV policy incentives across the 50 U.S. states. By using the difference-in-differences method to find the gap in the treatment and control group, Wee et al. (2018) find that a $1000 increase in incentive value per state would generate a 5-11% increase in EV registration. In addition, DeShazo et al. (2017) looks further into the progressive income rebate that the Californian state-level EV program entails. From their findings, this policy program has generated approximately 10.000 new plug-in vehicles and increased sales by 7% with a total market increase of 0.2%.

Aside from financial purchase subsidies and income rebates, we should also emphasise tax incentives as a way to integrate the EVs into the car market. In a study by Ferdousee

(2020), the effect of tax credit policy on EVs in Maryland is tested using a synthetic control group. Ferdousee (2020) finds a positive impact as EV sales in this state more than doubled in comparison to the predicted result. However, concerning the aim of the policy to have sold 300.000 EVs in five years, the pace of the sales was still ten times too slow. By January 1st 2024, a new American policy has been enacted which entails that consumers can transfer the tax credit by the purchase of the EV rather than waiting at the tax filing the following year to receive the tax credit. Even though it is too early to assess how this policy affects EV sales in the U.S., results have shown that the policy has increased consumers' intent to purchase EVs. It has also been shown that the policy is more effective in drawing new customers rather than existing customers who are already interested in buying an EV (Stekelberg & Vance, 2024).

Apart from direct financial incentives, the United States have in particular studied the effect on investment in charging stations. Li et al. (2017) scrutinise the network effects that arise with regard to expansion of charging stations and the effect it has on the policy incentives of EV. The authors find that the presence of charging stations generates a feedback loop that benefits the policy incentive for several years. This highlights the importance of charging stations that Sierzhula et. al. (2014) previously mentioned and will thus be of consideration for our own research. In addition, Clinton & Steinberg (2019) further supports this as crucial factors to decide the net welfare effect as the benefits from emission avoidance are not sufficient. Other factors include long term market growth, savings in production cost, and improved innovation within the industry.

Positive impacts from EV incentives are also seen across Europe. Plötz et al. (2016) looks at the policy measure of European EV incentives. Their findings were that income, gasoline prices, and direct incentives have a positive impact on EV sales shares. This was then followed up in Plötz et al. (2017) where they also find indirect subsidies to have a positive impact. Meanwhile, in Spain, the effectiveness of such policy depends on the population concentration. Similar to previous findings, incentive policy is the most effective in populous cities while holding the opposite in the rural parts of the country (Sánchez-Braza et al., 2014).

In Norway, which is one of the most intensive users of EV policy incentives in Europe, pricing incentives and increased investment in charging station infrastructure are considered the most effective policy incentives (Mersky et al., 2016). In addition, Østli et al. (2017) find that fuel taxes have encouraged car customers in Norway to buy lower-emission vehicles, such as EV cars. This is supported by Yan (2018) who claims that even though it is still costly to use tax incentives as a way to reduce CO2 emissions, he contends that a 10% total tax incentive will lead to an average increase of 3% in EV sales share. We thus see positive impacts on tax incentives from our findings in both Europe as well as the United States.

We should also further highlight studies that occur across European countries. Resemblant to Plötz et al. (2016), Münzel et al. (2019) conducted a panel data study of 32 European countries to gauge the effect on EV sales based on financial incentives. It has been shown in monetary incentives that a €1000 higher subsidy would lead to a 5-7 percentage points increase in EV shares within a country. In addition, energy prices also show positive indications for EV adoption. Charging stations, however, are not taken into consideration due to various factors such as the unevenness of use between different countries used in this study. To complement, this study has been followed up by Funke et al. (2019), whose focus has been narrowed down to the impact of charging stations across Europe by sifting down controlled countries to make them more homogenous in terms of charging station infrastructure. Still, the results vary from country to country but Funke et al. (2019) concludes that charging stations as opposed to home charging are demanded in some dense areas.

Looking at Sweden, there have also been particular studies on the bonus-malus system that were proposed before the current Klimatbonus became in use. Habibi et al. (2018) evaluates the bonus-malus system concerning the aim of reaching 95g CO_2/km average on new car sales in Sweden. They contend that this policy is insufficient in meeting this goal and thus needs stronger policy implementation to fulfill them. Some of the authors have followed up this article by putting this policy in perspective to the income distribution in Sweden. They find that the bonus-malus system has an adverse outcome on welfare which mostly burdens rural areas and smaller cities where the incomes are lower. In urban areas, however, people tend to have higher incomes and thus may be able to adapt to a greater extent to avoid welfare losses (Pyddoke et al., 2021).

Other studies have also tested the Swedish EV incentive policies over the years. Engström et al. (2019) evaluates Swedish incentive policies on alternative fuel vehicles, such as EVs. They find the subsidies to be effective on private buyers only if the costs of alternative fuel vehicles were comparable to conventional vehicles. This is not only due to the high price that alternative vehicle fuels have but also the high initial depreciation rate. It is therefore regarded as safer to buy these types of vehicles on the second-hand market where the high depreciation rate has already abated. Many of these findings show similarities with the aim of the current Klimatbonus: to integrate the EV market sufficiently for prices to compete with conventional vehicles.

In addition, other transportation policies implemented for Sweden to reach the emission goals in 2030 could also be based on the prices of gasoline and diesel. Tirkaso & Gren (2020) evaluates the gasoline and diesel prices through a panel data study on the county level between 2001-2018. Their findings show small differences in the effective carbon tax between short-run and long-run price elasticities. In the long run, the effective carbon tax would raise fuel prices to 145% while in the short run, fuel prices could be raised up to 280%. Tirkaso & Gren (2020) also divides up the fuel pricing based on regional and national level pricing. On a regional price elasticity, a higher social cost of CO2 was implied about gross regional product while the national price elasticity showed the lowest private cost of CO2. Fuel prices would thus need to at least double from 2020 fuel prices in order to satisfy the 2030 emission goals.

From our literature review, we find several articles that evaluate EV subsidies affection on demand. However, we also find an explicit gap in the effect on demand once these subsidies are abolished. Therefore, we justify our study by contributing to this literature gap.

4. Theoretical Framework

In this section, we will utilize two different economic theories that can be linked to the change in demand of EVs as a result of the abolishment of the Klimatbonus policy. The first theory relevant for our study is the law of supply and demand and secondly, we will explain the theory of social norms.

4.1 Supply and Demand

Supply and demand are one of the most fundamental concepts in economics. Among others, this notion serves as the main determinant in terms of price setting in economic theory and thus an indicator for our study in evaluating the outcome of continuous sales after the Klimatbonus abolishment. On the one hand, supply is the quantity of a good that can be provided in a market for a given price. Factors affecting supply include substitute products, production technology, and factors of production. On the other hand, demand is the quantity of a good requested by the market for that given price. This part is influenced by the price of substitutes, consumer income, and preferences (Britannica, 2024). Demand can be inferred as an instrument to gauge the consumer buying pressure, as opposed to supply which is more production-oriented. The dynamics between supply and demand is then derived graphically in the supply and demand diagram where the price variable is represented on the vertical axis while the quantity variable is represented on the horizontal axis. The point on this graph where the supply and demand curves meet each other is referred to as the equilibrium point which is depicted in Figure 1. (Schwager 2017).

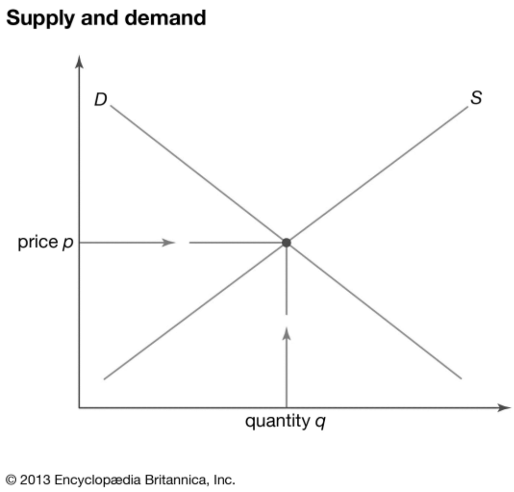
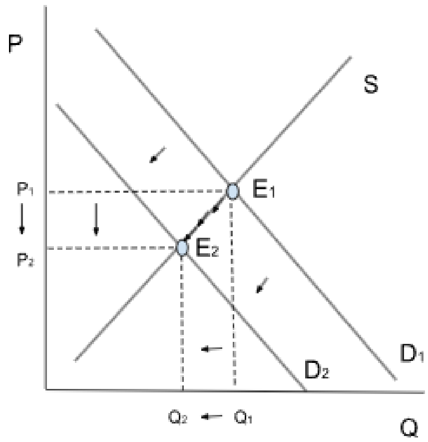


Figure 1: Graphical illustration of Supply and Demand. Source: adapted from Encyclopædia Britannica, Inc, (2013)

As our study will concentrate on the affection of consumer appetite for EVs as a result of the Klimatbonus abolishment, we will thus solely focus on the demand aspect in theory. As seen in the figure above, the demand curve has a negative relationship with price. That is, as price increases, demand will decrease. When only price changes, the point of demand will solely move along the demand curve. However, as the factors mentioned change, the whole demand curve will shift (Schwager 2017). When the Klimatbonus gets abolished, this would rationally cause an effect toward a decline in the demand curve as a result of subtracted benefits with no compensation as a tradeoff. This would thus result in a reduction in quantity demanded and finally a decrease in sales. Figure 2 depicts the old equilibrium (E_1), and the new equilibrium that occurs after a decrease in demand (E_2)



.

