Linnéuniversitetet
Kalmar Växjö

BACHELOR THESIS

BONUS-MALUS SYSTEM IMPACT ON THE DEMAND FOR ECO-FRIENDLY VEHICLES

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Subject: Economics
Level: Bachelor
Course code: 2NA11E/2NA12
Term: Spring 2022

ABSTRACT

Global warming issues are a widespread problem around the world and the emissions of greenhouse gases is one of the main contributors. The transport sector emits a significant amount of greenhouse gas emissions; thus, this contributes to global warming. To tackle this challenge the Swedish state introduced in July 2018 a system called bonus-malus system which aims to increase the proportion of eco-friendly cars and in the long run reducing greenhouse gases emissions from the transport sector. This paper examines the tax system within the Bonus-Malus system. Primarily investigating if Malus, tax system, impacted the demand for electric vehicles since it introduced. The study conducted based on a short panel data from Sweden´s 21 counties for the period 2016-2020 and the analysis method applied is a regression analysis. The results of this thesis confirm a strong positive relationship between the share of newly registered battery electric vehicles (BEV) and the Malus, but much weaker influence of the other studied variables. Suggesting that tax system induce on emission seem to be efficient at boost the demand for BEV.

Keywords

Bonus-malus-system, malus, taxes, eco-friendly vehicles, electric car, BEV, Average income, carbon dioxide emissions, gasoline prices.

List of abbreviations

EV	Electric vehicle
HEV	Hybrid vehicle
PHEV	Plug-in hybrid electric vehicles
FFV	Flexi fuel vehicle
ICEV	Internal combustion engine vehicles
BEV	Battery Electric Vehicle

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1 INTRODUCTION

Our planet's well-being is in a critical state where one of the climate's biggest challenges is the greenhouse effect. Many of the greenhouse gases emitted are originating within the transportation sector. Figures from the Swedish Environmental Protection Agency (naturvadsverket, 2020) show that emissions of greenhouse gases from transportation account for one third of Sweden's total emissions. While the transportation sector around the world accounts for 23 percent of the world´s energy-related greenhouse gas emissions (Ma et al., 2019). Thus, it is important that these emissions that are polluting our air are reduced as much as possible at the lowest cost to society. One way to do this is to encourage society to acquire eco-friendly vehicles, such as Electric vehicles (EVs) or Plug-in hybrid electric vehicles (PHEV) which are substitute goods to cars that run on conventional fuel. Many governments around the world subsidies electric vehicles to encourage people to use more EVs which are environmentally friendly compared to traditional internal combustion engine vehicles (ICEV). These subsidies are designed to support the governments' goals of electrifying the transportation sector to reduce their national greenhouse gas emissions (Olson, 2015). Since 2012, the Swedish government has provided many high subsidies for the private purchase of electric cars including tax exemptions. According to elbilsstatistik.se (2022), there are total of 341 756 registered EVs in Sweden.

In Sweden most of the greenhouse gas (GHG) emissions from transport sector come from road traffic where emissions from cars dominate. During Covid 19 pandemic, emission from passenger cars have decreased by ten percent and amounted to 9.4 million tons. The reduction is mainly due to declining car traffics during pandemic where the whole society were in partial lockdown (Naturvårdverket, 2021). Although, in recent years, Swedish consumers have shown interest in sustainability, which is a sign that the Swedish society have become more environmentally conscious (Svenskhandel.se, 2018). However, since human activities contribute to climate change and global warming, there is a need to better understand what factors that influence individual's willingness to change environmentally damaging behaviors, such as using fossil fuel cars, to less harmful ones.

The Swedish government have established and adopted climate and energy targets, which enable emission reduction as well upgrade the energy efficiency in the country. In non-trading sectors, greenhouse gas emissions had contracted by 30 percent in 2016 relative to

1990 period. To reach the climate targets, the government took an active approach and introduced the Bonus-Malus system in its budget bill for 2018, along with industrial Leap reform, to support the development of climate smart solutions and accelerate the transition to green and sustainable energy. The Bonus-malus system is a system that mainly applies to passenger cars, but also for light trucks and buses (Sweden's National Reform Programma, 2018). The policy is divided to two parts, the first part is the bonus, which states that newly purchased vehicles from July the first 2018, is entitled for government subvention, or subject to higher vehicle taxes, which reflect the malus part (Transportstyrelsen, 2022).

The incentives mechanism is solely dependent on the vehicle's emission of carbon dioxide and vehicle year, mainly the vehicle model. Purchased vehicles before 2020 and have a maximum of 60 grams carbon dioxide emission per kilometer, or vehicles that taken into service from 2020 and has maximum dioxide emission of 70 grams per kilometer is eligible for bonuses. However, for Vehicles that that emit more than 95 grams of carbon dioxide per kilometer is subject to Malus, a monetary penalty in form of raised vehicle tax, for cars that taken into service after June 2018, and is into effect during the first three years. The standard vehicle tax is 360 SEK per year for all vehicles that lays within Malus requirements. (Transportstyrelsen, 2021). Then there are further taxes/fees included to the standard tax, based on the fuel used in the vehicle. For instance, gasoline vehicles that emit a minimum of 95 grams of carbon dioxide per kilometer and a maximum of 140 grams, are exposed to addition 82 SEK per gram. Meanwhile, vehicles that emit above 140 grams of carbon dioxide per kilometer, are charged additional cost of 107 per gram. Alternatively, diesel driven vehicles have two more fees included, an environmental supplement and fuel supplement. The former consists of a cost of 250 SEK per year, while the latter comprise of a 13,5 SEK per gram of carbon dioxide that emitted (Bilbolaget, 2022).

