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Implications of Tax Policy Changes on the Norwegian Electric Vehicle Market

An empirical analysis of changes in the value-added tax and the one-off registration tax

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Abstract

Norway has been a global frontrunner in EV adoption over the past decade, largely driven by extensive subsidies. In January 2023, the Norwegian government implemented a value-added tax on EVs priced above NOK 500,000 and introduced a weight component to the one-off registration tax, both contributing to an increase in the tax payable for EVs.

In this thesis, we aim to analyze the impact of these tax policy changes on the number of first-time registered EVs in Norway. By employing the difference-in-differences methodology with Sweden as the control group, we estimate these effects after the tax policy changes are implemented. To interpret our findings, we draw on the theoretical principles of the elasticity of demand for durable goods, as well as substitution theory with a particular emphasis on intertemporal substitution and substitution across goods.

Our results suggest that the tax policy changes contributed to a significant decrease of 72.11 percent, on average, in the number of first-time registered EVs in Norway after the policy changes were implemented. Notably, despite this decline, the EV sales share remains consistent with the levels observed in 2022. Our findings indicate that a substantial portion of the observed effects may stem from a short-term response to the price increase, impacted by intertemporal substitution.

Keywords – electric vehicles, zero-emission vehicles, subsidies, VAT exemption, governmental policies, environment, elasticity of demand, substitution

Contents

1 Introduction **1**

2 Literature Review **4**

3 Background **7**
3.1 The Vehicle Tax Policy in Norway 7
3.1.1 The Tax Exemption for EVs in Norway 7
3.1.2 The EV Tax Policy Changes 8
3.1.2.1 Price Example 9
3.1.2.2 Governmental Intention 10
3.2 EV Policy in Sweden 10

4 Theory **12**
4.1 Durable Consumer Goods 12
4.2 Substitution 14
4.2.1 Intertemporal Substitution 14
4.2.2 Substitution Across Goods 16

5 Data **18**
5.1 Data Collection and Cleaning 18
5.2 Descriptive Statistics 19

6 Methodology **23**
6.1 Choice of Regression Model 23
6.2 Model Specification 24
6.2.1 Anticipatory Effects 25
6.2.2 Estimated Regression 27
6.3 Model Assumptions 27
6.3.1 Parallel Trend Assumption 28
6.3.2 SUTVA 28
6.3.3 Choice of Control Group 29

7 Analysis **34**

8 Discussion **37**
8.1 Implications of Results 37
8.1.1 Intertemporal Substitution 38
8.1.2 Substitution Across Goods 38
8.1.3 Practical Implications 40
8.2 Robustness and Limitations 41

9 Conclusion **43**

References **45**

Appendices

A Additional Regression Tables **48**

B Smoothed Time Series Data **50**

List of Figures

4.1 Short-run and long-run demand curves for durable consumer goods . . . 13
4.2 Substitution across goods 17
5.1 Split of first-time registered vehicles by fuel type in Norway (2008-2023) . 19
5.2 Split of first-time registered vehicles by fuel type in Sweden (2008-2023) . 20
5.3 Number of first-time registered EVs split by price categories in Norway . 21
5.4 Growth rates of first-time registered EVs split by price categories in Norway 22
6.1 Standard difference-in-difference model 25
6.2 First-time registered EVs in Norway and Sweden 26
6.3 Exchange rates between NOK and SEK. 30
6.4 Exchange rates between NOK, SEK and DKK to EUR. 31
6.5 Annual GDP growth in Norway and Sweden. 31
6.6 Growth rate in Norway and Sweden 33
B.1 Norway: Simple moving average of order 6 50
B.2 Sweden: Simple moving average of order 6 50

List of Tables

3.1 Historical development in Norwegian EV tax incentives 8
3.2 Price example of EV priced below NOK 500,000 9
3.3 Price example of EV priced above NOK 500,000 9
7.1 Regression Results 36
A.1 Regression with Removed Observations 48
A.2 Regression with Linear Time Trend 49

1 Introduction

As 2023 is coming to an end, it is clear that challenges related to climate change are becoming more impactful and visible in the global economy. 2023 is set to be the warmest year on record and has shattered climate records, accompanied by extreme weather leaving trails of devastation and despair, while greenhouse gas levels continue to increase, according to the World Meteorological Organization (2023). The Intergovernmental Panel on Climate Change (2023) emphasizes that the effects of global warming occur at lower temperatures than earlier estimated, and they infer that the choices made in this decade will impact the earth for thousands of years. The opportunity to secure a habitable and sustainable future for all is continuously being reduced, and the increase in climate extremes makes it more challenging to secure a climate robust development.

Road transport contributed to 24 percent of the EU's total emissions of CO_2 in 2020, and passenger cars and vans constitute around 15 percent of the EU's CO_2 emissions (European Commission, 2023). The International Energy Agency (IEA) highlights how electric vehicles (EVs) and improved energy efficiency are important measures to decarbonize road transport. The market for EVs stands out as one of the most rapidly evolving sectors within the realm of clean energy. In recent years, there has been a remarkable surge in sales, accompanied by notable advancements in range, broader model availability, and enhanced performance. The IEA estimates that nearly one in five new cars sold in 2023 will be electric, and if the growth experienced in the past two years is sustained, the rollout of EVs is set to avoid the need for 5 million barrels of oil a day by 2030 (Connelly & Dasgupta, 2023).

The Norwegian EV market has been particularly remarkable, and Norway has had the highest sales share of EVs globally over multiple years (International Energy Agency, 2023). This development is strongly impacted by extensive governmental subsidies, and political determination has been important in increasing the adoption of EVs in the Norwegian market (Johansen et al., 2023). Particularly since 2015, the EV share of sold cars has increased rapidly in Norway, and in the first half of 2023, 83 percent of all new cars were electric. The EV share of the vehicle fleet was approximately 20 percent (Norwegian Road Federation, 2023a).

In 2023, the Norwegian government implemented changes to the financial subsidies of EVs, partially removing the VAT exemption for EVs and introducing a weight component to the one-off registration tax. Given the historically high year-over-year growth rate in the EV share of sold cars in Norway compared to other countries, many argue that the policies have been effective, and should be sustained. In 2023, less than one in five new cars sold are fossil or hybrid, and some organizations argue that the tax policy changes are long overdue. Yet, the organizations that are negative towards these policy changes are worried that they will diminish the decarbonization of road transport in Norway.

In this thesis, we estimate the effect that this recent tax reform has had on the quantity of first-time registered EVs in Norway. To do so, we will apply the difference-in-difference (DiD) model, using the Swedish EV market as the control group. While the Norwegian Institute for Transport Economics has analyzed the effects of policy changes, they derived their results using only historical data before 2023. We believe that applying the DiD approach to 2023 data can provide valuable insights and a new understanding of the effects of the partial removal of the VAT exemption and changes to the one-off registration tax.

To achieve this, we need to specify our overall objectives. With this thesis, we aim to answer one specific research question. As we have stated, we want to quantify the effect of the tax policy changes on the Norwegian EV market, and more specifically, our research question is:

Research question: *"How did the partial removal of the VAT exemption and the introduction of the weight component in the one-off registration tax affect the quantity of first-time registered EVs in Norway?"*

Based on the DiD methodology, our estimator suggests a significant decrease in the number of first-time registered EVs in Norway in 2023. However, this decrease seems to be partly driven by few observations in the post-treatment period and very low observations directly after the implementation. The levels seem to return to pre-treatment levels from March, indicating that the negative effect is more prominent in the short-run, which is in line with theory on durable consumer goods. In addition, we find that the reduction can be partially attributed to intertemporal substitution.

To answer our research question coherently, we begin with a literature review of relevant literature, followed by an introduction to the relevant background on the tax policies and how the change impacts EVs. We proceed to present relevant theories on durable consumer goods and substitution, before providing an overview of our data. Then we present the methodology for the thesis, and thereafter, the analysis where we attempt to answer our research question. Finally, we discuss the findings of the analysis and draw an overall conclusion for our thesis.

2 Literature Review

To provide context to our research question, we will present empirical literature on EV subsidies and the adoption of EVs. Many studies on EV markets focus solely on the effects on greenhouse gas emissions and the general effects of EV subsidies on the adoption of EVs. Previous research suggests that financial EV incentives are effective in increasing the EV share of new car sales, while also being a costly initiative in achieving emission reductions. Particularly interesting to our analysis is the research by the Institute of Transport Economics, where they analyze the proposed and implemented changes specific to the Norwegian EV market in 2023.

We add to the existing literature by estimating the effect of EV tax policy changes using actual data, rather than a model and historical data like Johansen et al. (2023) at the Institute of Transport Economics. In addition, we estimate the impact of a subsidy reduction in a context where EVs are the norm, which differs from studies conducted in other markets such as the US, UK, and China, where EVs are more of an exception.

Johansen et al. (2023) at the Institute of Transport Economics researched various proposed and implemented changes to the Norwegian EV subsidies. Their study aimed to estimate changes in demand as a consequence of tax policy changes, and their results suggest an increase in the relative EV prices, while the demand for EVs is reduced as a share of the passenger vehicle sales. Specifically, Johansen et al. (2023) suggest that the partial removal of the VAT exemption, for EVs that cost more than NOK 500,000, would lead to a decrease in the relative EV share of new car sales of 2.0 percent. The estimated effect of the introduction of the weight component for passenger vehicles was a decrease in the relative EV share of new car sales of 2.0 percent. Both effects were estimated as isolated effects. From their study, we have that both the tax changes relevant to our thesis make it less desirable to own and use EVs, making emissions in Oslo decrease slower than previously assumed. In addition, they found that the most impactful changes are full toll rates and full VAT for EVs. This research is based on the model selection in 2019 and historical data up to 2022 to predict the impact of tax policy changes.

Bjerkan et al. (2016) researched the role of incentives in promoting EVs in Norway and found that exemptions from the one-off registration tax and VAT were crucial incentives for more than 80 percent of the EV owners who participated in the study. This suggests that an up-front price reduction is the most powerful incentive to promote EV adoption. To a substantial number of EV owners, however, exemption from road tolling or bus lane access was the only decisive factor. They further point to the strong incentives for promoting the purchase and ownership of EVs as an important reason why Norway became a global forerunner in the field of electromobility. However, Figenbaum (2017) found that the EV incentives in Norway, some of which have been in place since 1990, did not yield results until 2010 when the traditional vehicle manufacturers manufactured EVs based on lithium-ion batteries. Further, Figenbaum stated that the Norwegian financial incentives were sufficient to make EVs a competitively priced alternative for vehicle buyers and that an increased selection of models, improved technology, reduced vehicle prices, and extensive marketing have spurred further sales.

Similar effects of EV subsidy programs have been found in other countries. In Denmark, conventional petrol and diesel vehicles are subject to high registration fees, which according to Christensen et al. (2012) has contributed to making energy companies, transport companies, regulators, and public authorities more willing to adopt EVs.

In the US, Wee et al. (2018) estimated the effectiveness of policy incentives on EV adoption and found that a USD 1,000 increase in the value of EV policies resulted in 5-11 percent more new EV registrations. Further, Sheldon et al. (2023) found that EV subsidies are becoming less impactful and more costly over time. They argued that this was due to an increasing share of higher-priced EVs such as Teslas. In addition, they pointed toward the effect on different consumer groups. Had the subsidies been discounted in 2017, half of the below median income (USD 90,000) buyers would not have adopted an EV, highlighting the need to continue the subsidies.

Examining the incentives provided by national and local governments in China, Masiero et al. (2016) showed how EV subsidies combined with effective strategies implemented by vehicle manufacturers help to explain why the EV industry has expanded successfully in China. They argue that the priority to expand fleets of EVs cannot rely on subsidies indefinitely, which is also recognized by the Chinese vehicle manufacturer BYD, stating that "phasing out EV subsidies must be gradual, considering market maturity and consumption of its sustainable solutions".

Furthermore, Hao et al. (2014) found that especially before 2015, China's EV subsidy program was necessary for the cost-competitiveness of EVs, when comparing ownership costs. With gradual reductions in the subsidy intensity, a temporary rise of the EV ownership cost was expected, but with the decrease of EV manufacturing cost, this is expected to decrease despite the phase-out mechanism, making EVs less or not reliant on subsidies to maintain cost competitiveness in the long-term. However, given the performance disadvantages of EVs, especially the limited electric range, the authors found that the EV subsidy program in 2014 was not sufficient for the EV market to take off. A similar study was conducted in the UK, and Santos and Rembalski (2021) found that the total cost of ownership was very sensitive to the car purchase price, underscoring that subsidies would accelerate EV adoption in the UK, especially for impatient consumers with high discount rates.