Figure 2: Graphical illustration of decline in demand. Source: Own work

The demand side has been studied with regard to policymaking and is deemed to have a positive effect. In the EV consumer market, the role of purchase subsidies and tax reliefs play an integral role in stimulating demand (Featherman et al., 2021). This is further supported by Liu et al. (2023) as policy incentives on EVs are needed to uphold the demand as the growth stage of the EV market in China phases out. The author contends that purchase subsidies will be important for the demand not to decline. This shows resemblances to our study as the concern for the demand side to persist at the current level is based on the presence of Klimatbonus. As previously stated from the literature review, Qiu et al. (2019) supports the significance of demand over supply in financial incentive policy. However, the demand side may also be overstated. By conventionality, policymakers target the demand side when policy implementation to reduce CO_2, but this could be twice as ineffective as focusing on the supply side. The demand side may thus not always generate the impact that could be expected beforehand (Fæhn et al. 2017). However, in conclusion, based on the theory of supply and demand, the effect of the policy abolishment should result in a decrease in demand.

4.2 Social Norms

Social norms are "the behavioral expectations, or rules, within a society or group, or alternatively a standard, customary, or ideal form of behavior to which individuals in a social group try to conform" (Dolan et al., 2012, p. 267). By using the social norms as a cue for prevailing behavior, individuals anticipate other behaviors and can thus act according to these (Clapp & McDonell, 2000). Akerlof & Kranton (2000) find that decision-making is largely based on the avoidance of negative emotions that arise from social pressure. An individual's payoff is thus susceptible to change based on the view of a third party.

In particular, intervention in social norms toward pro-environment behavior shows support by research. In an article by Farrow et al. (2017), social norms intervention on pro-environment behavior proves to be the most effective when it, on the one hand, is subject to descriptive instead of injunctive norms. That is, when targeting the social norms on how people actually behave rather than ought to behave, pro-environment can prevail as social norms get skewed favorably towards it. This is also highlighted by Vesely & Klöckner (2018) who, on the other hand, also stresses injunctive norms as contributing factors to the change of pro-environmental behavior.

In the context of policy impact, social norms can trigger a response and affect behavior if it is sufficiently apparent within a group (Allcott, 2011). This is further supported by Lindman et al. (2013) who claim that those who feel particularly responsible for the emission of carbon dioxide will also be the ones who are most likely to buy emission allowances. They also find that the perceived willingness to purchase from others also has an impact on one's own willingness. Policymakers thus have the opportunity to affect consumer behavior by campaigning beliefs of other people's intentions in order for consumers to act themselves. When it comes to sales of EVs, positive opinions from the public generally lead to higher inclination of EV purchase (Kim et al., 2014), thus potentially being a factor to consider in our study. Consequently, social norms could hinder the decline in demand from decreasing as a result of EVs being integrated in a social context.

With these two theories in mind, we can vision them as opposing forces. On the one hand, if the price effect shows the greatest impact, our result should show a significant decrease in demand. On the other hand, prevailing social norms would entail that the demand shows an insignificant effect from the abolishment. Therefore, we could formulate our hypothesis as follows: if the social norm effect is small, the abolishment leads to a significant decrease in EV sales. Otherwise, the abolishment has no significant effect.

H_0: The abolishment of the Klimatbonus has an insignificant effect on EV demand

H_1: The abolishment of the Klimatbonus has a significant effect on EV demand

5. Data and Methodology

5.1 Variable Definition

The outcome variable of interest in this study, registrations of EVs, is taken from the European Alternative Fuels Observatory[4], where we obtained monthly data from July 2018 until December 2023. EVs are both battery electrical vehicles and plug in hybrids. In order to create a better comparison between Sweden and the countries in the donor pool, the absolute values of registrations were transformed into registrations per 100.000 inhabitants. The population data is inhabitants at age 15-64 years, which will be referred to as inhabitants or population throughout the paper. This data is extracted from the Federal Reserve Economic Data[5]. Population was, however, only available on a quarterly basis, when converting this to monthly values, the simple approach of three months having the same value was chosen since population is a non-volatile variable.

Additionally, we have quarterly data on GDP per capita which also is extracted from the Federal Reserve Economic Data. This will be used as a control variable in order to create a robustness test. Furthermore, we have quarterly data on the total number of recharging stations, extracted from the European Alternative Fuels Observatory. In line with previous literature, there is a positive correlation with implementation of EV infrastructure and EV demand. Therefore, the recharging stations will be calculated on the same per capita level as EV registrations and this will be used to evaluate a possible complementary explanation to our main result. Table 1 summarizes the data used.

---

[4] https://alternative-fuels-observatory.ec.europa.eu/

[5] https://fred.stlouisfed.org/

Variable name	Definition	Frequency	Source
EV Registrations	Total number of EVs registered per month	Monthly	European Alternative Fuel Observatory
Population/ Inhabitants	Working age population 15-64 years	Quarterly, transformed to monthly	Federal Reserve Economic Data
GDP per capita	Gross Domestic Product divided by total population	Quarterly	Federal Reserve Economic Data
Recharging stations	Total number of recharging stations	Quarterly	European Alternative Fuel Observatory

Table 1: Variable definition

5.2 Method

Studies on the causal effects of policy intervention have been subjected to discussion for a long time due to the challenges associated with these types of effect estimations. The standard methods of randomized controlled experiments are difficult to implement in regard to policy studies due to the ethical aspects of implementing a policy for some parts of the population (Athey & Imbens, 2017).

The synthetic control method is built on difference-in-differences estimation and is an alternative method for comparative case studies when estimating a treatment effect (Abadie et al., 2015). The main idea and motivation behind the synthetic control method is that choosing a single unit to compare with the treated unit does not provide the most accurate comparison, hence the synthetic control approach uses a combination of units to provide a better comparison for the treated unit (Abadie et al., 2010). In simple terms, the synthetic control method takes a treated unit (country, region, or city) that has been subject to policy intervention, compares it to a synthetic twin by applying weights to a number or other untreated units, and thus the effect of the intervention can be estimated. Athey & Imbens (2017) argued that the synthetic control approach is the most important innovation in the policy evaluation literature in the last 15 years.

As proposed by Abadie (2021), this method offers several advantages compared to other methods when estimating treatment effects. First of all, it prevents extrapolation since the weights on the untreated units sum to one and are non-negative. Secondly, it has complete transparency of the fit, which means that it shows clearly how well the untreated unit observations fit the treated unit observations. Thirdly, the synthetic control method has complete transparency of the counterfactual, that is, it shows the weights of the untreated units used to generate the synthetic twin (Abadie, 2021). Lastly, there is no requirement for post-intervention knowledge when estimating the weights of the untreated units, thus the design of the study can be conducted without any knowledge on how the design decisions affect the result of the study (Ferman et al., 2020).

Most statistical methods can be subject to specification searching, where if the result can differ widely depending on different specifications, researchers then have the opportunity to pick the specifications that make the result statistically significant. Combining the four points described above makes the method more reliable since it minimizes specification searching opportunities (Ferman et al., 2020). Different specification searching opportunities are described and discussed in greater detail further below.

Shortly summarizing the rationale behind the method; one region, Sweden, has been exposed to some kind of policy intervention, the abolishment of the subsidy, while others remain unaffected, the donor pool then consists of i regions with no intervention, making the total amount of regions observed equal to $i + 1$. Our donor pool consists of 12 countries, namely, Austria, France, Germany, Greece, Ireland, Italy, Luxembourg, Norway, Poland, Portugal, Spain and The Netherlands. The inclusion and exclusion of countries are discussed in greater detail in Section 5.4.

Let T be the total number of time periods observed and T_0 be the number of periods before the intervention, making $T - T_0$ the number of periods after the intervention. Y^N_{it} is the observed outcome of the variable of interest in the absence of the intervention for region $i = 1, \ldots, i+1$ at time $t = 1, \ldots, T$. Y^I_{it} is the observed outcome of the variable of interest for region i at time t if region i is exposed to the policy intervention in the post-intervention periods $T_0 + 1$ to T. Consequently, in our study we have $T = 66$ months, $T_0 = 52$ months, making $T - T_0 = 14$ months.

The main equation for the analysis is as follows:

$$Reg_{it} = \alpha + \beta T_{it} + \delta D_{it} + \gamma(T_{it} \, x \, D_{it}) + \epsilon_{it}$$

Where:

- Reg_{it} is the registration of EVs in country i at time t,
- α displays the intercept,
- β is the coefficient which captures the difference in EV registrations for Sweden compared to other countries, but strictly in the pre-treatment period,
- T_{it} is a binary variable indicating whether country i is the treated unit (1 for Sweden, 0 otherwise),
- δ represents the coefficient which measures the general time effect on EV registrations across all countries,
- D_{it} is a binary variable indicating whether the observation is in the pre- or post-treatment period (1 if post-treatment, 0 if pre-treatment),
- γ represents the coefficient for the interaction term, which specifically measures the effect of the abolishment in Sweden in the post-treatment period,
- $T_{it} \, x \, D_{it}$ is the interaction term between being Sweden and being in the post-treatment period (1 for Sweden in the post-treatment period, 0 otherwise),
- ε_{it} is the error term.

Furthermore, there are several requirements to use this method as proposed by Abadie (2021). In this section we will first go through the three main data requirements and how our analysis fits these requirements. We will then discuss four contextual requirements in terms of our study.

First of all, data on the outcome variable and potential predictors is an obvious requirement in any comparative case study. In the synthetic control method, this data needs to be available for both the treated unit and all units in the donor pool (Abadie 2021). As already described, we have all the data needed for our outcome variable. However, the topic of predictors has been the subject of discussion. Ferman et al. (2020), discuss specification searching within the synthetic control method. They argue that the transparency of fit advantage is weakened by the lack of consensus concerning the choices of control variables. Therefore, they recommend focusing on the outcomes of the variable of interest before the event date unless there is a strong belief that some specific control variables are crucial for the analysis. This is to minimize the risk of specification searching and increase the transparency of fit. The argument to exclude controls is supported by Doudchenko & Imbens (2016), who find that including other pre-treatment variables in the analysis tends to play a minor role in the result. The most relevant control variables for this analysis would be price indices on EVs for all countries which have been excluded due to lack of data availability. Another potentially relevant control is GDP per capita for all countries; this variable is not available on a monthly basis, it will however be included to conduct a robustness check on the quarterly level to check the validity of our results. This way the main result is conducted with as many data points as possible and complete transparency while still controlling for important variables. All robustness tests are stated and described in Section 6.3.