In this research paper, our objective is to assess the policy incentives by the Swedish government the so-called Bonus Malus system, essentially investigating how the monetary penalty of the malus part impacted the demand for EVs across regions, where demand is defined as the share of newly registered BEV. Also, we decided to omit the analysis of the bonus part, mainly due to time constraint as well as data limitation. The study will concentrate on passenger cars class 1, such as cars, SUV, vans, and pickups, while excluding class 2, which mostly incorporate light trucks. We are fully aware that evaluating one segment over the other of the policy may not be optimal and there is a high feasibility that the other segment, the bonus part has impacted the demand for EVs. Considering how the opportunity cost for EVs are reduced due to subsidies up to 60 000 SEK, relative to gasoline and diesel driven vehicles. Pay a close attention to terms such as EVs and BEVs are used interchangeably in the study, to a prevent and intercept any confusion.

The rest of this article is structured in 7 sections. In section 2 will present a review of previous research about EVs. In section 3 will be presented the economic theories related to the research question and explanation on relationship between government incentive and the demand for EVs are reviewed. A summary of the collected data can be found in section 4. The methodology and the empirical model used in this essay are presented in section 5. Results are presented in section 6 and then further discussed in section 7. This paper finishes with some conclusion in section 8.

2 LITERATURE REVIEW

Many examinations have been led to analyze the effect of policy instruments for the reason to advance the adaptation of eco-friendly vehicles. A study by Trosvik and Egnér (2017) analyzes the effect that local policy instruments have on battery-powered electric vehicles (BEV). The instruments discussed includes the important of charging infrastructure. The statistical method applied in the study is regression analysis, where the proportion of newly registered battery-powered vehicles is a dependent variable and described it by using several variables. The results show that increased charging stations, which are a political instrument, are an effective tool for enticing people to buy more battery-powered vehicles. In this thesis, like Trosvik and Egnér (2017), newly registered electric cars are used as a dependent variable to be able to answer the research question.

In terms of political instruments, there is also a study of the Swedish bonus-malus system, published by the Swedish *National Institute of Economic Research* (Konjunkturinstitutet, 2019). The main purpose of the study was to analyze the reform and its effect. what has been discussed in the study is the pros and cons of the state reform and suggested that the system should be revised if it is to be maintained. This is because according to their conclusion that the reform does not contribute cost-effectively to the goal of reducing greenhouse gases (GHG). The study has also discussed the undesirable distributional effects that the system may have caused. It has been noted that low-income earners generally do not buy new eco-friendly cars to the same extent as those with a higher income. What the Swedish *National Institute of Economic Research* means is that the direct distributional effect can be counterproductive, as the bonus ends up with high-income earners. The high-income earners are the ones who buy most electric cars, and with their highly income, it can be stated that some of them had bought a new car even without receiving a bonus. The important point that we can take from the study by the Swedish *National Institute of Economic Research* is that it is referred that the bonus-malus system that was introduced in France in 2008 has contributed to an increased proportion of electric cars.

Diamond (2009) analyze the impact of government incentives policies on hybrid-electric vehicles (HEVs) adaptation rate, by using cross sectional data. He's main discovery suggest a strong relationship between gasoline prices and HEVs adaptation rate. Also, (Beresteanu and Li 2011) displayed similar results, indicating that gasoline price to be the main driver of the HEV adaption. As Scott Hardman reported in his study (2018) several other studies have shown that there is a significant relationship between the price of gasoline and the demand for electric cars. Four of these studies have focused on the USA (Javid and Nejat, 2017, Adepetu et al., 2016, Narassimhan and Johnson, 2018, Wee et al., 2018), one study focused on the Netherlands (Kangur et al., 2017) and another investigated both the USA and Europe (Plötz et al., 2016). Most of the studies found that higher prices are significantly related to BEVs and PEV market share. Suggesting that if policymakers did increase gasoline prices the impact on PEV sales could be positive. Adepetu et al. (2016) did not find evidence to suggest that gas prices were effective in promoting PEV sales in the U.S., though most research does indicate that increasing petroleum prices will lead to more consumers adopting BEVs and PHEVs.

Shiyu Yan (2018) examined the role of incentives to reduce the total cost of ownership of battery-powered electric vehicles (BEV), increase sales of BEV and reap the environmental benefits of switching to BEV, the author conducted cost-benefit analyzes and standard least squares regressions. The author studied 10 pairs of BEVs and their combustion engine cars (ICEV) counterparts in 28 European countries from 2012 to 2014. One of his finds was 10 percent increase of total tax incentive leads to an increase in the sales share of BEV by around 3 percent on average.

Previous studies also shows that Environmental beliefs and Awareness of environmental problems has a direct effect on the intention to buy EV. According to a study from Japan by Okada et al. (2019) there is a relationship between individuals' awareness and purchase intentions of EVs. The authors utilized an online survey in Japan and construct two models, those models are based on Structural equation model. Where the authors strive to make a comparison between the estimates derived from purchase intention of non-EV user and post purchase satisfaction of EV users. In model one authors observed positive pass from environmental awareness to the evaluation of EVs. The first model exhibited environmental awareness has direct effect on purchase intention. In model two though author found that post-purchase satisfaction was not directly explained by environmental awareness. The study from Sweden by Westin et al. (2018) also displays that personal norm is attitudinal factor with the strongest explanatory power. Personal norm can influence behavior when activated, activations can come when humans become aware of the consequences of their behavior (Westin et al., 2018).