Thorne and Hughes (2019) studied the cost-effectiveness of achieving emission reductions through EV subsidy programs for each provincial electricity system in Canada, and compared these results to the cost-efficiency of other investments in climate change mitigation initiatives. They argued that the magnitude of emissions reductions achieved through EV subsidies relates to the emission intensity of the electricity used to power the EV heavily impacted the costs and benefits of such a program. Even in provinces where electricity generation is heavily reliant on renewables, the cost per tonne of reduced emissions through EV subsidies was much more expensive than other greenhouse gas mitigation investments.

3 Background

3.1 The Vehicle Tax Policy in Norway

When purchasing a new vehicle in Norway, the purchase is subject to a 25 percent VAT rate and a one-off registration tax. The VAT is calculated as 25 percent of the total price from the car dealership. Before 2023, the one-off registration tax was calculated based on the vehicle's tax group, CO_2 emissions, NO_X emissions, and engine power. Hence, vehicles with higher emissions have historically been subject to higher tax payments (The Norwegian Tax Administration, n.d.-a) (Hafsaas, 2023).

The point in time that triggers tax liability is the time for first-time registration. This does not directly reflect the time of purchase. The Norwegian Tax Administration assumes that the day a car is registered on the customer in the Norwegian Public Road Administration's register of motor vehicles is the same day ownership is transferred to the owner. At that time all legal obligations are considered to be fulfilled, particularly the owner's insurance obligations. Further, this point in time should determine the VAT and the one-off registration tax related to the purchase (The Norwegian Tax Administration, 2022).

3.1.1 The Tax Exemption for EVs in Norway

EVs have historically been exempt from both the 25 percent VAT and the one-off registration tax. The rationale behind such exemptions was to make EVs relatively cheaper to purchase compared to fossil vehicles, and to increase the demand for EVs.

In table 3.1, the most significant changes to EV taxation are listed to provide a historical overview. Though the EV sales share of new passenger vehicles was close to zero in Norway in 1990, a temporary exemption from the one-off registration tax for EVs was imposed, and this became permanent in 1996. Such early-phase incentives were initiated to support the Norwegian EV industry, although Norway lacked charging infrastructure and the Norwegian EVs had limited use potential due to short kilometers of range (Figenbaum & Kolbenstvedt, 2013).

In 2001, EVs were exempted from VAT, reducing the consumer's price by 20 percent.

Since 2001, new EV incentives have primarily been use-related. Examples of this are the allowance for EVs to drive in bus lanes, charging on public parking spaces without fee, and no car tolls, but these benefits have been modified in recent years. In addition, the government has provided funding for public charging stations to improve the infrastructure (Figenbaum & Kolbenstvedt, 2013).

In 2021, the Norwegian government announced a plan to gradually reduce the EV tax incentives. This was done in *Hurdalsplattformen*, the official political agenda for the government in the electoral period 2021-2025. The plan was to impose VAT for EVs that cost more than NOK 600,000. Although this plan was altered, it highlights that tax policy changes were proposed before the official announcement in October 2022. In January 2023, VAT for EVs that cost more than NOK 500,000 and the weight component to the one-off registration tax were implemented.

1990	Trial introduction of an exemption from the one-off registration tax for EVs.
1996	Permanent exemption from the one-off registration tax for EVs
2001	Implementation of the VAT exemption for EVs
October 2021	Announcement of political agenda for the electoral period 2021-2025 (Hurdalsplattformen) with proposed changes to the EV tax policy
October 2022	Announcement of EV tax policy changes for 2023
January 2023	Implementation of tax policy changes. VAT exemption removed for EVs that cost more than NOK 500,000. A weight component was added to the one-off registration tax.

Table 3.1: Historical development in Norwegian EV tax incentives

3.1.2 The EV Tax Policy Changes

As of January 1, 2023, EVs are no longer fully VAT-exempt, and VAT is applied to EVs priced above NOK 500,000. While all other vehicles are subject to a 25 percent VAT on the total purchase amount, EVs are only subject to a 25 percent VAT on the price exceeding NOK 500,000 (Norwegian Ministry of Finance, 2022). Additionally, a weight component was added to the one-off registration tax for all passenger vehicles, which particularly targeted EVs, since EVs typically are heavier than conventional vehicles due to their battery. Moreover, the more expensive EVs with longer kilometers of range are often heavier and hence subject to a higher one-off registration tax. The weight component in the one-off registration tax is calculated as NOK 12.50 for every kilogram that the vehicle exceeds 500 kilograms.

3.1.2.1 Price Example

To demonstrate how the tax policy changes impact the price of an EV to the consumer, we use a price example comparing two different EV models. Given that the partial removal of the VAT exemption specifically targets higher-priced EVs, and the one-off registration tax that applies to all EVs, we will differentiate between Tesla Model 3 and Tesla Model S. The former is priced below the threshold of NOK 500,000, whereas the latter is priced substantially above.

Tesla Model 3		
	2022	**2023**
Listed Price	409,741	409,741
Value added tax	0	0
One-off registration tax	0	14,875
Total Price	409,741	424,616

Table 3.2: Price example of EV priced below NOK 500,000

Tesla Model S		
	2022	**2023**
Listed Price	1,022,284	1,022,284
Value added tax	0	104,457
One-off registration tax	0	19,937
Total Price	1,022,284	1,146,678

Table 3.3: Price example of EV priced above NOK 500,000

In tables 3.2 and 3.3, the two price examples are illustrated, based on listed prices from November 2023. The Tesla Model 3 benefits from a full VAT exemption, while being subject to the one-off registration tax. With a weight of 1,690 kilograms, this results in a tax of NOK 14,875. In this instance, the total tax burden amounts to approximately 3.6

percent of the listed price (Tesla, 2023a). The Tesla Model S is subject to a 25 percent VAT on the price exceeding NOK 500,000 in addition to the one-off registration tax of NOK 19,937 calculated based on the vehicle's weight of 2,167 kilograms. With a price of NOK 1,022,284, the VAT is 25 percent of NOK 522,284, which equals NOK 104,457. Adding this to the one-off registration tax of NOK 19,937 leads to a tax payment of NOK 124,394. In total for the Tesla Model S, the tax burden is approximately 12.2 percent of the listed price (Tesla, 2023b).

3.1.2.2 Governmental Intention

The Norwegian government has an objective that all new light vehicles and city buses should be zero-emission vehicles in 2025. This goal is ambitious and depends on technological development making zero-emission technologies competitive with fossil fuel vehicles (The Norwegian Government, 2021b).

The purpose of adding the weight component to the one-off registration tax as well as the partial removal of the VAT exemption is, firstly, fiscally justified. Secondly, the initial intention of maintaining exemptions from VAT and one-off registration tax for EVs was to support the purchase of EVs and increase demand. The Norwegian government highlights the VAT exemption in particular as a key factor in why Norway has the highest EV sales share globally. In essence, the governmental support for the purchase of EVs is becoming a general subsidy for car purchases with the rapid increase in the EV share of the Norwegian vehicle fleet. It implies that the government is subsidizing the purchase of EVs over other forms of consumption, including more environmentally friendly modes of transportation, such as public transport (Norwegian Ministry of Finance, 2022).

3.2 EV Policy in Sweden

In Sweden, a climate bonus for zero- and low-emission vehicles was implemented on July 1, 2018, and gradually revised until discontinuation on November 8, 2022. A vehicle was considered a low-emission vehicle if it was equipped with technology that enabled the use of fuel gas other than liquefied petroleum gas. The eligibility for the climate bonus was dependent on the CO_2 emissions per kilometer driven, and these rates were also revised gradually. Low-emission vehicles that were purchased between July 1, 2018, and

November 8, 2022, were eligible for this bonus.

To receive the climate bonus, the owner had to submit a formal application after the vehicle had been first-time registered, and the size of the climate bonus depended on the vehicle's fuel type, emissions, price, and time for first-time registration. In contrast to the Norwegian tax policy, the date of purchase rather than the date of first-time registration was used to determine whether someone was eligible to receive the bonus, while the size of the climate bonus depended on the time of first-time registration. Vehicles that cost more than SEK 700,000 were not qualified for the bonus. For pure electric and hydrogen vehicles with zero emissions, the highest possible bonus was SEK 70,000 between April 1, 2021 and December 31, 2022, and SEK 50,000 if the car was first-time registered on January 1, 2023, or later. The rates for low-emission vehicles decreased for every gram of CO2 that the car emits, according to the Swedish vehicle register, and the maximum rates were lower compared to zero-emission vehicles (Swedish Transport Agency, 2023).

On November 8, 2022, the Swedish government simultaneously announced and implemented the discontinuation of the climate bonus system. This was after a gradual reduction in compensation rates from 2018. The reason was that the costs of purchasing and operating zero- and low-emission vehicles were deemed comparable to those of petrol or diesel vehicles. The Swedish government argued that a state subsidy for market introduction was no longer justified. Since the climate bonus is paid out at the earliest six months after the car is registered, many payments will still have to be made in 2023 for orders that were placed on November 8, 2022, at the latest.

The conclusion of the climate bonus in November 2022 marks a change in Swedish EV policy. As Sweden serves as our control group, it is important to confirm the absence of significant changes before the policy changes in Norway, as this could impact the number of first-time registered EVs in Sweden. We consider the discontinuation of the climate bonus not to cause any major issues for our control group. In section 6.3.3, we will provide a detailed rationale behind selecting Sweden as our control group.

4 Theory

To better understand the dynamics of the EV market, this chapter will present relevant theories on durable consumer goods, intertemporal substitution, and substitution across goods.

4.1 Durable Consumer Goods

Durable consumer goods are goods with a relatively high cost, posing a greater financial risk for the consumer. Additionally, after purchasing a durable good, consumers usually stay away from the market for a longer time, only to re-enter the market briefly, either to purchase an additional item or to replace an existing durable.

A characteristic of durable consumer goods is that the total stock of each good owned by the consumers is large relative to the annual production. As a result, a slight adjustment in the desired total stock held by consumers can lead to a relatively large percentage change in demand. In figure 4.1, the short- and long-run demand curves are illustrated for a durable good. D_{LR} refers to long-run demand, and D_{SR} refers to short-run demand. The graph illustrates that demand has higher price elasticity in the short-run relative to the long-run, and a price increase is related to a larger reduction in the quantity demanded in the short-run.

The partial removal of the VAT exemption for EVs and implementation of the weight component to the one-off registration tax for all vehicles are permanent but pre-announced tax changes. These led to a price increase for EVs. Since EVs are classified as highly durable consumer goods, a price increase could cause consumers to defer from purchasing new EVs in the short-run. However, at some point, automobiles will eventually need to be replaced, making the consumer re-enter the market. Hence, the change in demand for EVs is expected to be less elastic in the long-run compared to the short-run. In turn, this might cause the consumption response to the tax policy changes to suffer from a timing effect.

Such a timing effect was observed in the consumption response to a VAT rate increase in Japan. Cashin and Unayama (2021) estimated the effect of a pre-announced increase

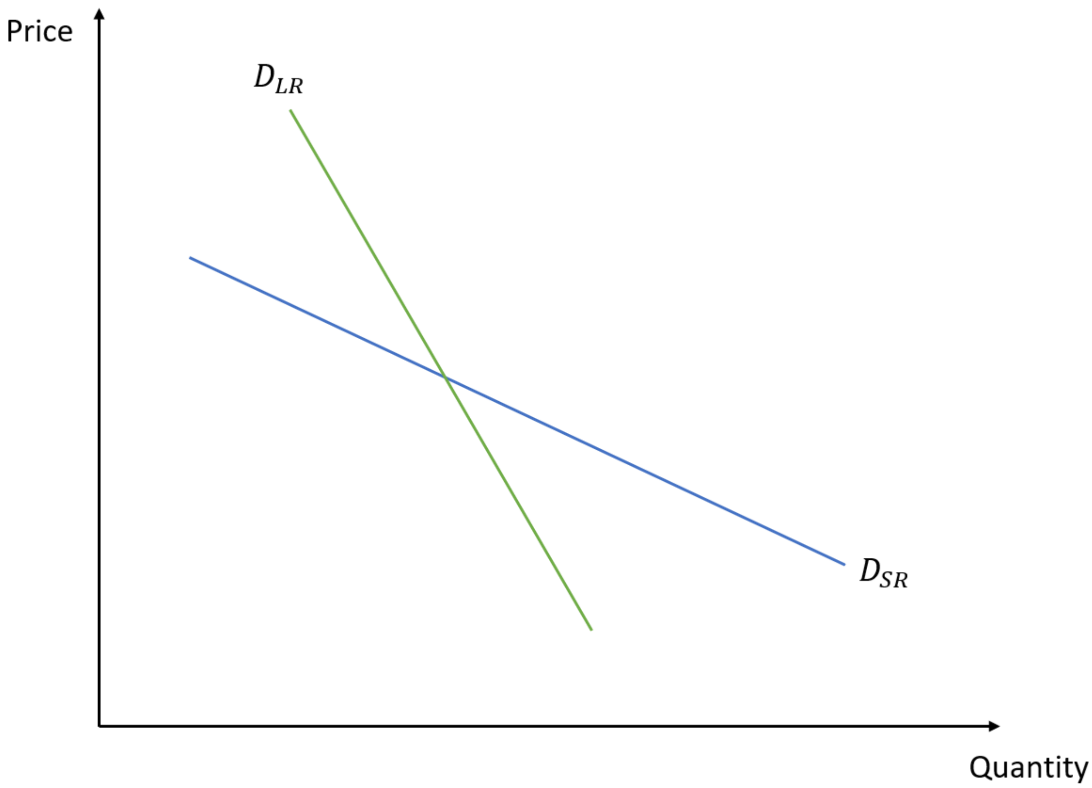

Figure 4.1: Short-run and long-run demand curves for durable consumer goods

of two percent in Japan's VAT rate on the timing of household expenditures on durable goods and consumption. They found that spending on a wide range of durables surged in the final two months before the tax rate increase, by 8 and 23 percent, respectively. Upon implementation, it dropped sharply but returned to its previous long-run levels within a few months. The authors found that the magnitude and duration of this substitution behavior depend critically on the ability and willingness of households to change the timing and composition of their consumption and their ability to engage in a form of "arbitrage" behavior such as the accelerated purchase of durables. Consistent with the predictions of a dynamic model of durable consumption, expenditures on goods with higher levels of durability, such as EVs, responded more strongly to a VAT rate increase.