Secondly, having a large pre-intervention window is important to obtain an accurate result (Abadie 2021). Since we have a limited time frame between the introduction in 2018 to the abolishment in 2022, we are left with 52 pre-intervention periods. Thirdly, having good post-intervention knowledge, where if the effect of the policy intervention on the outcome variable does not arise directly but rather arises gradually, good post-intervention information will generate a better understanding of the intervention effects. As is the case in our study, where it is possible to have a gradual effect, hence we have set our post-intervention timeline to end where we have the latest available data.

In terms of contextual requirements, the first is the effect and volatility of the outcome variable, where if the outcome variable is highly volatile, it might be impossible to distinguish between small effects and other shocks that affect the variable. Highly volatile data also increases the risk of overfitting in the analysis (Abadie 2021). The main variable in our analysis, registrations of EVs, is a highly volatile variable, which will be seen from the graphs in the Descriptive Analysis in Section 6.1. In the case of a volatile outcome variable, Abadie (2021), suggests that the volatility should be filtered out. By this, we decided to do exponential smoothing on Sweden and all countries in the donor pool, this is depicted and described in Section 6.1.

The second and third point refers to the donor pool, where the second point states that it is important that the units included are not exposed to any similar intervention during the period of interest. It is also important that the units in the donor pool have similar characteristics as the treated unit. The third point refers to interference between the treated and untreated units. If there is a spillover effect so that the intervention in the treated unit affects the outcome variable of any units in the donor pool, these should be excluded from the donor pool (Abadie 2021). In Section 5.3 we argue for the choice of country inclusion in our study.

The fourth point refers to anticipation, where if it is believed to be an anticipation or announcement effect prior to the implementation of the intervention, the treatment date should be adjusted to the point in time where the anticipation effect occurred (Abadie 2021). If an anticipation effect can be observed, the period T_0 should backdated to the time t where the outcome variable could have been affected or reacted to the announcement of policy intervention. Now we can assume the policy intervention does not affect the variable of interest during the pre-intervention period, hence for $t = 1,...,T_0$ and $i = 1,...,N$, we have that $Y^I_{it} = Y^N_{it}$ (Abadie et al., 2010). As stated in Section 2, the abolishment was announced one day prior to it coming into effect, therefore we strongly believe that there is no observable announcement effect. However, this will be both tested in Section 6.3 and further discussed in Section 7.

5.3 Donor Pool

To construct a trustworthy synthetic control analysis, the countries included in the donor pool are of utmost importance. Therefore, the countries we have chosen to include have been carefully selected based on two main criteria. The first criterion is that the country must be a member of the OECD to maintain homogeneous countries with several similarities. Using OECD member countries as a donor pool when constructing a synthetic twin of another OECD member is standard in the literature (e.g., Born et al., 2019; Abadie et al., 2015; and Hope, 2016). In relation to this, all countries except Norway are members of the EU which ensures further similarities in the donor pool. The second and most crucial criterion is the existence of a financial bonus on purchases of EVs. These two criteria narrowed the donor pool down to a total of 12 countries. While most of the exclusion occurred due to one of the two reasons, there are two exceptions. First, Switzerland and Belgium were excluded since the existence of a subsidy is regionally based and therefore the country as a whole does not meet the criteria for inclusion. Second, OECD countries outside of Europe were excluded due to lack of data availability. Table 2 shows the countries included in the donor pool and dummy variables showing which types of incentives in relation to EVs each country offers.

Country	Subsidy	Registration tax benefits	Ownership tax benefits	Charging station incentives	Parking incentives
Sweden	1	0	1	1	0
France	1	1	0	1	1
Germany	1	0	1	1	0
Netherlands	1	1	1	1	0
Ireland	1	0	1	1	1
Austria	1	1	1	1	1
Greece	1	1	1	1	1
Italy	1	0	1	1	1
Luxembourg	1	0	1	0	0
Poland	1	1	1	0	0
Portugal	1	1	1	0	1
Spain	1	1	1	0	1
Norway	1	1	1	0	1

Table 2: Donor pool countries, with respective incentive structure.

One usual assumption in the synthetic control method is the no interference between regions. In other words, it is assumed that the policy intervention has no effect on the variable of interest in the regions with no intervention (Abadie et al., 2010). According to EU regulations, subsidies on EVs are conditional, meaning that the EV must be registered for use in the country that paid the subsidy (Buying an electric car, 2023). Therefore, we find the assumption that there is no interference between our countries; in other words, the abolishment of the Swedish Klimatbonus does not affect the sales of EVs in any of the donor pool countries.

With all of this in mind, the main analysis will be made on monthly data with only smoothed historical registrations as control. Furthermore, Kaul et al. (2021) showed that pre-treatment fit is optimized when all pre-intervention points of the outcome variable are included as predictors. Therefore, to construct the synthetic twin of Sweden as accurately as possible, it will not be based on average but rather on each data point prior to the event date.

6. Results and Analysis

6.1 Descriptive Analysis

Figure 3 shows the total number of registrations per 100.000 inhabitants in Sweden for the full-time period. It shows a clear increase since the introduction of the Klimatbonus and the highest point in December 2022, right after the abolishment. It also clearly shows the volatility of the variable. For a depiction of all countries in the donor pool, see Appendix 1.

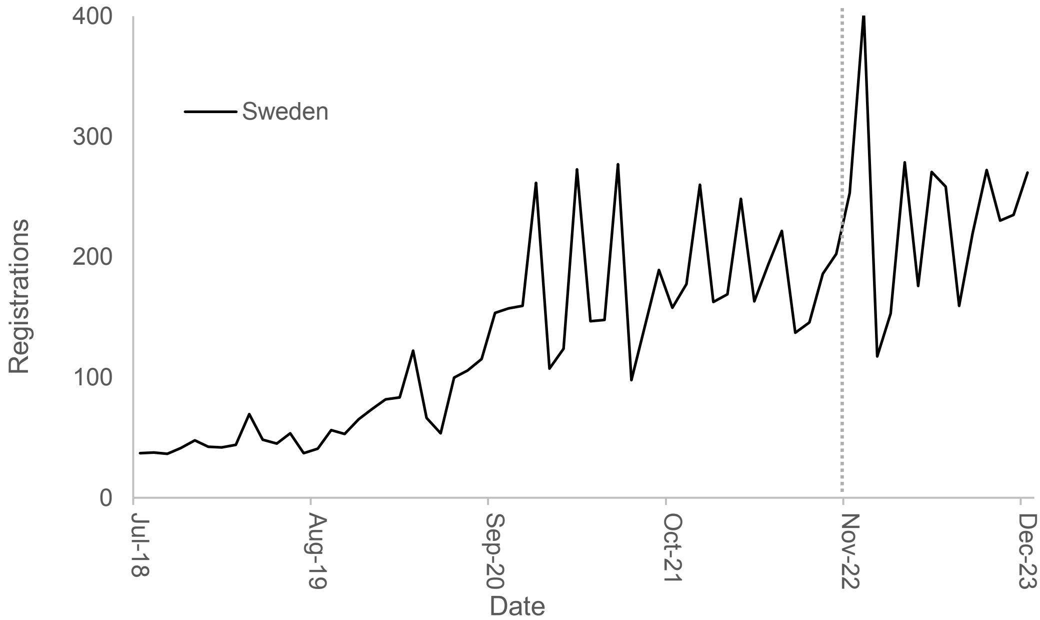


Figure 3: Total number of registrations in Sweden.

As argued in Section 5.2, highly volatile outcome variables should be filtered out to decrease the risk of overfitting, hence registration of EVs has been exponentially smoothed for all countries in the donor pool. Figure 4 depicts both the total number of registrations per 100.000 inhabitants in Sweden and the smoothed values as well as the trend line for both series. This shows that the smoothed series follows the same trend as the total registration series.

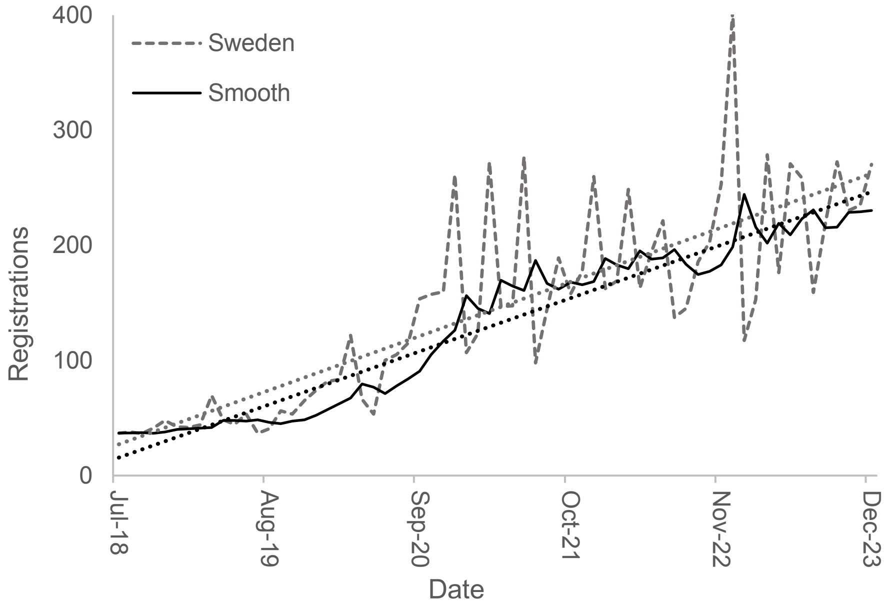


Figure 4: Total number of registrations in Sweden and the smoothed values.