Electric cars are expensive cars compared to conventional cars such as gasoline-powered vehicles. This makes it interesting for researchers to examine the importance of income level for electric car adoption. Previous research shown that the ownership of electric car is strongly correlated with income. Borenstein and Davis (2016) studied how the American electric car adoption differ between individual´s income level. They used data from U.S. income tax return which shows that the top income quintile has received 90% of all electric vehicle tax credit. Lucas W.Davis (2018) studied the relationship between the adoption of electric cars and the income differences between American households. In his study the author had two groups to compare between, homeowners and renters. The data that the author used shows that homeowners have significantly more electric cars then renters. To determine exactly how big a home ownership plays a role when it comes to adopting electric cars, run the author a regression. First, he estimates the probability that a household has an electric vehicle without any controls, such controlling the annual income differences between households. The results show that homeowners are three times more likely than renters to own an electric car. Secondly, the author tests whether this adoption gab between homeowners and renters can be explained by income. When controlling flexibly for income the estimate shrinks but remain statistically significant. this indicates that income is a predictor for an individual adoption of electric vehicle.

There are other factors that may contribute to people use less or more on electric cars. According to Giansoldati et al. (2020) Italy has a very low level of uptake of electric vehicles compare to other European countries, despite significant efforts put in place by policy makers to stimulate the use of electric vehicles. The result from the survey in their study shows that there are several barriers that deter prospective customers. The tree barriers that respondents perceived the most were the difficulty using an electric car due to the lack of charging stations along highways, the insufficient density of charging stations and the purchase price (Giansoldati et al., 2020).

In summary, many studies discussed what factors determine the adoption of electric vehicles. But the importance of policymakers' interventions on this market and how they affect the demand for EVs is also important to investigate. The expensiveness of electric cars is one of the main reasons why many didn´t decide to use EVs (Vilchez at el., 2019) and the main reason for subsidies is to attract the public to drive environmentally friendly cars. On the other hand, politicians and policy makers use taxes to eliminate fossil fuel vehicles. The goal for this is to investigate if, and by how much, the demand for EVs is affected by government incentives such as gasoline vehicle taxes. Therefore, this study is a contribution to whether government incentives, in this case Bonus-Malus system, do have big impact on the BEV market or not.

3 THEORETICAL FRAMEWORK

To establish the implication of Bonus-Malus system on the demand on EV, the analysis of this study is centered and influenced by previous research paper. Theories related to budget constrain and utility function, will aid to model consumers preferences and choices between ICEVs and BEV. Various studies share the similar results about the importance and it significance of income in relation to BEV share development (Mersky et al. 2016).

In general, the behavior of consumers is based on utility maximization, seeking the maximum utility for given budget constraint, or achieve as much satisfaction as possible from the consumption of the goods (Lundmark, 2020). It is a general utility function developed by Berry, Levinsohn & Pakes (1995) but which was then used by the study by Trosvik & Egnér (2017). The specification of the utility function permit some of the utility determinant to vary across time, therefore excluding for instance the time factor, which simplify the utility function as

$$U_{c,v} = f(\theta_v , P_v , T_v , B_c) + \varepsilon_{c,v} \quad (1)$$

The utility choice set of the consumer is restricted between BEV and ICEVs. A consumer chooses and purchase one vehicle from the choice set and an outside alternative each year. The outside alternative is when the consumer decides not to purchase a vehicle in same period. The notation (c) reflect consumer, while (v) indicate vehicle (BEV, ICEV). Consumer utility for purchasing vehicle v in each period, is a function of national policy instrument θ_v, the bonus part related to vehicle v. Other component of the function is price of vehicleP_v, T_v is the monetary penalty implemented on vehicle v due to the Malus part, which comes in a form of tax. B_c Consist of consumer c preferences, mostly represent environmental consciousness. While $\varepsilon_{c,v}$ is the error term and present the features that are not included in the model, such as vehicles features, consumer socio-economic characteristics or fuel prices.

$$U_{c,BEV} \geq U_{c,ICEV} \quad (2)$$

The expression above suggest is that consumer c will purchase a BEV if and only if the utility gained from BEV exceed the utility gained from ICEV. The construction of the demand function is reliant of acquiring a clear and defined utility function. The aggraded demand function for vehicle v for given population is defined as

$$AD_v = \{c : U_{cv} \geq U_{cr}\}, \ \ for\ r = 0, BEV, \ \ ICEV; r \neq v \quad (3)$$

What the expression denotes is that AD_v is the sum of consumers that have utilities because of procuring vehicle v, r stands for vehicles alternatives, while when r is equivalents to zero, it reflects that the alternative for not buying any form of vehicles. Subsequently, the market share of M_v for given vehicle and population is described as

$$M_v = f(\varpi_c , P_v , T_v , \theta_v) + \varepsilon_v \quad (4)$$

Function above suggest that the market share is a function of policy instrument, vehicle price, taxes, and the overall average of consumer preference ϖ_v. It is assumed that the regions are representative of the population and that it is in demand. The vehicle type is electric cars (BEV). It is assumed that the price of vehicles does not vary between the different regions, and we limit ourselves in this essay to focus only on the malus part and not the bonus part, thus price, P_v, and the political incentive in the form of bonus connected to vehicle v, θ_v, will excluded from the model. It has further assumed that the regional determining factors in the share of electric cars are constant for one year, but can vary within regions between the different years, where annually time index, t, added. The share of electric cars for a certain region, r, for year t can thus be defined according to:

$$BEV_{r,t} = f(\varpi_c, T_v) + \varepsilon_{BEV,r,t} \quad (5)$$

The economic theory of consumer is quite simple. It assumes that consumer choose the best bundle of goods they can afford. Individuals consume all sort of things, yet the there is a limit to the amount of goods it could be acquired, for simplicity purpose consumers have to choose between two goods, this will help to display consumer preferences graphically, since two goods is easier to illustrate. For example, to measure the consumer demand for milk per, good 1 is denoted x_1 , it represents milk consumption in month by the consumer, while donating x_2 as everything the consumer might wish to consume, or for conveniency we assume good 2 is a composite good and defined as dollars that the consumer can use to spend on other goods. Under this interpretation the price of good 2 will automatically be 1. Thus, the budget constraint will take the form

$$p_1 x_1 + x_2 \leq m \qquad \text{OR} \qquad p_1 x_1 + p_2 x_2 \leq m \quad (6)$$