Given the theory of durable goods, our hypothesis for the analysis is that the short-term elasticity will be high, while the long-term elasticity is expected to be more inelastic. We expect that consumers will adapt their behavior to the tax policy changes and either purchase an EV before the price increase or delay their purchase.

4.2 Substitution

The tax policy changes are also expected to affect intertemporal substitution and substitution across goods. There could be intertemporal substitution due to prices changing over time because of the tax policy changes, and there is a possibility for substitution effects across higher- and lower-priced EVs due to the different shifts in the price of these two types of goods.

The VAT change introduces a tax on the price exceeding NOK 500,000 for EVs and only affects higher-priced EVs. The weight component in the one-off registration tax targets all EVs, but the higher-priced more so than the lower-priced EVs, since they typically have longer kilometers of range and are heavier. Hence, the increased tax burden is disproportionate to price, which is illustrated in section 3.1.2.1. Additionally, the VAT on higher-priced vehicles is more pronounced in driving the price increase, since it increases more than the one-off registration tax when the vehicle price increases. This will lead to a permanent shift in the relative prices for the two categories, making it particularly interesting to discuss in the light of substitution between goods.

The pre-announced tax policy changes also make it interesting to consider the possibility of intertemporal substitution. The tax policy changes were announced in October 2022 but not implemented until January 2023. Given that the supply is somewhat elastic to changes in demand, this would enable consumers to purchase EVs at the end of 2022 instead of at the beginning of 2023. In this context, intertemporal substitution can contribute to describing how consumers shift their demand forward or delay their consumption, in response to a price increase.

4.2.1 Intertemporal Substitution

Individuals consider both the present and the future when deciding on their consumption and savings, and these decisions are impacted by the consumers' intertemporal budget constraints and preferences.

If we consider a two-period optimization problem, a household consumes a good c_t which costs p_t in each period $t \in \{0, 1\}$. The price of a good can vary over time. Within each period, the household has an exogenous income y_t. Further, the household can save an amount s between periods $t = 0$ and $t = 1$, and we assume that the household does not discount the future and that the interest rate on savings is equal to zero. The total lifetime expenditure has to equal the total lifetime income. Given that consumers are utility maximizing, their utility can be described by a standard utility function, $u(c_t)$, and the optimization problem is written in 4.1.

$$\begin{aligned} \max_{c_0, c_1, s} \quad & u(c_0) + u(c_1) \quad \text{s.t.} \\ & p_0 c_0 + s = y_0 \\ & p_1 c_1 = y_1 + s \end{aligned} \tag{4.1}$$

Given this optimization problem, we can solve it to obtain the expression 4.2. This explains how price changes in one period will affect the consumption in period $t = 0$ relative to $t = 1$.

$$\frac{c_1}{c_0} = \frac{p_0}{p_1} \tag{4.2}$$

The changes to the EV tax policy represent a permanent increase in the tax burden, causing a permanent increase in the purchase price of new EVs. If we assume that the tax policy changes increase the price by x percent in both periods, the effect on consumption in the two periods is illustrated in equation 4.3. Given the same percentage increase in the two periods, the tax incentive will not affect the relative prices of first-period consumption versus second-period consumption. In other words, the price increase caused by changes in taxation will not affect intertemporal substitution.

$$\frac{c_1}{c_0} = \frac{(1+x)p_0}{(1+x)p_1} = \frac{p_0}{p_1} \tag{4.3}$$

However, since the tax policy changes were announced in October 2022, almost three months before they were implemented, we can consider it a tax that only affects future (second-period) consumption. Assuming that the tax increases the price in the second period p_1 by x percent, but not the price in the first period p_0, we get equation 4.4:

$$\frac{c_1}{c_0} = \frac{p_0}{(1+x)p_1} < \frac{p_0}{p_1} \tag{4.4}$$

This illustrates a case of intertemporal substitution, where future consumption shifts to the present. In the case of the tax policy changes in Norway, we assume that the period $t = 0$ is the time between the announcement and implementation, and period $t = 1$ is the time after implementation. Given the theory about intertemporal substitution, we expect people to shift their consumption forward after the announcement of the tax policy changes. This would lead to an increase in the number of first-time registered EVs between the announcement of policy changes in October 2022 and the implementation in January 2023, followed by a reduction at the beginning of 2023.

4.2.2 Substitution Across Goods

Since the tax policy changes affect higher-priced EVs relatively more than lower-priced EVs, we expect there to be substitution across goods after the tax changes are implemented.

In a simple model with two goods, if the price increase is higher for one good compared to the other, the relative prices of the goods change. The relatively higher price increase for higher-priced EVs will change the rate at which you can exchange higher-priced EVs for lower-price EVs. This effect is referred to as the substitution effect, which describes how a change in the relative prices of two goods affects the quantity demanded of those goods. Specifically, when the price of one good changes while the price of another remains constant, consumers are inclined to substitute a good that has an unchanged price for a good that sees a falling price. In our case, the price increase is larger for one good compared to the other good, making the consumers inclined to substitute higher-priced EVs that are subject to a greater price increase for lower-priced EVs.

Figure 4.2 illustrates a scenario where the price of one good, X_1, decreases. The orange line, BC_1, depicts the initial budget constraint, given the consumer's preferences for the consumption of the two goods. The curved blue lines indicate different indifference curves and represent the consumer's utility. Starting from the initial consumption A, the price increases and the budget line rotates around intercept A to BC_2. The substitution effect is represented by the shift from the initial consumption A to a new consumption B, substituting away from X_2 towards the relatively cheaper X_1. This substitution increases the consumer's utility since the new consumption B is at a higher indifference curve.

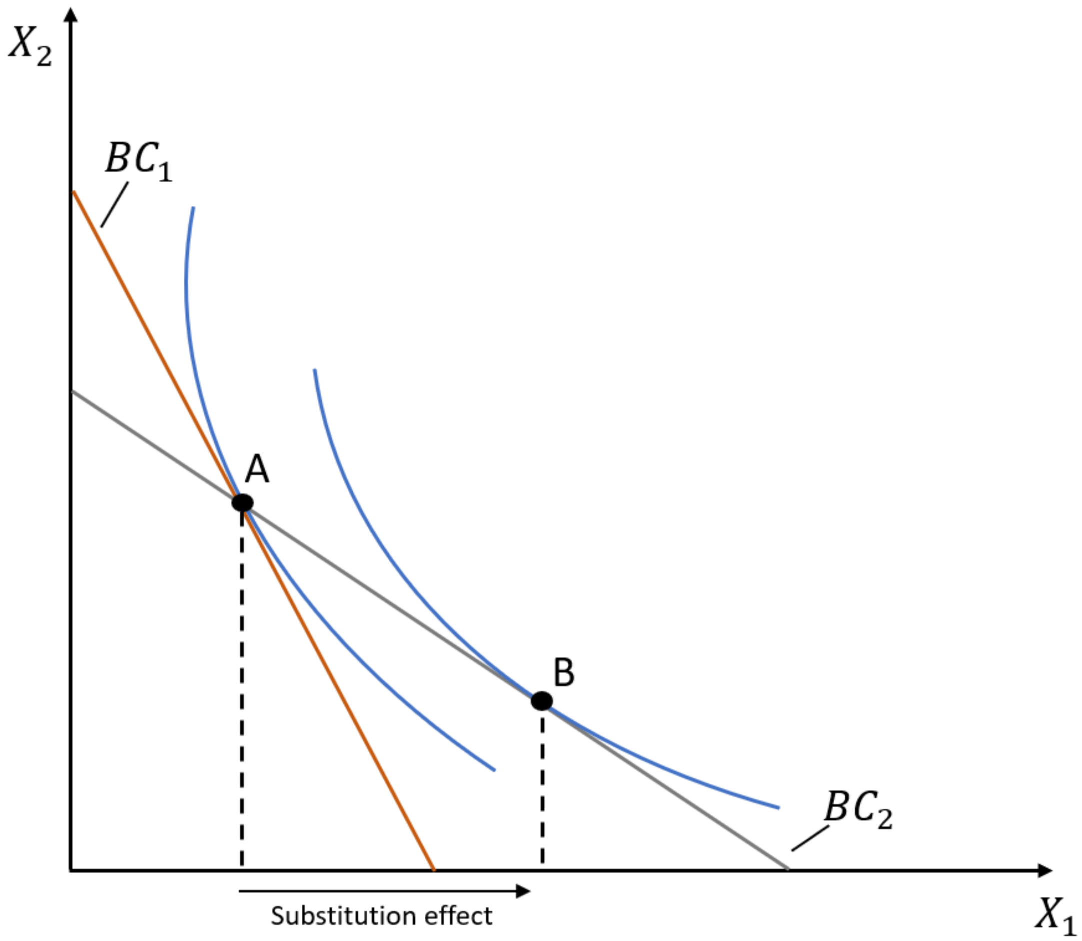

Figure 4.2: Substitution across goods

Though the tax policy changes introduce a higher tax burden for all EVs, the higher-priced EVs will be subject to a relatively higher tax burden. Since the two price categories are affected differently, we expect there to be substitution effects between them. Consumers are expected to substitute higher-priced EVs for lower-priced EVs since the relative prices change.

5 Data

In this chapter, we will present our data collection method, how we have constructed our data sets, and provide descriptive statistics.

5.1 Data Collection and Cleaning

Our primary data source is the Norwegian Road Federation (OFV) and its statistics on the Norwegian vehicle fleet. OFV retrieves its statistics about vehicle sales and the vehicle fleet from The Norwegian Public Roads Administration and offers detailed data about all registered vehicles in Norway (Norwegian Road Federation, n.d.). The data sets from OFV are split into two data sets, one with all first-time registered passenger vehicles split by fuel type, and one with all first-time registered EVs split by price category. For our control group, we have collected Swedish data on first-time registered passenger vehicles, grouped by fuel type. The data is retrieved from Transport Analysis, the Swedish provider of vehicle statistics.

Our main data sets for Norway and Sweden are structured as panel data with monthly observations from January 2008 to August 2023. The data sets contain information about the number of first-time registered vehicles for each fuel type, aggregated monthly for all observations. When constructing the data sets for our analysis, we use the data from January 2019, particularly since the number of first-time registered EVs in Sweden was very low before 2019, making it challenging to meet our model assumptions. The period from 2019 to 2022 constitutes our control period before the tax policy changes, and the observations for 2023, from January to August, are used to evaluate the effect of the tax policy changes after implementation.

The data for EVs in Norway is further split into two price categories. For each month from January 2019 to August 2023, this data set contains the number of first-time registered EVs that cost up to NOK 500,000, and more than NOK 500,000. As described in section 3.1.2, only the EVs that cost more than NOK 500,000 are subject to the VAT after tax policy changes, while the one-off registration tax applies to both price categories. Until 2023, all EVs have been exempt from VAT. The data is aggregated monthly for the two price categories, for all first-time registered EVs in Norway.

5.2 Descriptive Statistics

In figure 5.1, the total number of first-time registered passenger vehicles in Norway from 2008-2023 is illustrated, split by fuel type. We observe a substantial increase in the EV sales share from 2017, and in 2022 it accounted for more than 80 percent. Simultaneously, the share of diesel and petrol vehicles decreased annually since 2011 and 2013, respectively. While the growth in the EV sales share was relatively low between 2011 and 2017, the sales share of hybrids increased rapidly. However, it has decreased in recent years, likely in correlation with the drastic technological improvements for EVs.