Table 3 depicts simple regression statistics for the actual registrations in Sweden and the smoothed values per 100.000 inhabitants. From this, we can tell that both the slope and intercept follow closely, and the goodness of fit increases as the variable is smoothed. We can therefore conclude that smoothing will still generate a valid result.

Variable	Slope	Intercept	P-value slope	R- squared
Sweden	3,617383	-2512,129	0,000	0,6654
Smooth	3,550103	-2476,457	0,000	0,938

Table 3: Regression statistics for Sweden and the smoothed values.

In terms of infrastructure implementation and its correlation with EV demand, we constructed a simple regression on recharging stations and EV registrations. Since recharging stations are reported as the total number of recharging stations while EV registrations are reported as new registrations, we have made this part of the analysis by recalculating the new registrations into total registrations. Table 4 depicts the regression statistics where the result shows that a 1% increase in recharging stations leads to a 2.78% increase in EV registrations and vice versa.

	Coefficient	Standard error	P-value
Ln (Recharging stations)	2,769	0,284	0,000
Constant	-8,020	1,620	0,000

Table 4: Regression statistics of EV registrations and recharging stations from January 2020.

6.2 Main Results

When constructing the synthetic Sweden, only four out of 12 countries from the donor pool were included, namely, Germany, Ireland, Luxembourg, and Norway. Germany obtained the highest weight closely followed by Luxembourg, thereafter Norway, and lastly Ireland. Consequently, the outcome of our result is heavily based on Germany and Luxembourg. The weights and the four countries are depicted in Table 5.

Country	Weight
Germany	36.3%
Ireland	7.8%
Luxembourg	35.2%
Norway	20.7%

Table 5: Restricted donor pool with corresponding weights.

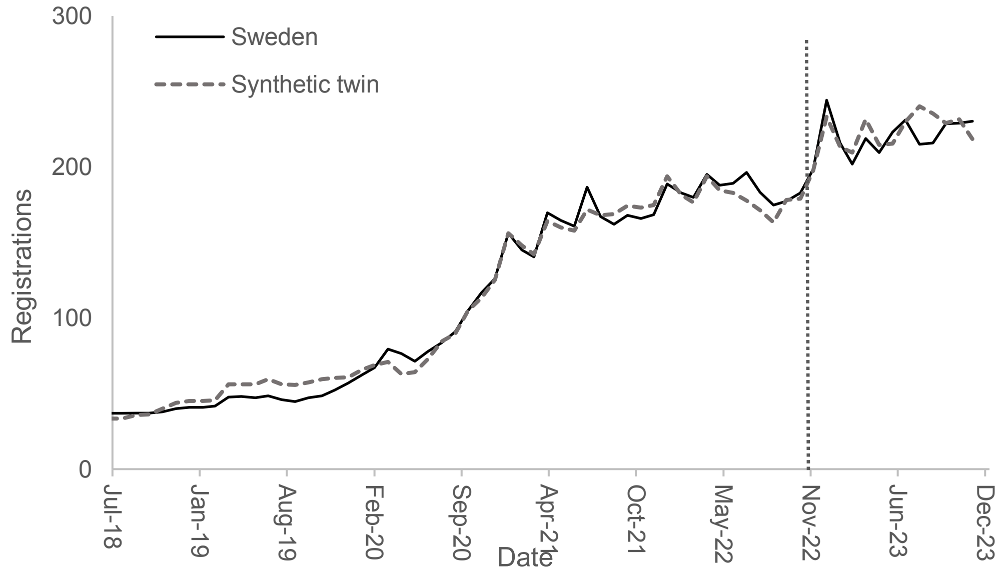


Figure 5: EV registrations for Sweden and its synthetic twin.

The main results from the analysis are shown in Figure 5 and Figure 6 gives a closer look at the two series after the treatment date. Looking at these two graphs, the registrations of synthetic Sweden closely track the registrations of actual Sweden prior to the treatment date. However, it is hard to evaluate from these graphs whether any major change in registrations have occurred after the treatment date.

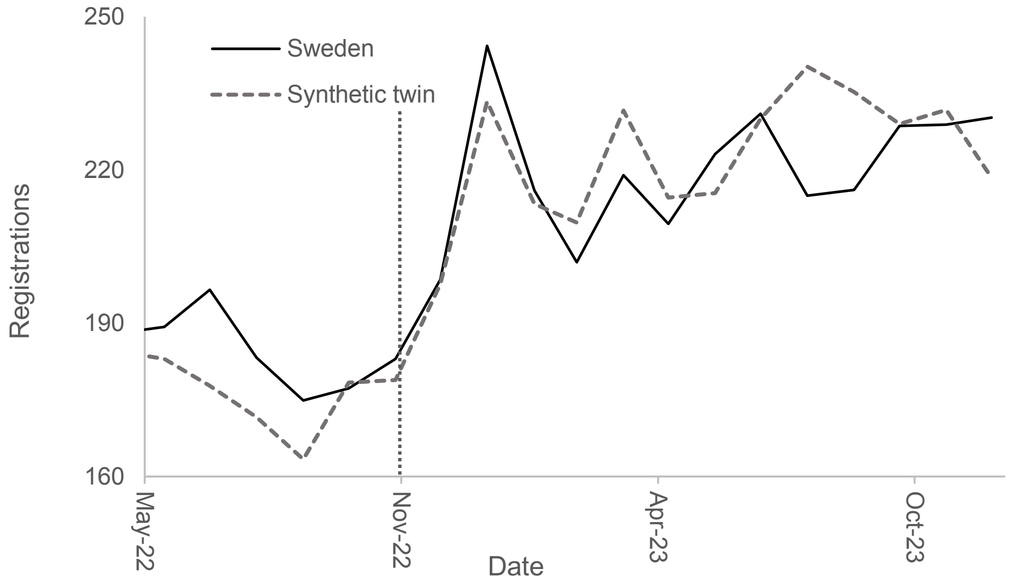


Figure 6: EV registrations for Sweden and its synthetic twin zoomed.

Depicted in Figure 7 below is Sweden and its synthetic twin and the linear trends for both series after the treatment, which gives a clearer view of the post-treatment period. The trends show that the demand has decreased slightly since the abolishment.

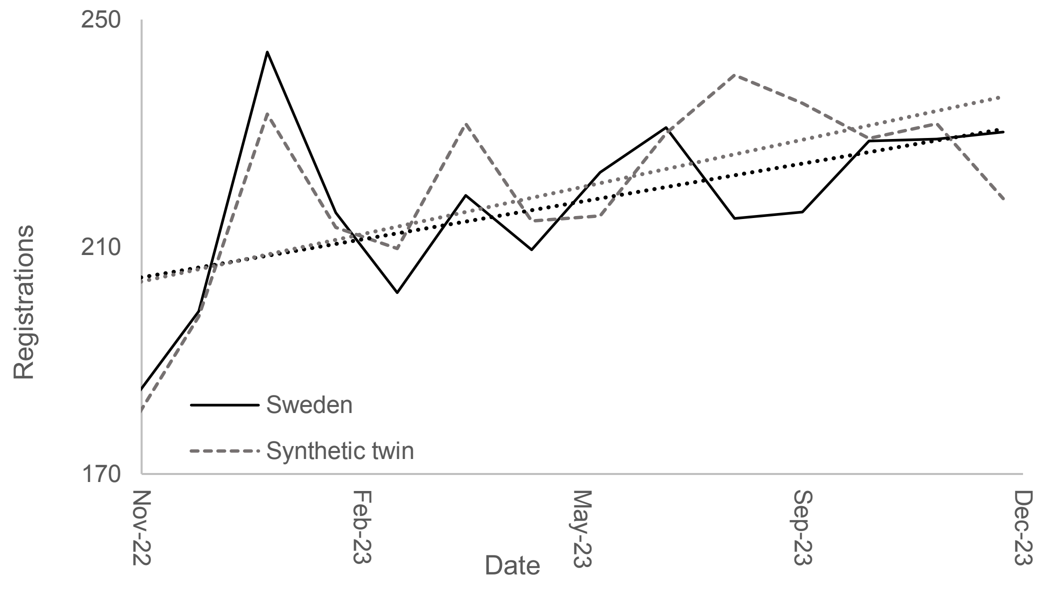


Figure 7: EV registrations for Sweden and its synthetic twin at post-treatment period.

Reported in Table 6 are the values for Sweden and the synthetic twin in the post-treatment period, based on this estimated coefficient the abolishment led to a total decrease in registration by 34.2 EVs per 100.000 inhabitants, which equals a 1.1% decrease. The decrease, however, is not statistically significant according to the p-values shown in Table 7.

Date	**Sweden**	**Synthetic twin**
Nov-22	182.9818	178.88682
Dec-22	198.6150	197.73304
Jan-23	244.2888	233.37215
Feb-23	215.9659	213.39238
Mar-23	201.9521	209.67503
Apr-23	218.9911	231.63400
May-23	209.4345	214.56325
Jun-23	223.1046	215.47541
Jul-23	231.0157	229.99271
Aug-23	215.0118	240.22882
Sep-23	216.0650	235.24828
Oct-23	228.6038	229.05309
Nov-23	228.9308	231.69537
Dec-23	230.2221	218.44188

Table 6: Post treatment registrations for Sweden and the estimated synthetic twin.

Month	**Estimate (P-value)**	**Month**	**Estimate (P-value)**
Nov-22	4.095 (0,583)	Jun-23	7.629 (0,667)
Dec-22	0.882 (0,750)	Jul-23	1.023 (1,000)
Jan-23	10.917 (0,500)	Aug-23	-25.217 (0,333)
Feb-23	2.574 (0,750)	Sep-23	-19.183 (0,417)
Mar-23	-7.723 (0,417)	Oct-23	-0.449 (1,000)
Apr-23	-12.643 (0,500)	Nov-23	-2.765 (1,000)
May-23	-5.129 (0,750)	Dec-23	11.780 (0,667)

Table 7: Estimates and P-values for the synthetic control estimation.