The expression simply that $p_1 x_1$ is equal to the amount of money the consumer is spending on good 1. On the other hand, $p_2 x_2$ is equal to the amount of money the consumer is spending on good 2. However, the spending for both goods should not exceed the income m. The expression above is then used to construct the budget line in figure 1. The figure shows a combination of good 1 and good 2 that equal m. A fluctuation in income influence consumer spending habits, which results to changes in sets of goods that the consumer can afford. For example, figure 2 illustrate how an increase in income will most likely result in a parallel shift outward of the budget line and reflecting a positive change in consumer purchasing power, and vice versa if the income decrease (Varian 2010).

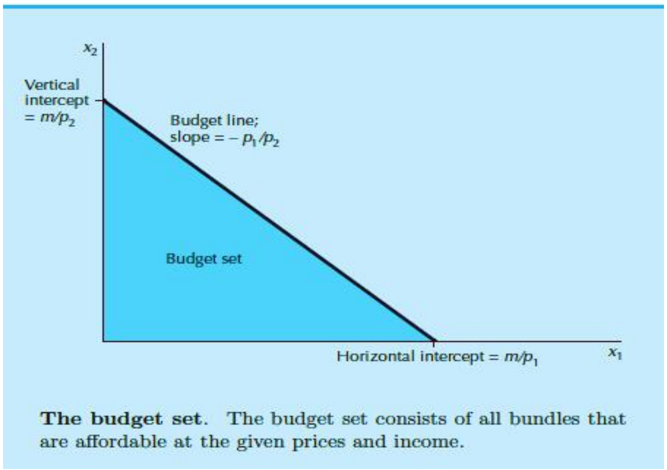

Figure 1: *Straight linear budget constraint (Varian, 2010).*

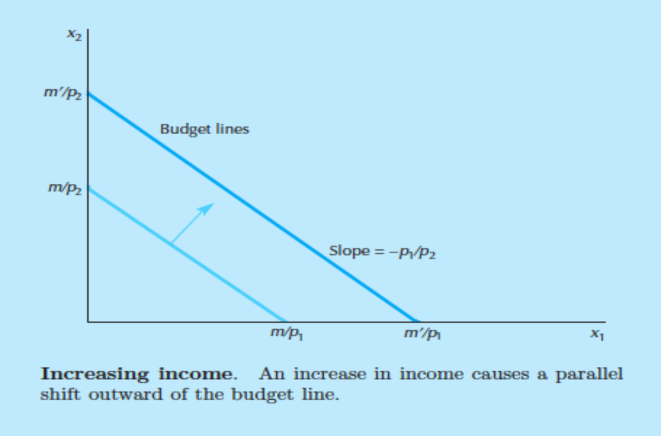

Figure 2: *Straight linear budget constraint, where increasing income causes a parallel shift outward of the budget line (Varian 2010).*

Privately owned vehicles produce generally many negative externalities, especially in relation to environment, taxation can attain a reduction in these negative externalities and provide a rationale for government intervention. In term of taxes, imposing a tax which directly or indirectly related to emission is plausible, to reach the EU emission targets for new cars (Hennessy and Tol, 2011). Vehicle- related taxes are generally divided into different sections, from taxes on car acquisition, ownership, energy consumption and road infrastructure. New vehicle buyers are obligated to pay VAT but also a registration tax. For ownership, it reflects the vehicle tax, where the owner bounden to pay an annual fee depending on the vehicle features. Furthermore, vehicle owners are taxed for the consumption of energy, partially for refueling and recharging, at the same time pay for utilizing the road infrastructure via road charges. A sufficient way to make BEVs and PHEVs significantly less costly relative to

ICEVs is to implement a system that make private buyers eligible to differentiated tax breaks for BEV and PHEV, and combinate that with an increase in taxes for conventional gasoline and diesel cars, such as Norway did (Wappelhorst, Mock, and Yang. 2018). Carbon tax is expected to contract both fuel consumption and CO_2 emission significantly, also increase the share of fuel-efficient cars among the new purchases (Givord, Grislain-Letrémy, and Naegele 2018). Equally, the output of the economy is subject to decrease if carbon tax is implemented, however the tax revenue collected will boost (Chua and Nakano 2013). Implying different tax schemes on different product and services lean on the fact that those goods and service externalities and its implication on the welfare of the society. Activities subject to taxation is associated with behavior adjustment due to individuals' factor in the tax payment costs. For example, consumption taxes on alcohol and fossil fuels lead to less consumption of those goods, than they would have otherwise do without the tax in place. Briefly, a reduction in demand occur due to higher cost linked to those goods (FutureLearn 2015).