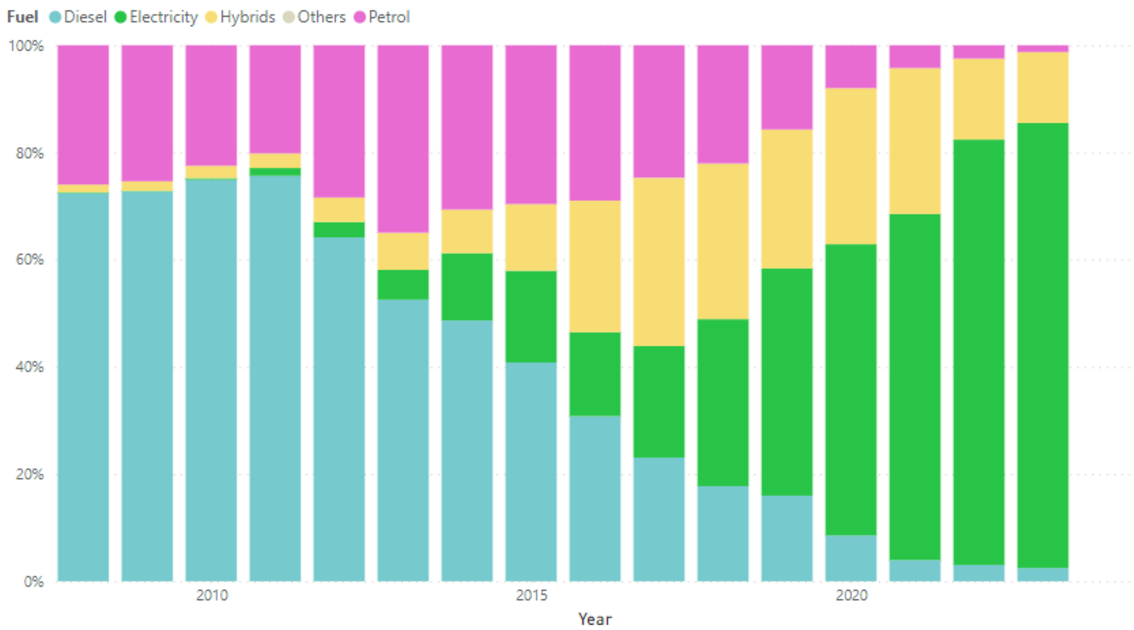

Figure 5.1: Split of first-time registered vehicles by fuel type in Norway (2008-2023)

The development in the Swedish vehicle market is illustrated in figure 5.2. We observe the same development in the EV sales share, but compared to Norway, the adoption of EVs has been slow and the development has intensified at a later point in time. Since 2015, this share has increased steadily in Sweden and reached 36.85 percent in the first eight months of 2023. Similar to Norway, we observe a substantial decrease in the petrol and diesel vehicle sales shares from 2012 and 2019, respectively.

In our analysis, the data from 2019 to 2022 serves as our pre-treatment period, and January to August 2023 serves as the post-treatment period. In Norway, the total number of first-time registered light vehicles from 2019-2022 was 633,844, with the corresponding EV sales share of 61.37 percent. From January to August 2023, the total number of

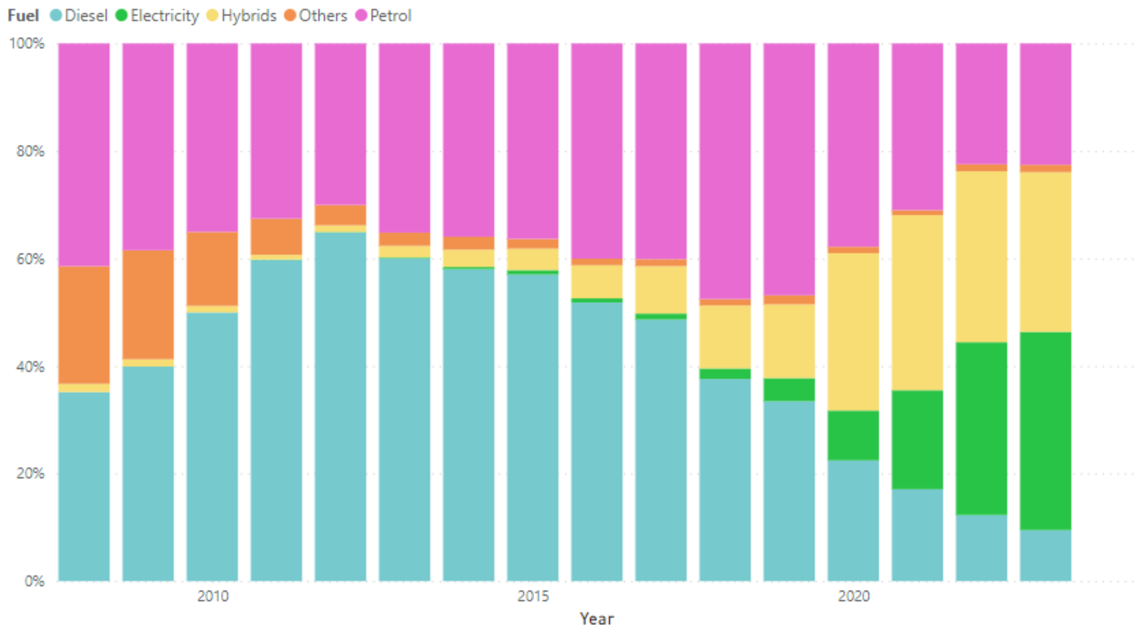

Figure 5.2: Split of first-time registered vehicles by fuel type in Sweden (2008-2023)

first-time registered light vehicles in Norway was 85,121 and the EV sales share was 83.02 percent. In contrast, Sweden had a total of 1,283,690 first-time registered light vehicles from 2019 to 2022, with an EV sales share of 15.42 percent. From January to August 2023, the total registrations in Sweden were 187,862, and the EV sales share was 36.85 percent.

From the data on first-time registrations, we observe a substantial increase in the EV sales share for both countries in recent years. For Norway, it is especially interesting to examine the different price categories of Norwegian EV sales when analyzing the tax policy changes. The total number of first-time registered EVs in Norway from 2019-2022 was 387,937. The split between the two price categories in this period was 47.20 percent of sales in the higher-priced category (above NOK 500,000) and 52.80 percent in the lower-priced category (below NOK 500,000). From January to August 2023, the total number of first-time registered EVs was 70,631 and the share of higher-priced EVs increased to 72.41 percent, while the share of lower-priced EVs was 27.59 percent.

The development in the number of first-time registered EVs in the two price categories is illustrated in figure 5.3. The dashed lines represent smoothed trend lines. We observe that the lower-priced category has had a declining trend in the number of first-time registrations since the middle of 2021, while the higher-priced category has had an increasing trend since the beginning of 2020. Since the end of 2021, higher-priced EVs have accounted for more first-time registrations than lower-priced EVs.

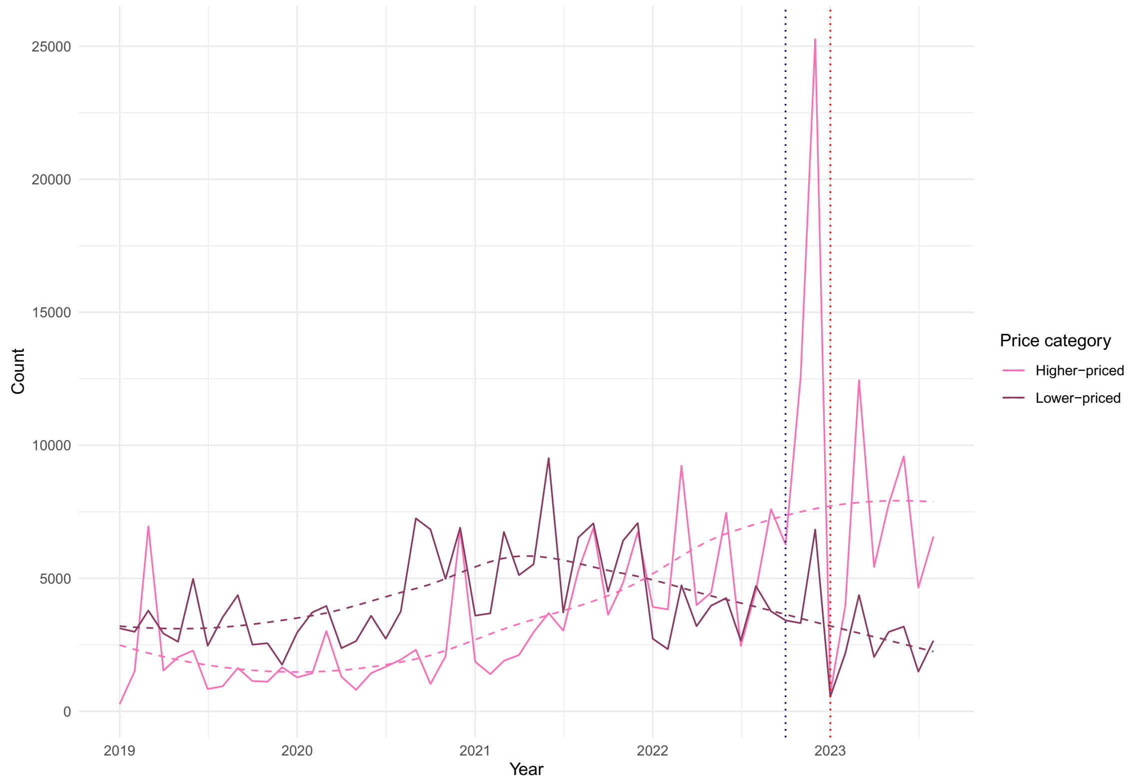

Figure 5.3: Number of first-time registered EVs split by price categories in Norway

Figure 5.4 illustrates the month-over-month growth rates for the two price categories. We observe greater fluctuations for higher-priced EVs compared to lower-priced EVs, especially right after the tax policy changes were implemented. Besides this, both categories exhibit a relatively close development, particularly in recent years.

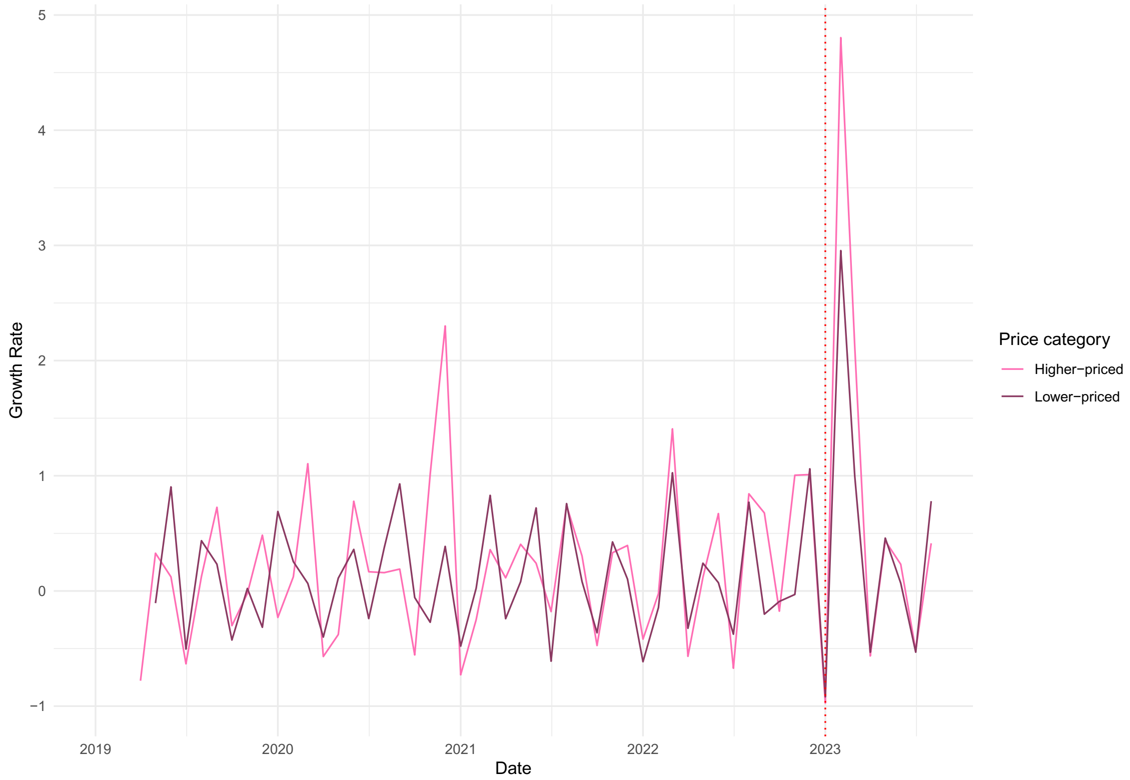

Figure 5.4: Growth rates of first-time registered EVs split by price categories in Norway

6 Methodology

For our analysis, we have chosen to apply the difference-in-difference (DiD) methodology. In this chapter, we will provide the reasoning behind our selected model, and explain the principles for this method, including a discussion about the model assumptions.