6.3 Robustness checks

In any empirical study, the main result needs to be robust in terms of changes in the design choices of the study. With the synthetic control method, there are two design choices that can affect the main result substantially; The first regard which units are included in the donor pool and the second concerns which control variables are used in the construction of the synthetic twin (Abadie 2021). To properly check the credibility and sensitivity of our main result, we have conducted four robustness checks: one quarterly check with one control variable, two different kinds of leave-one-out tests, and backdating. The reasoning for each test is described in the respective subsection.

6.3.1 Quarterly Check

In order to check if the exclusion of control variables had any effect on our result, we have constructed the same analysis on quarterly data where we can include GDP per capita as a control. Figure 8 depicts the synthetic Sweden and actual Sweden on a quarterly basis with smoothed values and GDP per capita as a control variable. Figure 9 depicts the same result, with trend lines, zoomed in on the post-treatment dates. From the trendlines we can draw the same conclusion as before, the average sales decrease after the abolishment compared to what the synthetic twin predicts.

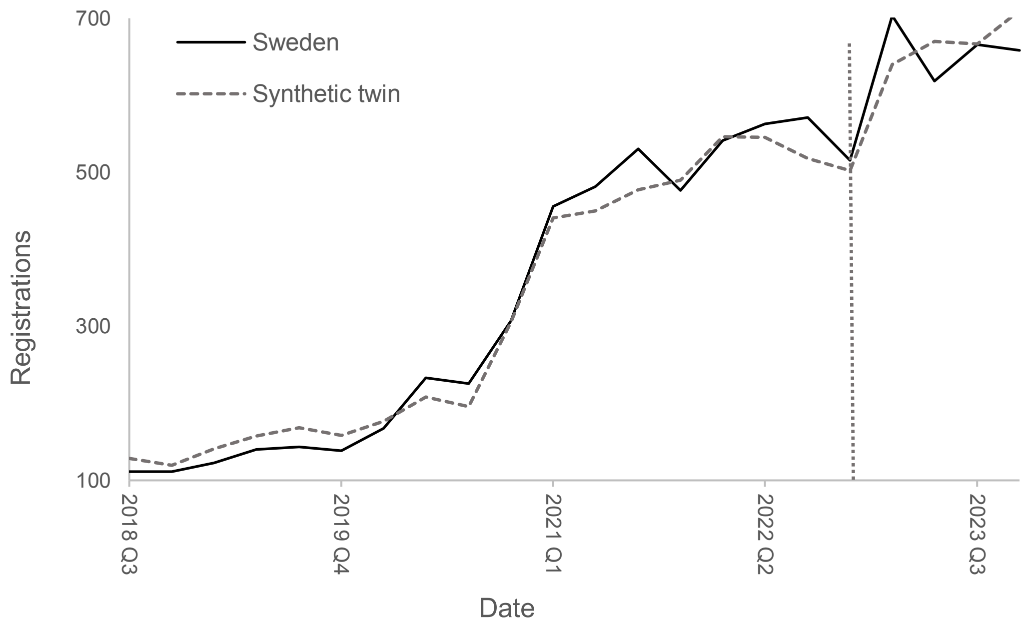


Figure 8: EV registration for Sweden and its synthetic twin with control.

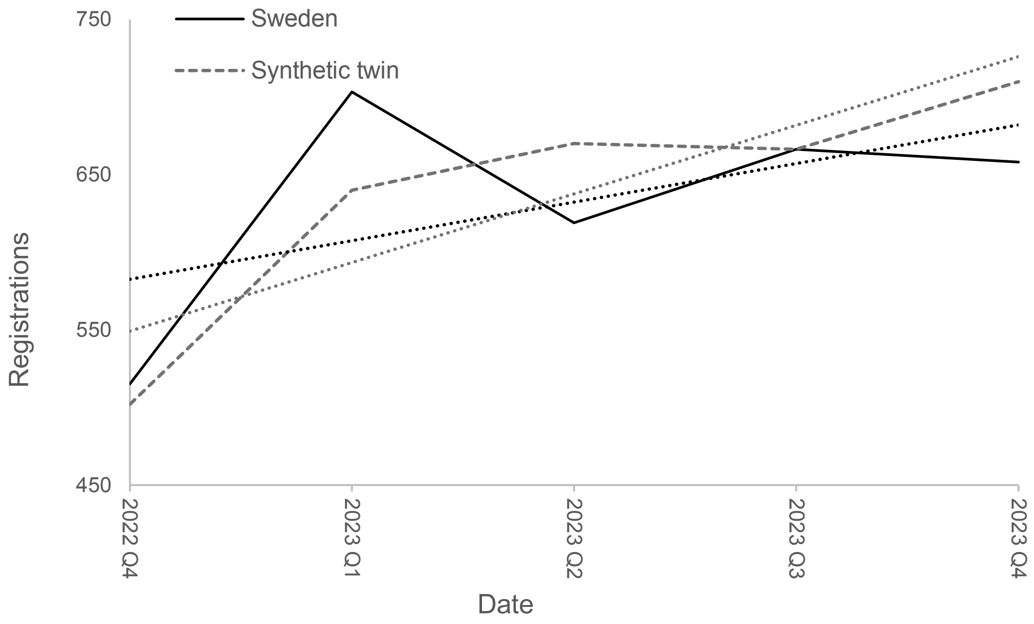


Figure 9: EV registration Sweden and its synthetic twin with control zoomed.

Weights and p-values are depicted in Appendix 2, which shows that this test still fails to reject the null hypothesis. Hence, with this test we can conclude that our main result is robust in terms of control variables and the exclusion of control variables did not affect the significance of our result.

6.3.2 Leave One Out

"By excluding countries that received a positive weight we sacrifice some goodness of fit, but this sensitivity check allows us to evaluate to what extent our results are driven by any particular control count" (Abadie et.al, 2015 p.13). In order to test how the countries in our donor pool affect the result, we have constructed two different leave-one-out tests. In the first, we constrained the donor pool to only the four countries with weights in the main result. From this, one country gets excluded at a time. In the second, we keep all 12 countries in the donor pool and from there exclude the countries with initial weights one at a time.

The results from the two tests are fairly similar, where a majority of the tests seem to follow the trend before the abolishment, however, the results after the treatment date differ widely in both cases. Figure 10 depicts the results from the first test and Table 8 shows the weights of the first leave one out tests. In Appendix 3, the average post-treatment P-values for the first test are reported, which show an insignificant result. The weights and results from the second test are in Appendix 4. With this we can conclude that restricting the donor pool changes the result substantially, hence keeping the full donor pool is important for the analysis.

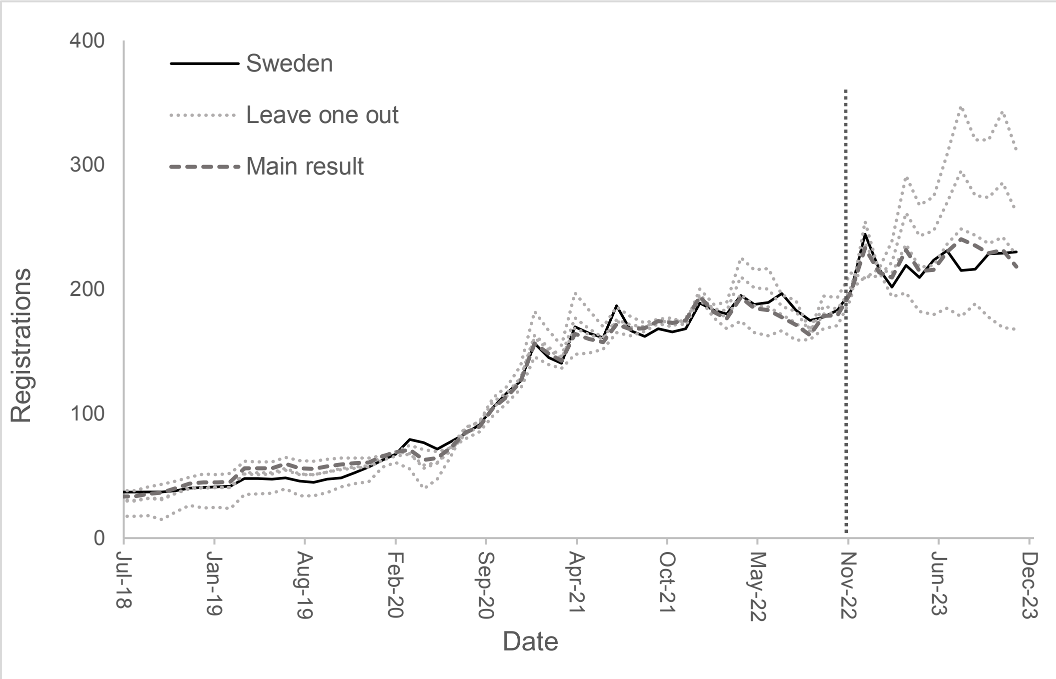


Figure 10: First leave one out test.

Country	Weight	Weight	Weight	Weight
Ireland	19.3%	0.0%	0%	-
Norway	14.5%	28.5%	-	17.0%
Luxembourg	66.2%	-	100%	41.2%
Germany	-	71.5%	0%	41.9%

Table 8: Country weights for the first leave one out test.

6.3.3 Backdating

The last robustness test we have chosen to include is the backdating, which shows how sensitive the result is to the intervention date. When conducting a backdating test, two parts of the result should be paid extra attention to. First, the new synthetic estimators closely track the treated unit up until the actual treatment date. Second, a gap between the outcome variable for the treated unit and its synthetic estimators occurs at the time of the actual treatment date. These two points, especially in combination, provide great credibility to the synthetic control estimator (Abadie 2021). Figure 11 depicts the main result and four different results based on other treatment dates. The dates chosen are 6-month jumps from the actual event date; May 2022, Nov 2021, May 2021, and Nov 2020.