Fluctuations in fuel price clearly influence the probability that consumer shift to more fuel efficient, also inspire the innovation of new energy efficiency technologies by the industry (Diamond, 2009). Electrics cars is more attractive due to low fuel cost relative to fuel-driven cars. In the current gas price volatility due to Russian invasion in Ukraine, EV is now three to six times less costly in operation cost than their counterpart, as it attracts the more consumer attention (Lambert 2022). Consumer sentiment toward EV appear to surge during high gas price periods, as many consumers expect to own an EV in the next 5 years. High gas prices have clearly pushed consumer to consider fuel efficient alternative that otherwise would not have sooner (Popli 2022). A nation environmentalism is a good predictor of the demand for green products and advocate for the interest of the environment (Wang and Xu, 2016).

4 DATA

To investigate the possible effect the malus had on the share of newly registered electric vehicles in Sweden of total number of newly registered passenger cars between the years 2016–2020, relevant dataset was used. The dataset was collected from relevant sources such as from websites and reliable databases. We faced limited data access during this investigation for the purpose of the thesis, thus a limited scope of observation was determined for this study. Therefore, the dataset was collected for each of determined variables in this study. Besides malus which is the main and the explanatory variable that investigates in this thesis, several other control variables have been considered. The variables used for regression model are influenced by previous studies, such as the adoption of electric vehicles, as these variables has been shown to influence the demand for EVs. The variables that will be used in the model are the share BEV per year, Malus, income, or average yearly income for age group 30-59 years old, green party voters and lastly fuel prices.

4.1 DATA DECISIONS

We have collected a dataset consisting of panel data on regional level in Sweden between years 2016 to 2020. Because the Swedish “bonus-malus” system was implemented in July 2018 which aims to new vehicles that are registered in road traffic register sometime from 1 July 2018, and because the current data is calculated annually and not monthly, the transition year (2018) was excluded in the regression to achieve a more equitable result. Thus, we used data from the pre-intervention years 2016-2017 and post-intervention years 2019-2020. During the collection of our data, we made some different data decision. In this section we present the background of data decisions for the variables in this study.

Share of BEV is our dependent variable that consist of the share of newly registered electric car per region of total number of newly registered passenger cars per year, between the years 2016-2017 and 2019-2020. The dependent variable consists therefore a percentile market share of electric cars in Sweden each year during 2016-2020. The data for this variable was collected and then calculated through Transport Analysis (2022) databases. Transport Analysis is a government charged agency and according to SCB (2021) from January 2021 statistical news for new vehicle registrations in Sweden will be published on the Traffic

Analysis website. The total number of observations are the number of regions, 21, multiplied with numbers of study years, 4, which are 84 observations.

The variable *Malus* is an explanatory variable, and this is a dummy variable that shows data annually. The variable assumes the value 1 for the following years after the introduction of the bonus-malus system, 2019 and 2020. For the remaining years, 2016- 2017, the variable assumes the value 0. This helps us to see if malus had an impact on the demand for electric vehicles after introduction of bonus-malus system.

The variable *Average yearly Income* constitutes the average annual income per county for the age group 30 – 59. The reason we choose this age group is that only one age group could be chosen in this data system that we have available, and 30-59 years best represented the combined average. An individual's income affects its ability to consume and thus the choice of car. Electric cars are usually relatively expensive in relation to alternative cars (konjunkturinstitutet, 2019), regions with higher average incomes are expected to have a higher number newly registered electric cars in relation to the regions with a lower average income. The data was collected from the Swedish statistics agency (SCB, 2022) which is responsible for official statics and other government statics in Sweden.

The variable *Green Party Votes* represents the proportion of votes in the county council election that goes to the *Miljöpartiet* for each individual county council, where the election results for the 2014 and 2018 elections are used for all years. 2016 and 2017 we used election results from 2014 and the remaining years, 2019-2020, election results from 2018 have been used. This variable was included to see if there is positive correlation between the proportion of green votes and the share of newly registered electric cars per region. It is important to point out that can be misleading, as individuals do not necessarily need to vote for the *Miljöpartiet* to be environmentally conscious or to buy an electric car. This data was also collected from SCB.

Variable *Fuel Price* represents the average yearly sales price of gasoline per liter at a pump at a manned petrol station each year 2016-2020 in Sweden. The used data are sales prices for gasoline, so tax and VAT are included. The data for gasoline prices per liter at municipality or regional level over the years is missing. We take into consideration that fuel prices countrywide may vary over time, but not much across regions. Thus, in this thesis we used data for average yearly gasoline prices per liter in national level for all 21 Swedish counties. More than 60 percent of the gasoline price contains tax, which applies to the whole of Sweden. The rest of the price contains the sellers' purchase price, which is the same for the whole of Sweden, as the price of petrol is mostly impacted by the world market price. But the gas stations also add a few Swedish öre or a couple of Swedish crowns to the price, which does not differ much between different regions (SvD Näringsliv, 2019). This variable was included to see if there is positive correlation between the possible price changes on gasoline over the years and share of newly registered electric cars per region. The data för this variable was collected from the Swedish petroleum & Biofuels institute (SPBI, 2022).

Figure 3 illustrate how the passenger cars show different trends depending on the fuel type. Gasoline driven cars seem to show an overall negative pattern from 2012 up to 2021. Conversely, diesel vehicles appear to have a polar trend movement relative to gasoline vehicles, yet it reveals a shift of the momentum from 2020 and forward. The EV share in use of the total seems insignificant in terms of magnitude, but the volume appears to grow exponentially. Meanwhile, figure 4 is only the EV passenger cars in use, the trend of this vehicle class shows a positive trend, specifically the volume skyrocketed from 2016 and forward.