6.1 Choice of Regression Model

To examine the impact of the EV tax policy changes on the quantity of first-time registered EVs, we depend on isolating this effect. Since we are analyzing the effect of a specific policy change and our data is structured as panel data, the effect can be isolated by employing DiD estimation. Utilizing this method, our goal is to analyze the change in the number of first-time registered EVs after the policy change was implemented on January 1, 2023.

The DiD method requires there to be two groups and two time periods. One of the groups serves as the treatment group, while the other group is used as a control group. In addition, there is a period before and after the implementation of a treatment effect. DiD is suitable for estimating the effects of an exogenous event that changes the environment for individuals, firms, cities, etc. The EV tax policy changes, with the partial removal of the VAT exemption and the introduction of the weight component to the one-off registration tax, are regarded as exogenous events that affect the market for passenger vehicles. The impact of these policy changes can be estimated by comparing the outcomes in the affected market to a control group that is not affected by the policy changes. In other words, the DiD estimation captures the average treatment effect of the policy changes. Moreover, the demand for EVs in Norway is influenced by both observable and unobservable factors that would be difficult to include as explanatory variables in a standard regression. However, the DiD model controls for such factors when comparing the change in the treatment group to the change in the control group. By controlling for the counterfactual trend, the method depends on the assumption that the control group captures the development in the treatment group in the absence of the treatment. Hence, the DiD model enables us to estimate the true effect of the tax policy changes on the number of first-time registered EVs in Norway.

Due to the nature of panel data, consisting of repeated observations over several years and months, it will exhibit serial correlation. To account for this we have used heteroskedasticity and autocorrelation corrected standard errors (HAC).

6.2 Model Specification

DiD estimation is a type of multiple linear regression estimated through ordinary least squares (OLS). It is used to estimate the difference between the development in a treatment group and a counterfactual development in a control group. This provides a DiD estimator for the average treatment effect. The DiD estimator depends on the strict assumption that if the exogenous event never occurred, the trends in the two groups would stay the same over time. This is called the parallel trend assumption and will be discussed further in section 6.3.1.

In its simplest form, the following regression specification denotes DiD estimation:

$$y = \beta_0 + \delta_0 d_{\text{post}} + \beta_1 d_{\text{treated}} + \delta_1 (d_{\text{post}} \cdot d_{\text{treated}}) + \epsilon \tag{6.1}$$

In this regression model, y is the dependent variable and represents the outcome that we want to explain. d_{treated} is a dummy variable that captures potential differences between the treatment group and the control group before the policy changes. The time dummy, d_{post}, captures factors that would cause changes in y regardless of whether the treatment was implemented or not. The coefficient of interest in the DiD model is predominantly the DiD estimator, denoted as δ_1. By including an interaction term between the two dummy variables d_{treated} and d_{post}, the effect of the policy after implementation is isolated.

The DiD estimator itself can be intuitively expressed as:

$$\hat{\delta}_1 = (\bar{Y}^{\text{treated, post}} - \bar{Y}^{\text{treated, pre}}) - (\bar{Y}^{\text{control, post}} - \bar{Y}^{\text{control, pre}}) \tag{6.2}$$

Figure 6.1 illustrates the standard DiD model, with the development in the treatment and control group before and after the policy change at time t_1. The policy change only affects the treatment group. In the pre-treatment period, the groups have the same trend. After the policy change, in the post-treatment period, there is a shift in the treatment

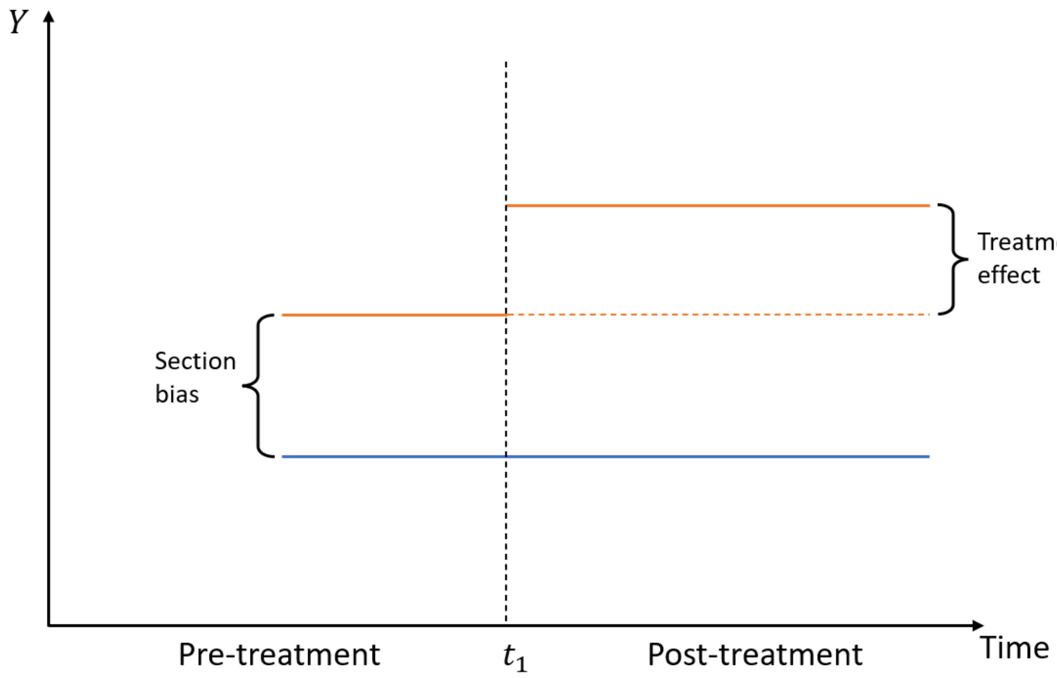

Figure 6.1: Standard difference-in-difference model

group, and this effect can be attributed to the treatment. The development in the control group remains the same and represents the counterfactual progression of the treatment group. This is based on the assumption that the development in the treatment group would have been equal to the control group had it not been for the treatment. Differences in levels are attributed to section bias. The objective of DiD estimation is to estimate the treatment effect. This effect is determined graphically by examining the difference between the treatment group after receiving treatment and the counterfactual progression of the treatment group without treatment.

6.2.1 Anticipatory Effects

As outlined in section 6.2, the DiD model depends on a counterfactual scenario to estimate the impact of the policy change. By creating a comparison scenario, the counterfactual outcome represents what would have occurred without the policy change. Estimating the causal effect of a policy change becomes complex if the agents actively choose to participate in the policy rather than being randomly assigned to it. In other words, if agents choose to self-select based on the outcome variable, which the policy is designed to affect, a standard DiD model might not provide a credible estimate of the true effect

(Heckman & Smith, 1999). In our case, consumers had the opportunity to shift their consumption forward because they were informed about the policy changes in October 2022, three months before their implementation in January 2023.

Ashenfelter (1978) examined the limitations of the conventional DiD approach. He observed that the mean earnings of participants in government training programs experienced a steep decline before the implementation of the program. This phenomenon is often referred to as *Ashenfelter's dip*. If we do a visual examination of figure 6.2, we observe that there could be anticipatory effects present in Norway before the treatment period. From the illustration, we observe that the number of first-time registered EVs in Norway surged in December 2022, the month before the EV tax policy changes were implemented. This could be a violation of the parallel trend assumption, which is discussed in section 6.3.1.

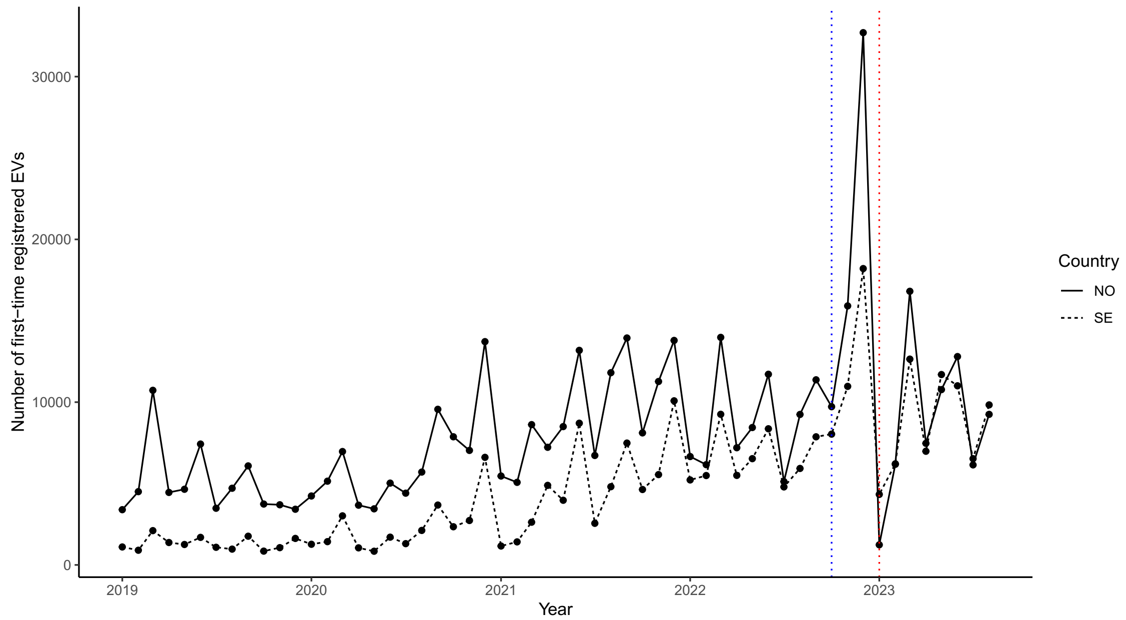

Figure 6.2: First-time registered EVs in Norway and Sweden

A method to relax the parallel trend assumption is to add a time trend which would allow for non-parallel development between the two groups. This is done to distinguish treatment effects from trend effects, which otherwise could lead to imprecise results. In our regression, we have included a second-order polynomial time trend to the standard DiD model. By including this time trend we can control for differential trends between the treatment and the control group. Quadratic trends are often more suitable when there are indications of seemingly non-linear patterns. Given the presence of curvature observed in the data for the treatment group (see appendix B.1), a second-order polynomial time trend appears fitting.

6.2.2 Estimated Regression

We aim to estimate the average treatment effect of the EV tax policy changes implemented in 2023 on the quantity of first-time registered EVs. Including controls to more precisely estimate this effect, our regression specification is expressed as:

$$\begin{aligned}\log(y_{i,t}) =& \beta_0 + \delta_0 d_{\text{post}} + \beta_1 d_{\text{treated}} + \delta_1(d_{\text{post}} \cdot d_{\text{treated}}) + \gamma_1 t + \gamma_2 t^2 + \gamma_3(d_{\text{post}} \cdot t^2) \\ &+ \gamma_4(d_{\text{treated}} \cdot t^2) + \gamma_5(d_{\text{post}} \cdot d_{\text{treated}} \cdot t^2) + \epsilon\end{aligned} \quad (6.3)$$

In our DiD model, we have log-transformed the dependent variable for comparison of percentage changes instead of comparison on the original scale. This eliminates the differences in levels between the groups that might otherwise generate omitted variable bias.

Our treatment group comprises the number of first-time registered EVs in Norway, while our control group consists of the number of first-time registered EVs in Sweden. In our regression, the dummy variable $d_{treated}$ takes the value 1 if the observation belongs to Norway, and 0 if the observation belongs to Sweden. Furthermore, if the dummy variable d_{post} is equal to 1, the observations happened in the treatment period after the implementation of the tax policy changes. The DiD coefficient, $\delta_1(d_{\text{post}} \cdot d_{\text{treated}})$ captures the effect of the EV tax policy changes in Norway on the quantity of first-time registered EVs after this policy change. Lastly, the second-order polynomial time trend coefficient t^2 is added to control for non-linear yearly time trends that are observed in the data.

6.3 Model Assumptions

A causal interpretation of the DiD results requires that certain fundamental assumptions must be met. These assumptions will be described and discussed in the context of our particular model.