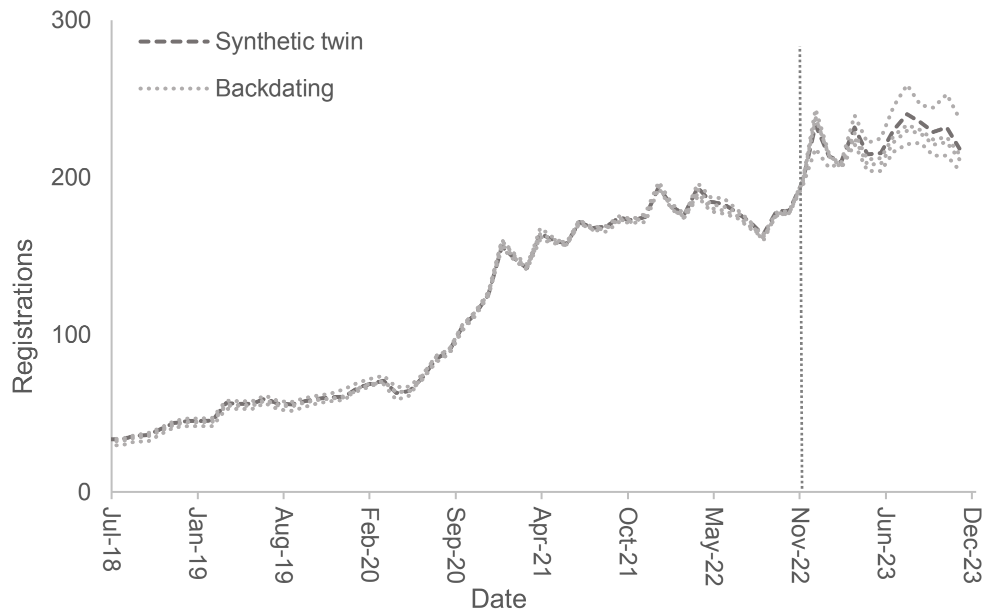


Figure 11: Backdating test

The results indicate that changing the intervention date does not interfere with the goodness of fit prior to the actual event date, which is in line with the first feature proposed by Abadie (2021). Furthermore, any gap between registrations of EVs in Sweden and its synthetic estimator occurs at or around the actual treatment date, however, the prediction after the event date varies slightly. We can from this test conclude that there is no announcement or anticipation effect, and this shows great credibility to our synthetic control estimator.

7. Discussion and Limitations

In this section, we will discuss our result as well as the limitations that this study exhibits. Forces both for and against the main result are discussed before we move into our limitations in terms of timeframes, variable inclusions, and missing literature.

We can refer to our hypothesis as to whether the policymaker's action was justified or not. Since the results from our analysis is shown to be statistically insignificant, the policymaker's decision was in line with the predicted evaluation per date of abolishment. The insignificant result could thus indicate the role of social norms. As the EV gets more integrated, society may both accept and encourage ownership of EVs which makes status prevail over the economic benefit of the Klimatbonus. This reduces the impact of the bonus, thus making it more negligent once the abolishment takes place.

In this case, we can also speculate the role of descriptive norms against injunctive norms. As previously stated in the theoretical framework (see Section 4.2), descriptive norms describe how people actually behave as opposed to injunctive norms which direct how people ought to behave. If the sentiment of owning an EV is prevailing, injunctive norms may uphold the demand as a result of norms pushing in favour of this demand. However, the limited span of this study inhibits the reach to include measured data on social norms. We would have to include qualitative data aside from existing quantitative data which stretches well beyond the scope of our work. The impact of this theory is solely of speculation, not only in terms of forces of descriptive and injunctive, but also of social norms at large.

In addition, the presence of infrastructure in the form of charging stations may be a partial explanation of the main result. Both from previous literature as well as the descriptive result, we find a positive correlation between investment in charging stations and an increase in demand for EVs. We could thus speculate about the role of charging station investment in the integration of EVs in the Swedish car market. With regard to the insignificant result of the demand when the abolishment was enforced, this investment may have been a force that opposes a larger drop in demand than if investment in this field was not present. However, we can neither derive a causal effect nor explain to what extent investments in charging stations have impacted the demand for EVs after abolishment. Furthermore, another factor that could thwart further decline in demand is the fact that the malus part of the bonus is still active. With the malus part still active, there is a disincentive to purchase conventional vehicles which indirectly favor demand for EVs.

The slight decrease in sales may have been within the cost frame for the enactment of the abolishment, thus justifying its action. Referring back to the theoretical framework, the theory of demand holds as we see a decrease in demand in absolute terms. However, the force of demand does not seem to be adequately strong for the outcome to be significant. In order to fully support the decision, the analysis should be followed up with a longer post-treatment time period. At the time of constructing this study, the bonus is still being paid out for cars purchased before the abolishment but yet to be delivered and registered.

As mentioned previously, the data we have used is the registrations of EVs, thus some of these registrations after the treatment date have been eligible for the bonus. Additionally, the effect of demand may be gradual which can only be evaluated over time. Therefore, the slight decrease that we see in our result could turn significant with a longer timeframe which would give support for the stronger force of demand. However, this study gives the opportunity to fill the gap in this field of research with more follow ups.

In the following paragraphs we discuss potential improvements of the study in terms of our variable selection, choices of country inclusion, and treatment date.

Starting with the variable selection, to draw a solid conclusion in terms of what drives the null result, the price index for EVs over time would have been a useful variable to include. A report on the Car Cost Index published in 2021 by LeasePlan (2023) concludes that the total cost of owning an EV was lower than that of a petrol or diesel-driven vehicle. Their study was conducted on premium mid-size-segment cars in 22 countries, where Sweden ranked as the third cheapest country in terms of the total cost of owning an EV. The 13 countries included in our donor pool are all included in their report. Ayvens (2023) published a similar report in 2022, where they came to the same result, the total cost of owning an EV was lower than that of a petrol or diesel-driven car. It would, however, be interesting to get an update on this index for the post-treatment period in order to use this for our analysis. Another important point in the variable selection is our main variable, purchases of EVs. As discussed above, this is based on the date of registration rather than the date of purchase. The main issue with having registration rather than sales is that it gives a certain lag in our data, which could be solved by either collecting purchasing data or as previously argued, having a longer post-treatment time frame.

The choice of country inclusion is well described and argued for in section 5.3. However, the two robustness tests made to check the donor pool, the leave-one-out tests, show that the result is highly sensitive to country exclusion. We can therefore speculate whether the restrictions on our donor pool could be evaluated differently to receive a more even weight distribution. As mentioned, OECD countries outside Europe were excluded due to lack of data availability while other European OECD countries such as Belgium and Switzerland were also rejected due to EV policies operated regionally. These are examples of countries that could qualify to our donor pool but due to mentioned factors were excluded.

The treatment date, T_0, was set according to the date of abolishment as described in Section 2. Potential issues concerning an announcement effect were described and dismissed in Section 5.2. However, we still checked the validity of the treatment date through backdating in Section 6.3. The result of the robustness test shows clearly that changing the treatment date does not affect the result.

With this study, we contribute to filling a gap in research in the demand effect on EV policy abolishment. On the one hand, as few other studies have researched the impact of abolishment of purchase subsidies, we justify our work to expand on previous literature. On the other hand, no other literature is presented where the focus is on the abolishment of similar policies. It would have thus been of our benefit to have complimentary literature to fill in gaps where our own study flaws. This could be implemented in several aspects. First, it would be beneficial to expand the literature on policy abolishment in general and its implications on sales. Second, the impact of social norms likely plays a major role when a policy is both ongoing as well as abolished. Complimentary literature would thus possibly bring a clearer explanation of our outcome. Third, as previously stated, data on the price index would add to our data by showcasing the price development of EVs in Sweden.

8. Conclusion

Several countries have incentives on EV purchases as an attempt to integrate EVs into the market. However, Sweden was one of the earliest countries to introduce such a scheme when the Klimatbonus was presented in July 2018. With this enactment, the incentive worked to compete the EV prices to conventional vehicles, thus raising the demand on the market for these types of vehicles. By November 2022, policymakers deemed the policy to have accomplished its goals which caused Sweden to abolish the Klimatbonus. This together with the other countries that have ongoing EV incentives enables us to conduct a synthetic control group to evaluate potential demand change if abolishment would not occur.

Using the synthetic control method on the total amount of EV registrations per 100.000 working-age inhabitants to estimate the effects of the abolishment of the Klimatbonus, shows no significant result. This indicates support for the policy makers decision, where the policy had reached its goals and no longer served a purpose. The incentives thus have an effect but solely to a certain point in which the EVs get integrated on the car market. This integration, in turn, is not only influenced by monetary factors but also social norms. As society accepts the subsidized product/service to a greater extent, the effect on the subsidy reduces.

Even though the result is generally robust, as shown by the robustness test, the findings can still shed clearer light through several aspects that would complement this study. To give a better view of the outcome of the abolishment, we would need a longer time frame from the post-treatment. In addition, we also need to bring in other facets such as social norms as well as greater support from previous literature as current literature does not focus on the pure demand effect from abolishment. For a better evaluation of supply and demand, we would also need more data on domestic prices. The result of the analysis could indicate the importance of social norms. However, we can not draw a firm conclusion if it is social norms or supply and demand that drives the null result without information on prices.

From our study, we believe this can give rise to further research on the demand side from the abolishment of subsidy policies. We suggest this can be made on both a qualitative and quantitative basis. As demand can be evaluated from many different aspects, more research needs to be made on what impact social influences have on the demand once a policy has been abolished. In particular, we would be interested in evaluating to what extent social norms explains the effect of demand in abolishment policy. In addition, since the abolishment occurred fairly recently and we can only gather data as of point in time written, our study can be followed up by including a longer time horizon to measure the effect more properly. In sum, as the subject potentially has several explanations for the outcome, we are thus only embarking on the beginning of the intuition to the effect of abolishment policies.