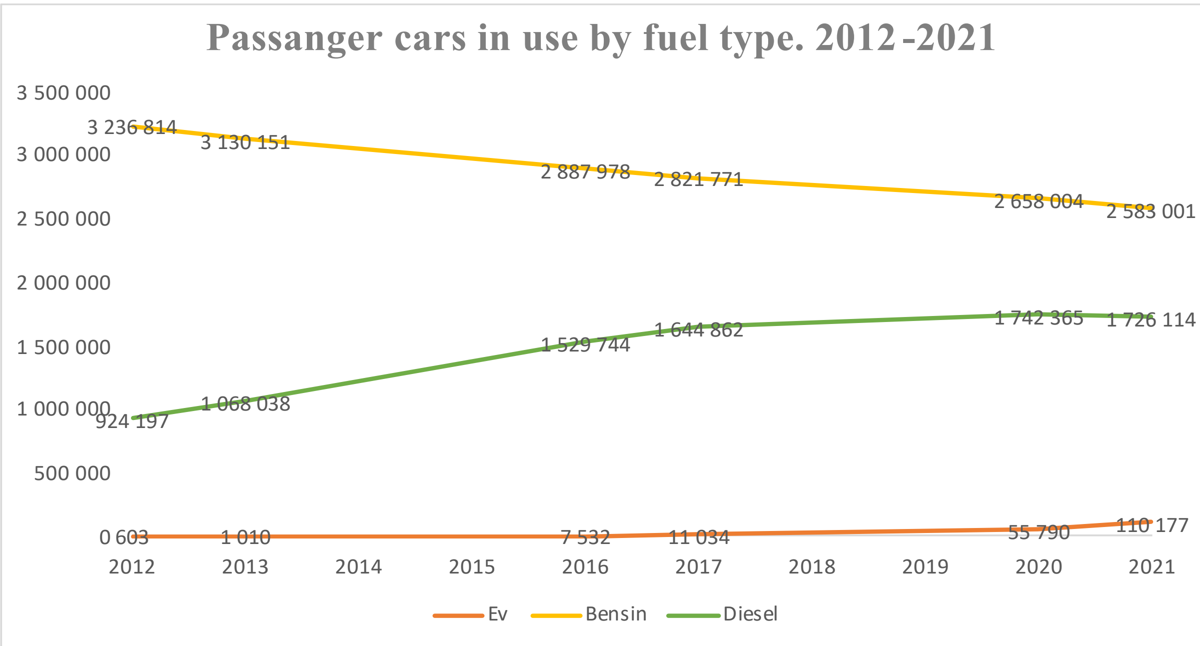

Figure 3: *Graphic representation of the average number of newly registered electric vehicles, gasoline vehicles and diesel vehicles per year between 2012-2021.*

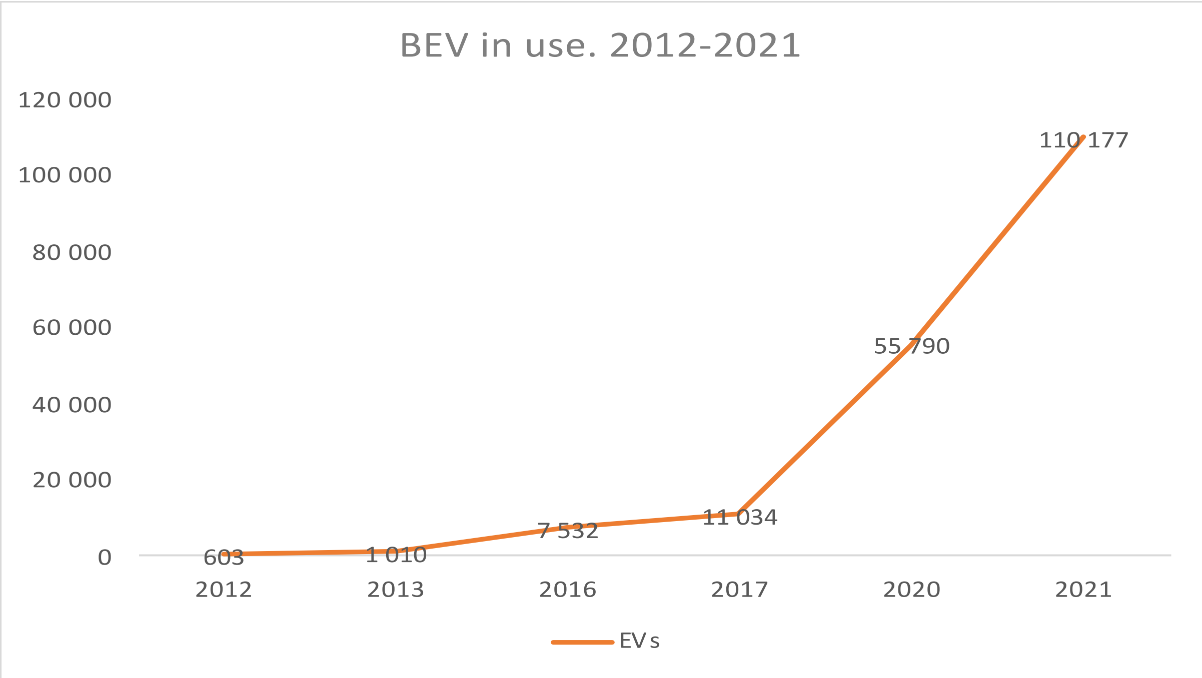

Figure 4: *Graphic representation of the average number of newly registered electric vehicles between years 2012-2021.*

4.2 LIMITATION

Variables that are desired to be included are differences in charging infrastructure in the different regions. Previous research has shown that the variable is of great importance in attracting people to buy more rechargeable cars. Public procurement of electric cars per municipality or region is a variable of interest. These variables are excluded due to data are missing for the years examined in the report. Despite its omission, these are factors that should have been investigated because they most likely affect the proportion of newly registered electric cars per region.