6.3.1 Parallel Trend Assumption

The most crucial assumption for a causal interpretation of our DiD estimator is the parallel trend assumption. In practice, it infers that the treatment and control groups would have developed similarly in the treatment period in the absence of the treatment. A credible counterfactual development is important because it accounts for pre-treatment differences in levels. With the appropriate choice of a control group, there exists a systematic relationship between the groups. Consequently, the counterfactual development can be determined by utilizing the trend of the treatment group. Subsequently, the counterfactual development can be compared to the actual development in the treatment group, and the difference between the actual and counterfactual developments makes up the treatment effect. If the parallel trend assumption does not hold, one cannot isolate the effect of the treatment, and thus, the result cannot be interpreted causally.

In figure 6.2, the number of first-time registered EVs from January 2019 to August 2023 is plotted for Norway (treatment group) and Sweden (control group). The red dashed line indicates January 2023, when the policy changes were implemented, while the blue dashed line indicates the announcement in October 2022. From the figure, we observe that the two groups moved approximately in parallel before 2023, and after the policy was implemented, there was a steep decline in the observation for Norway compared to Sweden. Based on visual inspection, this development is consistent with the parallel trend assumption, and it seems like the Swedish data constitutes a reasonable control group. This means that we would expect to observe the same development in Norway in 2023, had it not been for the tax policy changes.

6.3.2 SUTVA

The second assumption is that the outcome of one unit should be unaffected by the assignment of treatments to other units. In other words, there should be no spillover effect. This assumption is referred to as *the stable unit treatment value assumption* (SUTVA). It ensures that randomized assignment yields unbiased estimates of impact. If the treatment received by the treatment group indirectly affects the control group, then the comparison would not accurately capture the true counterfactual effect (Rubin, 1980).

Ensuring that the SUTVA assumption holds is crucial in the DiD model. Therefore, it is interesting to investigate the possibility of spillovers between our treatment and control groups. A conceivable scenario could involve registering a vehicle in Sweden in the treatment period and relocating it permanently to Norway, given that it reduces the price payable to the consumer. This situation could lead to spillover effects by allowing individuals to bypass the treatment, potentially reducing the EV sales in Norway while simultaneously increasing the EV sales in Sweden. However, according to Norwegian customs laws, if the value of the EV is above NOK 500,000, it is mandatory to pay 25 percent VAT of the excess amount even if the consumer is responsible for importing the vehicle (Norwegian Customs, n.d.). Furthermore, in principle, a person cannot use a foreign-registered vehicle in Norway if they have a permanent residence in Norway (The Norwegian Tax Administration, n.d.-b). Hence, given the Norwegian customs laws, there is no reason to believe that the consumer would shift their consumption to Sweden. Based on this, we can confidently assert that our groups satisfy the SUTVA assumption.

6.3.3 Choice of Control Group

To assess whether the control group is a credible counterfactual, it must meet three criteria: 1) The registration volume in markets for electric vehicles in the control group must be driven by the same factors as in the treatment group, 2) these factors should affect the two groups similarly, and 3) the development of these factors must be approximately equal. These criteria will be reviewed when discussing the choice of control group.

Firstly, similarity in economic and market conditions between the treatment and control groups is crucial for the parallel trend assumption to hold. Norway and Sweden are recognized as relatively similar economies, and based on historical data, the EV markets appear to be comparable. Important factors are exchange rates and GDP growth. In figure 6.3 the exchange rate between NOK and SEK is illustrated, presented as NOK per 100 SEK. The average exchange rate from 2019 to August 2023 is NOK 97.68 per SEK 100, and though the rate fluctuates, it remains stable over time, signaling that the economies are affected similarly by exogenous events. Further, figure 6.4 illustrates the exchange rates of the Norwegian, Swedish, and Danish krone to Euros. Denmark has a fixed exchange rate to the Euro and hence, the exchange rate does not fluctuate in response to macroeconomic factors. This also illustrates how the exchange rates for NOK and SEK follow each other closely even compared to Euros, strengthening the argument of using Sweden as a control group. The same goes for GDP growth, as seen in figure 6.5. By using Sweden as the control group in our analysis, we aim to control for the underlying economic and market developments in the treatment period, given that the markets are affected similarly by such exogenous events.

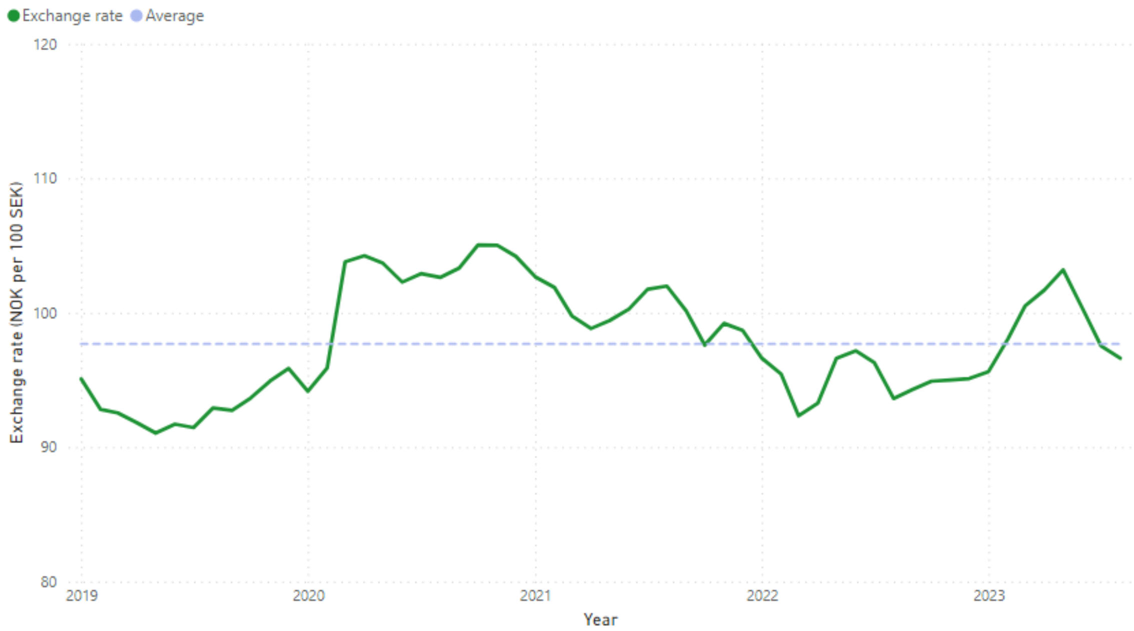

Figure 6.3: Exchange rates between NOK and SEK.

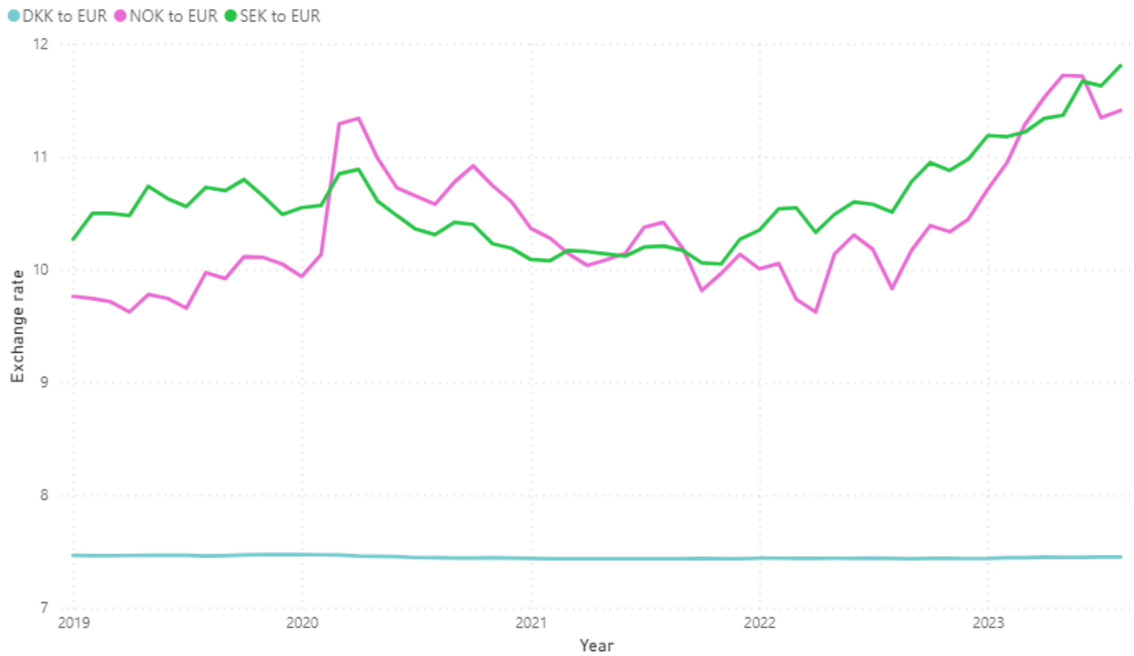

Figure 6.4: Exchange rates between NOK, SEK and DKK to EUR.

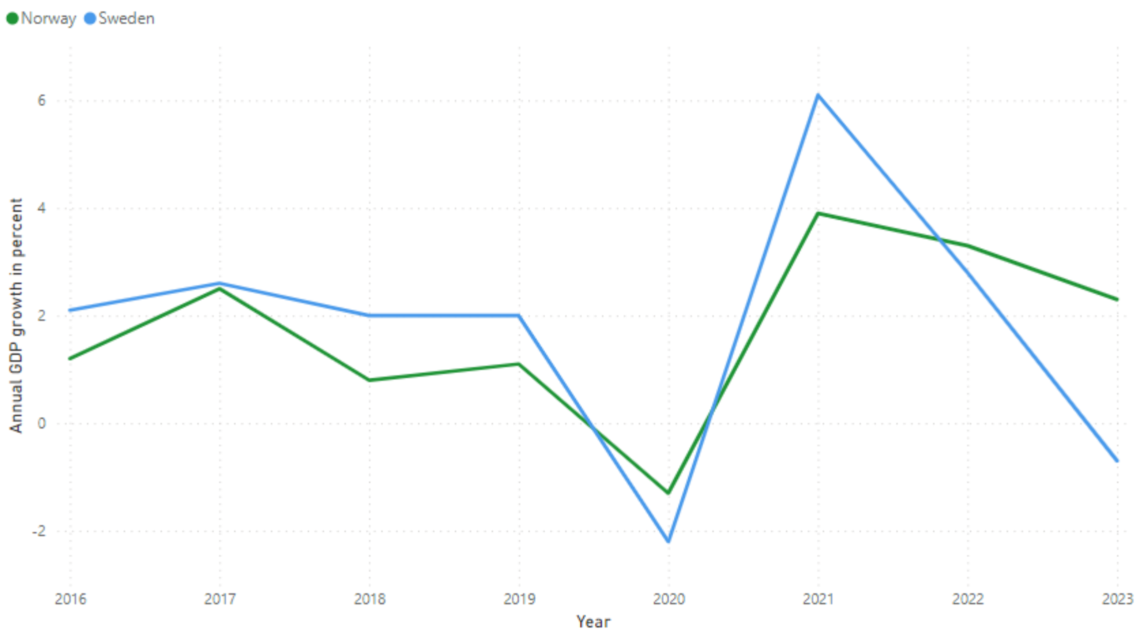

Figure 6.5: Annual GDP growth in Norway and Sweden.

Using Sweden as a control group, their policy environment should be stable over time. There have been adjustments to their EV taxation scheme in the pre-treatment period, but the political environment remains stable over time. Sweden has had a climate bonus system for low-emission and zero-emission vehicles since 2018, as outlined in section 3.2. The benefits of the climate bonus system have been gradually reduced, as part of the climate bonus design, providing predictability for the consumers. This stability ensures that any observed differences in 2023 can be attributed to policy changes in Norway. In addition, there have been no observed anticipatory effects in the control group that would violate the parallel trend assumption and influence EV sales before our treatment.

Additional external factors that could affect the number of first-time registered vehicles independent of the policy changes, will be controlled for in the DiD model given the similarity in market conditions. During the first half of 2022, the vehicle markets in Norway and Sweden were characterized by logistic issues, causing delays in the delivery of new vehicles. Parts of these delivery issues were attributed to the COVID-19 pandemic, with restrictions affecting both production and delivery across borders. Russia's invasion of Ukraine also disrupted the vehicle market and amplified the existing challenges. In addition, subcontractors of the vehicle manufacturers experienced shortages, particularly for components that are required to produce EVs. These challenges were largely resolved in the second half of 2022, and this effect is assumed to be comparable in Norway and Sweden (Møller Mobility Group, 2023) (Hedin Mobility Group, 2023). The delays meant that for instance, customers who ordered a vehicle in the first half of 2022 were not guaranteed delivery before the end of the year. After the announcement of increased taxes on EVs, incentives were also created for the industry to push forward first-time registrations before 2023 following increased demand from consumers (Norwegian Road Federation, 2023b). In combination, these factors caused a rush of registrations at the end of 2022 before the tax policy changes.