Reference list

Abadie, A. (2021). Using synthetic controls: Feasibility, data requirements, and methodological aspects. Journal of Economic Literature, 59(2), 391–425.

Abadie, A., Diamond, A., & Hainmueller, J. (2010). Synthetic Control Methods for comparative case studies: Estimating the effect of California's tobacco control program. Journal of the American Statistical Association, 105(490), 493–505.

Abadie, A., Diamond, A., & Hainmueller, J. (2015). Comparative politics and the Synthetic Control Method. American Journal of Political Science, 59(2), 495–510.

Akerlof, G. A., & Kranton, R. E. (2000). Economics and identity*. *Quarterly Journal of Economics*, *115*(3), 715–753.

Allcott, H. (2011). Social Norms and energy conservation. *Journal of Public Economics*, *95*(9–10), 1082–1095.

Athey, S., & Imbens, G. W. (2017). The state of Applied Econometrics: Causality and policy evaluation. Journal of Economic Perspectives, 31(2), 3–32.

Ayvens. (2023, November 3). *Car cost index 2022*. https://www.ayvens.com/en-cp/blog/total-cost-of-ownership/2022-car-cost-index/

Bonus - for low emission vehicles. Transportstyrelsen. (2024, January 7). https://www.transportstyrelsen.se/en/road/Vehicles/bonus-malus/bonus/

Born, B., Müller, G. J., Schularick, M., & Sedláček, P. (2019). The costs of economic nationalism: Evidence from the Brexit Experiment. The Economic Journal, 129(623), 2722–2744.

Britannica, T. Editors of Encyclopaedia (2024, March 5). *supply and demand*. *Encyclopedia Britannica*. https://www.britannica.com/money/supply-and-demand

Buying an electric car in another EU country. Tips for buying an electric car in another EU country. (2023, September 19). https://www.evz.de/en/travelling-motor-vehicles/motor-vehicles/electric-vehicles-in-the-eu/buying-an-electric-car-abroad.html

Clapp, J. D., & McDonnell, A. L. (2000). The relationship of perceptions of alcohol promotion and peer drinking norms to alcohol problems reported by college students. *Journal of College Student Development, 41*(1), 19. http://proxy.library.ju.se/login?url=https://www.proquest.com/scholarly-journals/relationship-perceptions-alcohol-promotion-peer/docview/195177536/se-2

Clinton, B. C., & Steinberg, D. C. (2019). Providing the spark: Impact of financial incentives on Battery Electric Vehicle Adoption. Journal of Environmental Economics and Management, 98, 1–17.

DeShazo, J. R., Sheldon, T. L., & Carson, R. T. (2017). Designing policy incentives for cleaner technologies: Lessons from California's plug-in electric vehicle rebate program. *Journal of Environmental Economics and Management*, *84*, 18–43.

Dolan, P., Hallsworth, M., Halpern, D., King, D., Metcalfe, R., & Vlaev, I. (2012). Influencing behaviour: The mindspace way. *Journal of Economic Psychology*, *33*(1), 264–277.

Doudchenko, N., & Imbens, G. W. (2016). *Balancing, regression, difference-in-differences and synthetic control methods: A synthesis* (Working Paper No. w22791). National Bureau of Economic Research. https://www.nber.org/papers/w22791

Encyclopædia Britannica, Inc, (2013), *Illustration of the relationship of price to supply (S) and demand (D) [Photograph].* Encyclopædia Britannica. https://www.britannica.com/money/supply-and-demand

Engström, E., Algers, S., & Beser Hugosson, M. (2019). The choice of new private and benefit cars vs. climate and transportation policy in Sweden. Transportation Research Part D: Transport and Environment, 69, 276–292.

European Commission. (n.d.). Incentives and Legislation, Sweden. European Alternative Fuels Observatory. https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/sweden/incentives-legislations

Fæhn, T., Hagem, C., Lindholt, L., Mæland, S., & Rosendahl, K. E. (2017). Climate policies in a fossil fuel producing country – demand versus supply side policies. *The Energy Journal, 38*(1)

Farrow, K., Grolleau, G., & Ibanez, L. (2017). Social norms and pro-environmental behavior: A review of the evidence. *Ecological Economics*, *140*, 1–13.

Featherman, M., Jia, S.-J., Califf, C.-B., Hajli, N., 2021. The impact of new technologies on consumers beliefs: reducing the perceived risks of electric vehicle adoption. Technol Forecast Soc 169, 120847.

Ferdousee, A. (2020). The effect of tax credit policy on Electric Vehicle Sales: A Synthetic Control Approach using bayesian structural time series. Journal of Applied Business and Economics, 22(13), 201–214.

Ferman, B., Pinto, C., & Possebom, V. (2020). Cherry picking with synthetic controls. Journal of Policy Analysis and Management, 39(2), 510–532.

Frågor och svar Om beslutet Om Hur klimatbonusen ska avvecklas. Regeringskansliet. (2023, January 31). https://www.regeringen.se/artiklar/2022/11/fragor-och-svar-om-avskaffad-klimatbonus/

Funke, S. Á., Sprei, F., Gnann, T., & Plötz, P. (2019). How much charging infrastructure do electric vehicles need? A review of the evidence and international comparison. Transportation Research Part D: Transport and Environment, 77, 224–242.

Grant amounts. Sustainable Energy Authority Of Ireland. (n.d.). https://www.seai.ie/grants/electric-vehicle-grants/grant-amounts/

Habibi, S., Hugosson, M. B., Sundbergh, P., & Algers, S. (2018). Car fleet policy evaluation: The case of bonus-malus schemes in Sweden. International Journal of Sustainable Transportation, 13(1), 51–64.

Hope, D. (2016). Estimating the effect of the EMU on current account balances: A synthetic control approach. *European Journal of Political Economy*, *44*, 20–40.

Jenn, A., Azevedo, I. L., & Ferreira, P. (2013). The impact of federal incentives on the adoption of hybrid electric vehicles in the United States. Energy Economics, 40, 936–942.

Kaul, A., Klößner, S., Pfeifer, G., & Schieler, M. (2021). Standard synthetic control methods: The case of using all preintervention outcomes together with covariates. *Journal of Business & Economic Statistics*, *40*(3), 1362–1376.

Kim, J., Rasouli, S., & Timmermans, H. (2014). Expanding scope of hybrid choice models allowing for mixture of social influences and latent attitudes: Application to intended purchase of Electric Cars. *Transportation Research Part A: Policy and Practice*, *69*, 71–85.

Kong, D., Xia, Q., Xue, Y., & Zhao, X. (2020). Effects of multi policies on electric vehicle diffusion under subsidy policy abolishment in China: A multi-actor perspective. *Applied Energy*, *266*.

Ladda hemma-stöd för laddbox. Vattenfall.(n.d.). https://www.vattenfall.se/fokus/eldrivna-transporter/laddbox-stodet/

LeasePlan. (2023, March 3). *Car cost index 2021*. https://www.leaseplan.com/sv-se/om-oss/nyheter/undersokningar/carcostindex-2021/

Li, S., Tong, L., Xing, J., & Zhou, Y. (2017). The market for electric vehicles: Indirect Network Effects and policy design. *Journal of the Association of Environmental and Resource Economists*, *4*(1), 89–133.

Lindman, Å., Ek, K., & Söderholm, P. (2013). Voluntary citizen participation in carbon allowance markets: the role of norm-based motivation. *Climate Policy*, *13*(6), 680–697.

Liu, B., Song, C., Liang, X., Lai, M., Yu, Z., & Ji, J. (2023). Regional differences in China's electric vehicle sales forecasting: Under supply-demand policy scenarios. *Energy Policy*, *177*.

Liu, X., Sun, X., Zheng, H., & Huang, D. (2021). Do policy incentives drive electric vehicle adoption? evidence from China. Transportation Research Part A: Policy and Practice, 150, 49–62.

Lu, T., Yao, E., Jin, F., & Yang, Y. (2022). Analysis of incentive policies for electric vehicle adoptions after the abolishment of purchase subsidy policy. *Energy*, *239*.

Luxembourg. Incentives and Legislation | European Alternative Fuels Observatory. (n.d.). https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/luxembourg/incentives-legislations

Mål för transportpolitiken. Regeringskansliet. (n.d.). https://www.regeringen.se/regeringens-politik/transporter-och-infrastruktur/mal-for-transporter-och-infrastruktur/#:~:text=Antalet%20omkomna%20till%20f%C3%B6ljd%20av,minska%20med%20minst%2025%20procent.

Malus - for high emission vehicles. Transportstyrelsen. (2023, May 22). https://www.transportstyrelsen.se/en/road/Vehicles/bonus-malus/malus/

Manthey, N. (2023, December 18). Germany cuts the EV purchase premium umweltbonus with immediate effect. https://www.electrive.com/2023/12/18/germany-cuts-all-zero-emission-vehicle-subsidies-with-immediate-effect/

Mersky, A. C., Sprei, F., Samaras, C., & Qian, Z. (Sean). (2016). Effectiveness of incentives on electric vehicle adoption in Norway. Transportation Research Part D: Transport and Environment, 46, 56–68.

Moms, Vektavgift og engangsavgift - hva gjelder for Elbiler?. Norsk elbilforening. (2024, April 15). https://elbil.no/elbil-fordeler/null-avgift-for-elbil/

Münzel, C., Plötz, P., Sprei, F., & Gnann, T. (2019). How large is the effect of financial incentives on electric vehicle sales? – A global review and European analysis. Energy Economics, 84, 1–21.