5 METHODOLOGICAL APPROACH

This study is based on panel dataset and the structure of this dataset has various advantages over cross-sectional data, such as capturing time variation as well as the cross-sectional variation. Nevertheless, it enables us to control for unobserved cross-sectional heterogeneity (Baltagi, 2005). Notice that there are cases where specific variables vary across regions and time, which may affect the demand for Evs. In addition, national policy instruments are applicable countrywide and do not present variation across regions, yet the reaction to the policy may differ depending on time and region-specific characteristics (Egner and Trosvik).

There are two standard approaches when analyzing panel data, the first one is the fixed effect model (FE) and the second one is the random effects model (RE). The Random effect model generally produce more efficient estimate through the generalized least square (GLS) method, relative to the fixed effects, using ordinary least square method (OLS). However, those estimates may be biased, specifically if the assumption regarding the error term and associated with the random effect model does not hold. Hence, there is a trade-off between fixed effect and random effect model in terms of pursuing either efficient or biased estimates. The main point to consider when deciding between the two models depends on whether there is a correlation between the unobserved individual characterizes α_r and the predictor variables (Dougherty, 2007). To determine which approach is more appropriate to apply, a test called Hausman-test is needed, the test evaluate the consistency of the estimators. The null hypothesis expresses no correlation between the error term α_r and the predictor variables. Yet, when correlation arise between the error term and the predictor variables, a statistically significant difference is interpreted as evidence against the RE model. Alternatively showing that FE estimators provide more consistency relative to RE. In this case, the Hausman test indicates that FE is the preferred model (Egnér and Trosvik 2018). The empirical approach chosen is based primarily on the structure of the panel data, also we acknowledge that a linear regression analysis will prove to be favorable to evaluate the impact of the Malus instrument on the BEV share, therefore baseline model is defined as:

$$Y_{S,t} = \beta\, x_{r,t} + u_{r,t} \qquad r = 1, \ldots., N; t = 1, \ldots, T \qquad (7)$$

$$u_{r,t} = \alpha_r + v_{r,t}$$

Where $Y_{r,t}$ is the dependent variable BEV share for region s at time t, reflecting share of newly registered vehicles in Sweden regions between 2016-2017 and 2019-2020. $x_{r,t}$ is vector of predictor variables that varies across time and regions, while β I. is vector of parameters in question. The advantages of panel data are that enable to divide the error term to two segments, α_r represent the non-observable effect that varies for each region, but not across time, on the other hand $v_{r,t}$ represent unsystematic error. The idiosyncratic error is assumed to be normally distributed, if not the data could be examined for normality test, such as Jarque-Bera, where the null hypothesis states that the data follow a normal distribution pattern (Logström and Mossberg). This could be also verified through a graphic representation of residuals, which in figure 5:1 displayed a normal distribution of the residuals. Therefore, we cease to convert the data to natural logarithm.

The model below emerges as we include the constructed variables from the dataset into the base model. This model will be the new model when estimating the regression for the full sample.

$$ShareBEV_{r,t} = \beta_0 + \beta_1 Malus_{r,t} + \beta_2 AverageyearlyIncome_{r,t} + \beta_3 GreenPartyVotes_{r,t} + \beta_4 Fuelprice_{r,t} + \varepsilon_{r,t} \quad (8)$$

Where the dependent variable is the share of newly registered electric car per region of total number of newly registered passenger cars per year, between the years 2016-2017 and 2019-2020. In the regression, control variables are included to obtain a consistent analysis of the bonus-malus reform´s possible causal effect on the proportion of newly registered electric cars (Stock &Watson, 2020). Regression analysis with control variables helps us to check for other variables that can have a significant effect on the result of an experiment.
If only variables of interest, Malus, were included, it would have been difficult to establish that a possible change in the proportion of newly registered electric cars would be a consequence of Malus (Voxco, 2021).

6 RESULTS

Table 1 : Regression for fixed effect model on ShareBEV

VARIABLES	(1) Model 1	(2) Model 2	(3) Model 3	(4) Model 4
Malus	0.042***	0.039***	0.039***	0.052***
	(0.002)	(0.003)	(0.003)	(0.003)
AverageyearlyIncome		0.000095*	0.000096*	0.000096**
		(0.000)	(0.000)	(0.000)
GreenPartyVotes			-0.017	-0.017
			(0.025)	(0.021)
Fuelprice				-0.010***
				(0.002)
Constant	0.009***	-0.028	-0.022	0.114***
	(0.001)	(0.019)	(0.022)	(0.026)
Observations	84	84	84	84
R-squared	0.776	0.788	0.790	0.865
Malus FE	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 1 demonstrate the result of fixed effect regression. The regression is based on equation (8) and examines the effect of bonus malus-system, primarily the Malus component. It portrays if the variables in the model had an influence on share of newly registered battery electric vehicles BEV. The table is divided into four different models, and control for each variable separately. Model (1) includes only the variable of interest, *Malus*. Model (2) includes two variables, *Malus*, and variable *Average yearly Income*. Model (3) includes *Malus*, *Average yearly Income* and controls the share of *Green party Votes* in each county council in Sweden. In model (4) includes all predictor variables in the regression model.

The estimated coefficient for the variable *Malus* is positive and significant at different significance levels, also across all models. Through all the models, the coefficient assumes the value close to 0.04, except in model 4 as the coefficient increased to 0.05 due to factoring in other variables. The BEV share increases nearly 5% if the Malus increase by one unit, indicating that Malus does indeed determine the outcome for BEV demand. However, the coefficients for the other variables show some fluctuations regarding to it significances.