It is challenging to accurately quantify the number of first-time registered EVs that were pushed forward to avoid additional taxes in 2023. Part of the observed peak in December is likely due to the easing of production and delivery problems, though the tax policy changes could suggest the presence of intertemporal substitution. Since we do not know when the EVs that were first-time registered were purchased by the consumers, differentiating between the effect of intertemporal substitution and macroeconomic factors in the automotive industry becomes complicated. However, such macroeconomic factors are controlled for in our DiD model, given that Norway and Sweden are affected similarly by exogenous factors like changes in the production and delivery situation in the vehicle sector, which we find reasonable to assume.

Besides similarities in economic and market characteristics in Norway and Sweden, similarities in cultural and social factors between Norway and Sweden help control for unobservable factors that could affect the treatment and control groups. Further, both Sweden and Norway are small, open economies and neighboring countries. This strengthens the assumption that using Sweden as a control group will control for exogenous macroeconomic factors in the regression. Given these factors, the high inflation and reduced purchasing power in Norway and Sweden in 2023 are assumed to impact the vehicle markets in the two countries similarly. Both the Norwegian and Swedish krone have depreciated in the treatment period, making imports relatively more expensive.

Although a greater share of the first-time registered vehicles in Norway are electric compared to Sweden, we deem the growth rates to be comparable, as illustrated in figure 6.6. First-time registration is based on the same criteria for the two countries, and the categorization of passenger vehicles is equal, which provides consistent and comparable data for both groups.

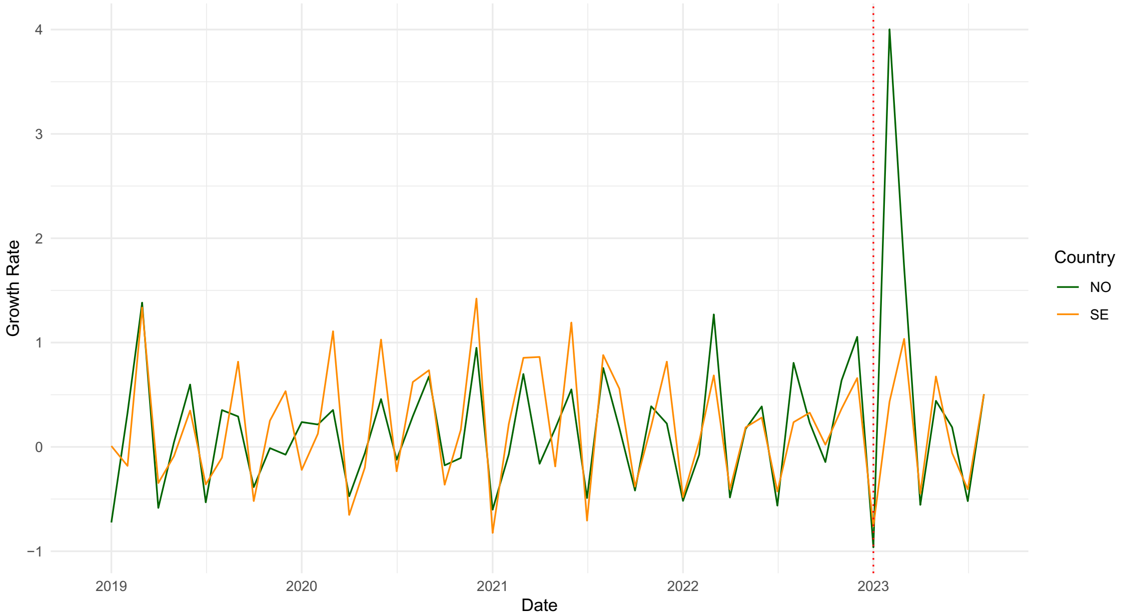

Figure 6.6: Growth rate in Norway and Sweden

7 Analysis

In table 7.1, the results from the DiD estimation are presented. It estimates first-time registered EVs in the period 2019 to August 2023, with January 2023 as the breakpoint. The regression table reports the explanatory variable coefficients and their HAC standard errors in parentheses.

The regression model includes coefficients in both the linear and logarithmic form. The linear form represents the change in the dependent variable on the original scale, while the logarithmic form represents the percentage change in the dependent variable. Our primary interest is the logarithmic interpretation of the coefficient, as this refers to the growth rate in the markets. All of our independent variables are binary variables that take the values 0 or 1, and the interpretation is reliant on the all-else-equal assumption.

Our main variable of interest is the interaction term between the treatment period 2023 and the treatment group Norway, *Treated:Post*. This is the DiD-coefficient, which estimates the differential effect of the policy change implemented in Norway compared to the control group Sweden in the same period. When we define the dependent variable in the logarithmic form, the term is negative and statistically significant at the five percent level, indicating that the number of first-time registered EVs in Norway was reduced by 72.11 percent, on average, after the tax policy changes were implemented in January 2023.

In addition to the DiD-estimator, the effect of the time trend is of interest. The inclusion of a time trend in the DiD model serves as a control for potential unobserved time-varying effects. It helps address the concern that trends in the outcome variable could be influenced by other factors than the policy change. The coefficients *Trend* and $Trend^2$ are positive and statistically significant at the one and five percent level, respectively, which indicates the presence of an upward trend with curvature in the pre-treatment period in Sweden.

The *Treated* coefficient represents the average difference in first-time registered EVs in Norway compared to Sweden. The estimated coefficient is positive and significant at the one percent significance level. It indicates that Norway on average has a 169.12 percent higher number of first-time registered EVs than Sweden.

Furthermore, the *Post* coefficient is positive but not statistically significant. This implies that there is no significant change in the monthly average of first-time-registered EVs in Sweden in the post-treatment period compared to the pre-treatment period, all else equal.

The regression results reveal that none of the interaction terms with trend, hereunder $Treated{:}Trend^2$, $Post{:}Trend^2$, and $Treated{:}Post{:}Trend^2$ are statistically significant. The coefficient for $Treated{:}Trend^2$ indicates that there was no significant deviation in the time trend between Norway and Sweden before the policy changes were implemented in Norway. The absence of statistical significance in *Post:Trend* indicates that the growth rate in first-time registered EVs 2023 does not significantly differ from that in the pre-treatment period for Sweden. Lastly, the $Treated{:}Post{:}Trend^2$ coefficient implies that the time trend does not employ a significant modifying effect on the effect of the policy changes in 2023.

Table 7.1: Regression Results

	Dependent variable:	
	Count	log(Count)
	(1)	(2)
Treated	3,112.289***	0.990***
	(918.163)	(0.145)
Post	−203.372	0.137
	(1,906.452)	(0.259)
Trend	186.839***	0.036***
	(27.963)	(0.004)
$Trend^2$	16.616*	0.003**
	(8.915)	(0.002)
Treated:Post	−2,868.875	−1.277**
	(3,618.140)	(0.584)
Treated:$Trend^2$	16.033	−0.002
	(20.483)	(0.002)
Post:$Trend^2$	−0.834	−0.002
	(41.080)	(0.005)
Treated:Post:$Trend^2$	−18.544	0.009
	(82.691)	(0.013)
Constant	−1,353.955*	6.907***
	(776.804)	(0.123)
Observations	112	112
R^2	0.570	0.705
Adjusted R^2	0.536	0.683
Residual Std. Error (df = 103)	3,204.654	0.457
F Statistic (df = 8; 103)	17.050***	30.827***
Note:	*p<0.1; **p<0.05; ***p<0.01	

8 Discussion

In this chapter, we discuss our results, their implications, relevance, and validity, based on the theory of durable consumer goods and substitution, as well as our hypotheses. Based on economic theory, we expected the short-term elasticity to be high for EVs, and the long-term elasticity to be more inelastic. Moreover, we expected people to shift their consumption forward after the announcement of changes to the EV tax policy, introducing intertemporal substitution. Lastly, we expected there to be a substitution effect from higher-priced EVs towards lower-priced EVs in 2023 due to changes in the relative prices.

8.1 Implications of Results

Following standard economic theory, we would expect a decline in demand as a result of the price increase following the tax policy changes. Our regression analysis reveals that the number of first-time registered EVs in Norway decreased by 72.11 percent, on average, relative to the expected development in the absence of the policy changes. This suggests that the policy effectively reduced the demand for EVs.

Our DiD coefficient does not differentiate between short- and long-run effects. Nonetheless, if we examine the development of first-time registrations in figure 6.2, we observe that the number of first-time registered EVs surged in November and December 2022, followed by a great decrease in the first two months of 2023. Subsequently, the levels of first-time registered EVs appear to return to pre-treatment levels. These observations seem to align well with the theory on demand elasticities of durable goods, with a demand response that is highly elastic in the short-run and more inelastic long-term. It appears as if consumers deferred from purchasing new EVs right after the implementation of the policy changes, as these changes resulted in a relative increase in the price of EVs. Moreover, since the number of first-time registered EVs appeared to return to pre-treatment levels within the first eight months after the tax policy implementation, it indicates that the demand elasticity is lower in the long-run.

8.1.1 Intertemporal Substitution

The tax policy changes were announced in October 2022, three months before its implementation. Given the very high observations in November and December, this could indicate the presence of intertemporal substitution from the period after the tax policy changes to the period between their announcement and implementation. Considering the total price, encompassing taxes and fees, increased in 2023, it became relatively more expensive to purchase the same vehicle model in January 2023 compared to December 2022. From section 4.2.1, we know that the anticipation of a future price increase could lead to a shift in consumption from the future to the present.

However, for there to be intertemporal substitution in our case, it would have to be possible to shift consumption forward after the announcement in October. This requires a somewhat elastic supply, being able to respond to changes in demand. As described in section 6.3.3, the light vehicle importers in Norway and Sweden experienced delays in deliveries in 2022. Nevertheless, these problems were largely resolved at the end of 2022, enabling the registration surge at year's end. A substantial number of vehicles were in transport to Norway when the policy changes were announced. The constrained preparation capacity for new vehicles limited the possibility of accelerating deliveries to consumers, according to the vehicle importers. This means that some vehicles could have been delivered to Norway and cleared through customs but not delivered to the consumer at the end of 2022. This would make them subject to the tax burden in 2023 after the policy changes (The Norwegian Tax Administration, 2022). If consumers were under the impression that it would not be sufficient to order a vehicle in October or November, in fear of the vehicle not being delivered in time to avoid the upcoming tax increase, it weakens the argument of intertemporal substitution. Such factors make it challenging to claim that there is intertemporal substitution, but the observations remain quite prominent.

8.1.2 Substitution Across Goods

While all EVs are subject to the one-off registration tax, the partial removal of the VAT exemption only impacts EVs exceeding the price threshold of NOK 500,000. In addition, more expensive EVs are typically characterized by longer kilometers of range, with larger batteries making them heavier. Hence, the weight component in the one-off registration tax will have a greater impact on the already higher-priced EVs. In total, the tax policy changes impose a disproportional increase in the tax burden for EVs. Since lower-priced EVs become relatively cheaper, we expected consumer preferences to shift from higher- to lower-priced EVs after the tax policy changes. We assume the function of higher- and lower-priced EVs covers the same primary needs.

From figure 5.3 we observe that the number of first-time registrations for both price categories increased at the end of 2022 and fell steeply at the beginning of 2023. Studying the month-over-month growth rate for the price categories in figure 5.4, the relative changes indicate a strong decrease in January and a strong increase in February. Moreover, the growth rates move in the same direction, and only differ in magnitude, with the higher-priced EVs having a greater growth rate right after the policy change. Hence, the growth rates were negative for both price categories but the effect of the tax policy changes appears to be stronger for the higher-priced EVs. However, we are not able to determine the potential substitution effect from our DiD analysis.

In our analysis, we have only considered changes within the Norwegian EV market. Yet, there could be substitution effects across the market for new EVs and the second-hand vehicle market. While the number of first-time registered EVs decreased in 2023, the number of vehicles in the second-hand vehicle market that changed ownership remained stable in 2023, with a minor increase in the first half of 2023 (Norwegian Road Federation, 2023a). Given the price increase of new EVs relative to prices in the second-hand vehicle market, we could expect that parts of the demand response we observe is due to substitution away from the EV market. This is strengthened by a price reduction among many vehicle models in the second-hand market in 2023 (Skogstad, 2023). If substitution from the new EV market to the second-hand vehicle market is deemed to be the case, it could be an important explanatory factor for the high estimate of a 72.11 percent reduction in the number of first-time registered EVs in 2023. Such substitution is also not controlled for in the DiD model.