Norway. Incentives and Legislation | European Alternative Fuels Observatory. (n.d.). https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/norway/incentives-legislations

Østli, V., Fridstrøm, L., Johansen, K. W., & Tseng, Y.-Y. (2017). A generic discrete choice model of automobile purchase. European Transport Research Review, 9(2), 1–20.

Plötz, P., Gnann, T., & Sprei, F. (2016). Can policy measures foster plug-in electric vehicle market diffusion? World Electric Vehicle Journal, 8(4), 789–797.

Plötz, P., Gnann, T., & Sprei, F. (2017). What are the effects of incentives on plugin electric vehicle sales in Europe? ECEEE 2017 SUMMER STUDY, 799–805. https://aladin-model.eu/aladin-wAssets/docs/publications/4-188-17_Ploetz.pdf

Pyddoke, R., Swärdh, J.-E., Algers, S., Habibi, S., & Sedehi Zadeh, N. (2021). Distributional effects from policies for reduced CO2-emissions from car use in 2030. *Transportation Research Part D: Transport and Environment*, *101*, 1–19.

Qiu, Y. Q., Zhou, P., & Sun, H. C. (2019). Assessing the effectiveness of city-level electric vehicle policies in China. Energy Policy, 130, 22–31.

Regulatory environment and incentives for using electric vehicles and developing a charging infrastructure. BMWK. (n.d.). https://www.bmwk.de/Redaktion/EN/Artikel/Industry/regulatory-environment-and-incentives-for-using-electric-vehicles.html

Sánchez-Braza, A., Cansino, J. M., & Lerma, E. (2014). Main drivers for local tax incentives to promote electric vehicles: The Spanish case. Transport Policy, 36, 1–9.

Schwager, J. D. (2017). *A complete guide to the futures market : Technical analysis, trading systems, fundamental analysis, options, spreads, and trading principles*. John Wiley & Sons, Incorporated. https://ebookcentral.proquest.com/lib/jonhh-ebooks/detail.action?pq-origsite=primo&docID=4778484#

Shang, W.-L., Zhang, J., Wang, K., Yang, H., & Ochieng, W. (2024). Can financial subsidy increase electric vehicle (EV) penetration---evidence from a quasi-natural experiment. Renewable and Sustainable Energy Reviews, 190, 1–14.

Sierzchula, W., Bakker, S., Maat, K., & van Wee, B. (2014). The influence of financial incentives and other socio-economic factors on electric vehicle adoption. Energy Policy, 68, 183–194.

Slowik, P., & Lutsey, N. (2017). Expanding the electric vehicle market in U.S. cities. International Council on Clean Transportation, 1–38.

Stekelberg, J., & Vance, T. (2024). The effect of transferable tax benefits on consumer intent to purchase an electric vehicle. Energy Policy, 186, 1–6.

Sveriges Riksdag. (2017, December 21). Förordning (2017:1334) om klimatbonusbilar. Sveriges riksdag. https://www.riksdagen.se/sv/dokument-och-lagar/dokument/svensk-forfattningssamling/forordning-20171334-om-klimatbonusbilar_sfs-2017-1334/

The bonus malus system. Transportstyrelsen. (2023, June 27). https://www.transportstyrelsen.se/en/road/Vehicles/bonus-malus/

Tirkaso, W. T., & Gren, I.-M. (2020). Road fuel demand and regional effects of carbon taxes in Sweden. Energy Policy, 144, 1–10.

Vesely, S., & Klöckner, C. A. (2018). Global Social Norms and Environmental Behavior. Environment and Behavior, 50(3), 247-272.

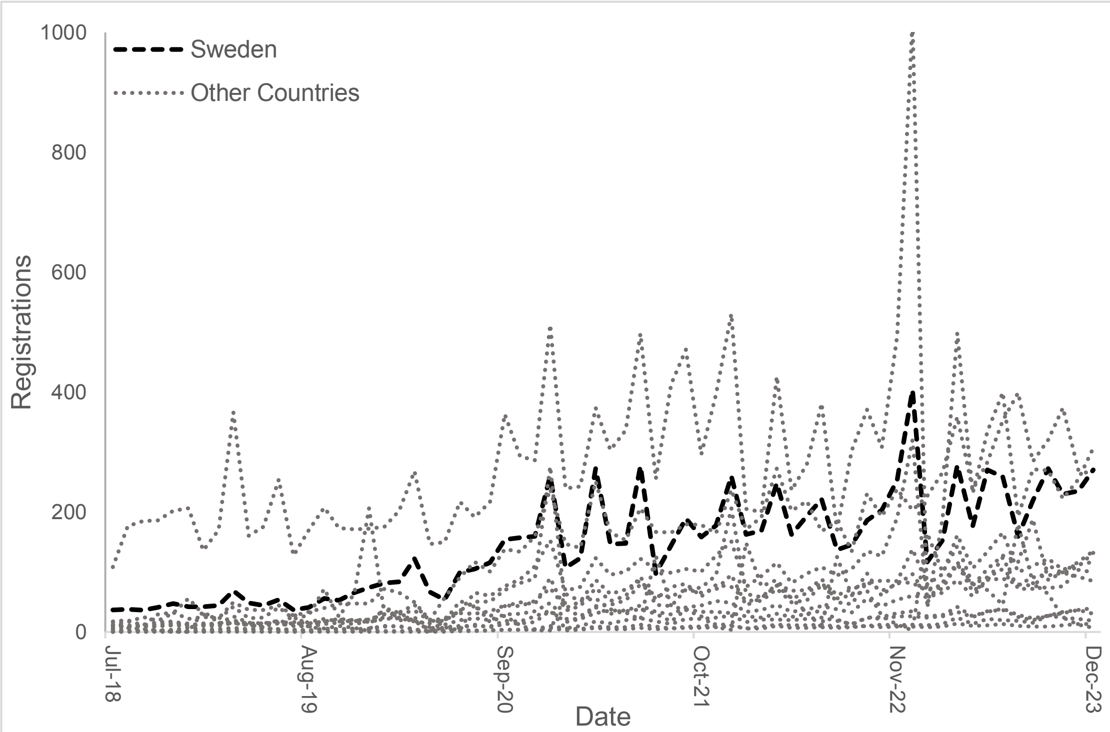
Wee, S., Coffman, M., & La Croix, S. (2018). Do electric vehicle incentives matter? evidence from the 50 U.S. states. *Research Policy*, *47*(9), 1601–1610.

Yan, S. (2018). The economic and environmental impacts of tax incentives for battery electric vehicles in Europe. Energy Policy, 123, 53–63.

Zheng, X., Menezes, F., Zheng, X., & Wu, C. (2022). An empirical assessment of the impact of subsidies on EV adoption in China: A difference-in-differences approach. Transportation Research Part A: Policy and Practice, 162, 121–136.

Appendix

Appendix 1: Total number of registration for all countries in the donor pool



Appendix 2: Weights and P-values, quarterly test

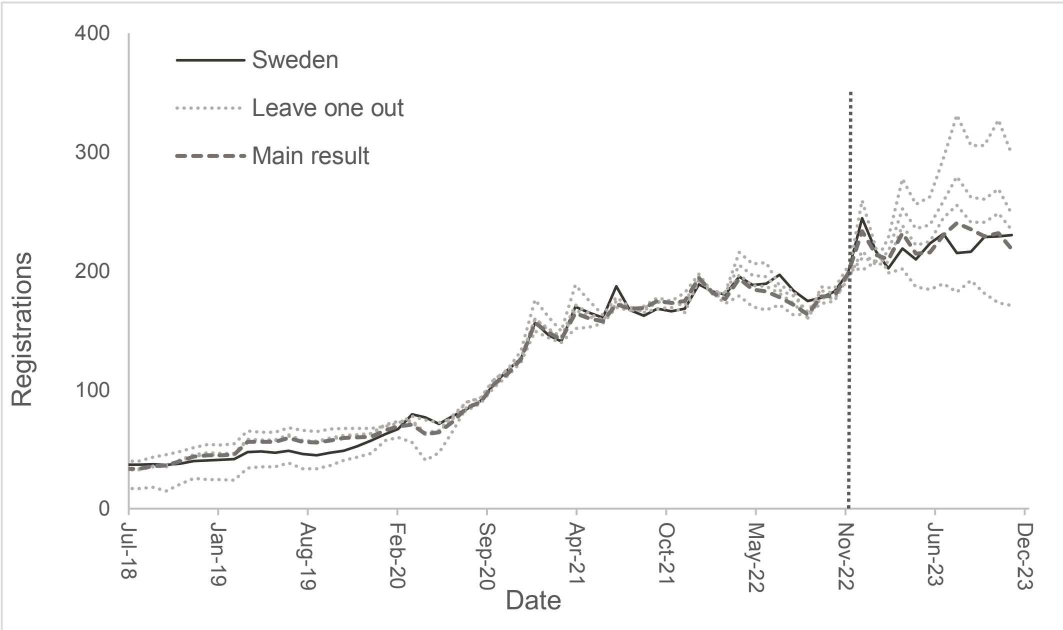
Country	Weight
Germany	33.0%
Luxembourg	40.2%
Norway	17.9%
Portugal	8.9%

Quarter	P-Value	Standardized P-value
2022 Q4	0.583	0.833
2023 Q1	0.167	0.167
2023 Q2	0.333	0.583
2023 Q3	1.000	1.000
2023 Q4	0.583	0.833

Appendix 3: Average post-treatment P-value, first leave one out test.

Excluded country	Average post-treatment p-value
Ireland	0.929
Norway	0.500
Luxembourg	0.643
Germany	0.857

Appendix 4: Result and weights, second leave one out test.



Country	Weight	Weight	Weight	Weight
France	0.0%	0.0%	0.0%	28.9%
Germany	-	69.9%	0.0%	5.5%
Ireland	21.0%	0.0%	0.0%	-
Luxembourg	56.0%	-	93.0%	43.9%
Netherlands	0.0%	0.0%	7.0%	0.7%
Norway	18.4%	30.4%	-	21.0%