8.1.3 Practical Implications

The initial intention of exempting EVs from VAT and the one-off registration tax was to incentivize the purchase of EVs and contribute to increasing the zero-emission vehicle sales share. In 2022 and 2023, more than 80 percent of all new passenger vehicles were electric, meaning that more than four out of five new cars have been exempted from taxation. Moreover, the quality of EVs has improved greatly over the past decade, making EVs closer substitutes for conventional fossil-fueled vehicles. This implies that the EV subsidies were becoming general subsidies supporting the purchase of passenger vehicles. Further, the government was subsidizing EVs over other modes of transportation, including more environmentally friendly transportation such as public transportation.

The Norwegian government argues that such a system is neither economically nor environmentally sustainable (Norwegian Ministry of Finance, 2022). The government has both fiscal and political reasons behind the tax policy changes. The governmental revenue increase due to the partial removal of the VAT exemption is estimated at NOK 1.2 billion for 2023, and the introduction of the weight component in the one-off registration tax is estimated at NOK 2.36 billion. However, the latter includes all passenger vehicles and not solely EVs (Norwegian Ministry of Finance, 2022).

Though we expected a reduction in the number of first-time registered EVs after the tax policy changes, our results reveal a substantial significant decrease of 72.11 percent. However, our results do not distinguish between the short-run and long-run effects. Had this been a long-run effect of the tax policy changes, it could pose significant challenges in making road transport in Norway zero-emission.

Trying to capture the long-run effect, we conducted an additional regression without the observations in the periods two months before and two months after the tax policy changes were implemented. This is illustrated in table A.1. If the effect of the tax policy changes is temporary, and the demand for EVs returns to pre-treatment levels shortly after the implementation, the DiD coefficient in this regression is expected to be smaller and insignificant. However, it is negative and statistically significant, indicating that the number of first-time registered EVs in Norway was 54.11 percent lower in 2023. If we believe that this represents the long-run effect of the tax policy changes, it is large compared to our expectation of a temporary decrease at the beginning of 2023. Nevertheless, we only have data for the first eight months of 2023, making it challenging to accurately capture the true long-run effect.

8.2 Robustness and Limitations

From our regression, our main variable of interest *Post:Treated* is statistically significant and negative. The direction of the coefficient seems reasonable, while the magnitude is quite large. In addition, the high standard deviation suggests variability in the data points around the regression line, reducing the predictive accuracy. This is likely related to the fact that there are few observations in the treatment period. Further, it is important to acknowledge the limitations of the DiD methodology and how they affect the credibility of our estimates.

Firstly, the validity of the estimates critically depends on the parallel trend assumption being satisfied. In November 2022, Sweden changed its climate bonus system for zero- and low-emission vehicles, which increased the cost of purchasing an EV compared to before the policy change. However, the removal of the climate bonus was set into effect immediately, which removed the presence of anticipatory effects in the control group. In addition, the climate bonus system was already gradually reduced over multiple years, reducing the relative price increase caused by its removal. Yet, it is important to recognize that the effect of changes to the Swedish EV bonus system has not been tested formally, and may introduce bias to our DiD estimate.

Secondly, the credibility of our DiD estimate depends on how sensitive it is to other model specifications. In the appendices, the regression model A.2 includes a linear trend instead of the quadratic trend from our analysis. Examining this model, the DiD coefficient *Post:Treatment* is no longer statistically significant, at $-99,83$ percent. Since the statistical significance of the DiD estimate seems to be sensitive to an alternative specification of the time trend, this could weaken the reliability of the estimated model. Simultaneously, the inclusion of a time trend component poses the risk of overfitting the model. Overfitting the pre-treatment period may cause the regression coefficients to be misleading.

Furthermore, due to the possible anticipatory effects, the high observations in November and December 2022 might increase the average in the pre-treatment period, while the very low levels in January and February might make the averages in 2023 appear relatively lower than they otherwise would have been. This is given that the model does not fully control for Ashenfleter's dip. The significant negative effect we estimated might therefore be unrealistically high.

An alternative way to control for anticipatory effects is to remove the observations right before and right after the tax policy changes were implemented, as illustrated in regression table A.1. However, removing observations might not be a realistic option since vehicles are durable consumer goods. If many consumers purchase EVs at the same time, we would expect that this in itself contributes to lower sales in the subsequent period. Removing two periods before and after the implementation of the tax policy changes reduces the possible consequence of this. However, it poses new problems due to the limited number of observations in the post-treatment period, with only six months of observations. In addition, the standard deviation for this DiD coefficient is quite high. Though it could be a way of estimating the long-term effect of the policy changes on the number of first-time registered EVs, as discussed in section 8.1.2, these issues reduce the credibility of the long-run estimate.

We do not consider possible changes in listed prices in our analysis. If the listed prices are changed in the post-treatment period, it could potentially explain parts of the decrease we observed or the development in the two price categories. Possible price changes that would impact our analysis are particularly those that could have happened simultaneously as the treatment or in the treatment period. We are aware that the listed prices were reduced for some vehicle models in the first half of 2023 (Hafsaas, 2023). The DiD model does not account for the effects of such changes to the listed prices in the treatment period. Our results rely on the assumption that the only factor that impacts prices is the tax policy changes.

9 Conclusion

In this thesis, we have analyzed the effect of tax policy changes on the number of first-time registered EVs in Norway. This is particularly interesting in Norway since the policy changes are implemented in a context where EVs are the norm rather than the exception.

The tax policy changes of interest are the partial removal of the VAT exemption for EVs priced above NOK 500,000, and the introduction of the weight component to the one-off registration tax. To answer our research question, we have used a DiD approach with the inclusion of a time trend. From our results, we have that the number of first-time registered EVs was reduced by 72.11 percent, on average, in Norway after the implementation of tax policy changes in January 2023. Though the reduction is significant, considering the number of first-time registered EVs in 2023, our data suggests the presence of a strong short-run effect with greater fluctuations around the implementation, before the effect is reduced long-term.

The direction and significance of our DiD estimator align with standard economic theory, with higher prices leading to lower demand. However, in our data, we observed that the number of first-time registrations increased substantially directly before the tax policy changes were implemented and declined steeply directly after. This could imply the presence of intertemporal substitution as an elastic short-run response in demand to the price increase. Based on the observed development, the levels of consumption returned to pre-treatment levels shortly after the steep decline at the beginning of 2023. However, the long-run effect appears to be more prominent than first expected, though the demand response is more inelastic in the long-run. Moreover, we anticipated substitution from higher-priced to lower-priced EVs. However, our analysis does not provide a conclusive substitution effect across price categories.

The EV subsidies are considered important drivers for making Norway a global frontrunner in electric road transport and reducing emissions by shifting demand. Since 2013, the EV market has experienced rapid growth, and EVs account for 83 percent of new car sales, and 20 percent of the total vehicle fleet in 2023. A potential risk of reducing these subsidies is the relative price increase on EVs could reduce the demand, and shift consumer demand to other markets and more polluting alternatives. Given the government's high ambitions, this seems counter-intuitive. However, as long as the tax policy changes do not shift consumers' preferences towards fossil vehicles, the effects of the policy changes might still align with the government's main objective of all new passenger vehicles being zero-emission by 2025. This is supported by a stable EV sales share in Norway in 2023 compared to 2022, though the growth has been lower than in previous years, which is natural given the already high EV sales share. The Norwegian government has justified the policy changes with fiscal arguments. Since more than four out of five first-time registered cars are EVs, the exemptions are increasingly becoming general subsidies for vehicle purchases. This indicated that it was time to reduce EV subsidies, even though it reduced the number of first-time registered EVs in 2023.

The aim of our thesis is to shed light on the impact of the policies on the Norwegian EV market, and not to express an opinion on whether the policy changes should have been implemented or not. Further research could analyze whether the observed effect is sustained in the long-run, or if the registration levels return to the levels seen before 2023. In addition, it would be interesting to examine whether there was a shift in demand towards fossil fuels from EVs, or a shift of consumer preferences towards other markets, such as the second-hand vehicle market.

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Appendices

A Additional Regression Tables

Table A.1: Regression with Removed Observations

	Dependent variable:
	log(Count)
Treated	0.980***
	(0.146)
Post	0.559**
	(0.272)
Trend	0.034***
	(0.004)
Trend^2	0.003
	(0.002)
Treated:Post	−0.779**
	(0.386)
Treated:Trend^2	−0.002
	(0.002)
Post:Trend^2	−0.009*
	(0.006)
$\text{Treated:Post:Trend}^2$	−0.003
	(0.009)
Constant	6.975***
	(0.125)
Observations	104
R^2	0.735
Adjusted R^2	0.712
Residual Std. Error	0.421 (df = 95)
F Statistic	32.874*** (df = 8; 95)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table A.2: Regression with Linear Time Trend

	Dependent variable:
	log(Total_count)
Treated	1.557***
	(0.166)
Post	−1.505
	(2.522)
Trend	0.052***
	(0.004)
Treated:Post	−6.379
	(7.007)
Treated:Trend	−0.028***
	(0.006)
Post:Trend	0.020
	(0.048)
Treated:Post:Trend	0.117
	(0.131)
Constant	6.710***
	(0.117)
Observations	112
R^2	0.742
Adjusted R^2	0.724
Residual Std. Error	0.426 (df = 104)
F Statistic	42.662*** (df = 7; 104)
Note:	*p<0.1; **p<0.05; ***p<0.01

B Smoothed Time Series Data

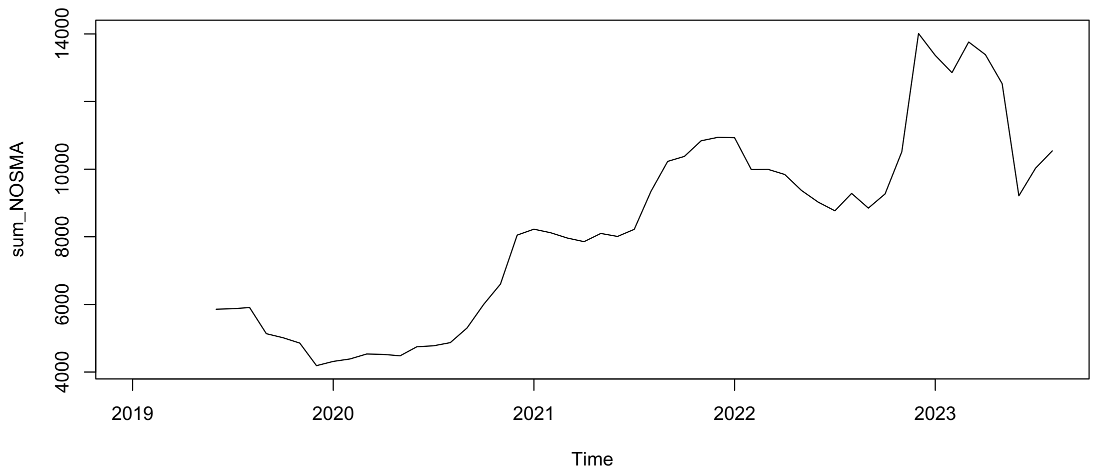

Figure B.1: Norway: Simple moving average of order 6

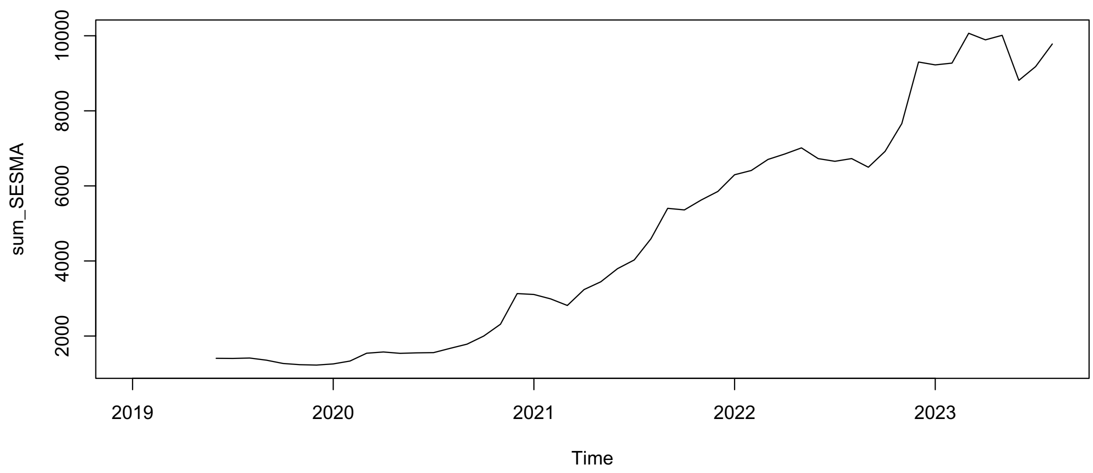

Figure B.2: Sweden: Simple moving average of order 6