Average yearly Income prove to be significant at a 10% significance level in model 2 and 3, but in model 4 the coefficient is a five percent significant level. The coefficient assumes a value close to 0.000096 in all models, which means that if the variable Average yearly Income increases one unit, the proportion of newly registered electric cars would increase by 0.0096 percent. Variable *GrenpartyVotes* is the only predictor variable that do not show significance in models 3 and 4, meaning it has not major effect on the proportion of newly registered electric cars. Although, Variable fuel price which includes in model (4) is significant at one percent significant level, but it is also important to point out that the coefficient is negative, reflecting a negative relationship. The coefficient has value close to –0.01 and it means that if fuel price increase one unit, it affects the proportion of newly registered battery electric vehicles negatively, specifically it will decrease BEV share by one percent.

R^2 display a minor fluctuation across the different models, but it can still be stated that the model's fit increases slightly as the number of predictor variables increases. When all variables included R^2 assumes a value 0.86, this indicates that a large part of the variation in the dependent variable is explained by the independent variables. While the non-observable component, $\mathcal{E}_{r,t}$, captures the rest of the variations.

7 DISCUSSION

According to our results, the malus from bonus-malus system had a significant and positive effect on the proportion of newly registered electric vehicles in Sweden. The Malus system states that certain vehicles is subject to higher taxes if vehicles emit more than 95 of carbon dioxide per kilometer, theoretically it incentive an increase in the demand for BEV. The results reveal that the introduction of the system has indeed influenced the share of newly registered electric cars, consequently boosting its demand. Figure 3 illustrate how share of newly registered cars by fuel type have contracted across years, while other surged during the same period. The main point to observe in that graph is how BEV share show an explosive bounce between 2017-2020, which clearly is the same period the system presented. Then we can concentrate those increased taxes has helped to reduce the demand for cars that run on conventional fuel. The bonus-malus system also includes subsidies for environmentally friendly cars such as BEV, but that part and how subsidies contribute to the increasing adoption electric cars is not something that has been investigated in this essay and can therefore not be found to be behind the increased in newly registered electric cars.

As mentioned earlier in the thesis, previous research also shows that the tax has a significant impact on the share of BEV. The tax increase on conventional cars increases the demand and the adoption of electric cars. Such a result has been shown by Shiyu Yan's (2018) study. Where a 10 percent increase in the total tax incentive leads to an increase in BEV's sales share of about 3 percent on average.

To be able to interpret whether the effect of malus is large or small, it should be put in relation to other political incentives. Trosvik and Egnér (2017) stated in their thesis that charging infrastructure and public procurement are the political incentives that have had the greatest effect on the proportion of newly registered electric cars in Sweden. The coefficients assume values close to 0.3 and 0.2, respectively, in all regressions, which correspond to an increase of 0.3 and 0.2 percent on the proportion of electric cars. Comparing the value of these coefficients with the coefficient for our interest variable, malus, the malus' effect on the share of newly registered electric cars is significantly greater. Malus causes an increase in the share of newly registered electric cars by about 5 percent.

During the covid 19 pandemic the Swedish society were partly suffered a lock down which reduced social activates. Thus, it is assumed that the need to buy new cars are reduced. As Transport Analysis official monthly statistics show the total number of newly registered cars decreased by 32 percent in May 2020, compared to May in 2019. It is also important to point out that the statistics show that from June 2020 and the rest of the year, the newly registered electric cars in Sweden will increase drastically. Covid 19 pandemic has reduced the number newly registered cars for all types of fuel, but those worst affected are cars that run on conventional fuel, though statics from newly electric vehicles have shown better numbers. Thus, we can concentrate that Malus and the elevated taxes on fossil fuel vehicles is an underlying factor.

According to theoretical framework on which this essay is based, individuals are profit-maximizing when they are making financial decisions. An individual will purchase a BEV if and only if the utility gained from BEV exceed the utility gained from ICEV. The increased adaptation of electric cars in Sweden in recent years could thus be explained by the fact that individuals receive a higher benefit from an electric car (BEV) than a car with an internal combustion engine vehicle (ICEV). Higher taxes on fossil fuel cars contributed but also higher subsidies for electric cars and better charging infrastructure assumes that it has also contributed. We have not examined in our thesis whether and how much Increased subsidies that belong to the bonus part in the bonus-malus system has contributed the share of newly registered electric cars but a study by Lögstrom and Mossberg (2020) shows that the bonus part has contributed by increase around 5 percent on the proportion of newly registered electric cars.

There have been previous plans to minimize fossil fuel cars and their use by taxing cars and fuels. Despite this, we see higher increased in the proportion of newly registered electric vehicles in Sweden after the introduction of the bonus-malus system. With this one can assumed that the bonus-malus system has contributed a lot to electrify the transport sector in Sweden, higher than before. The conclusion that increased share of electric vehicles in recent years would only be due to the Malus as a single variable cannot be deducted, but the regression result shows that the Malus was a contributing factor.

Malus impact on the proportion of newly registered electric cars in Sweden can still be expected to be seen different if charging infrastructure had been a variable included in the regression. Due to missing data for region level for examined years, this variable was excluded. Nevertheless, it is a factor that should have considered, as previous studies have shown that its effect has been positive on the proportion of newly registered electric vehicles. The Trosvik and Egnér (2017) study has also proven that public procurement is one of the variables that had the greatest impact on the proportion of newly registered electric cars. Charging points and public procurement can thus be expected to be an underlying factor. The malus effect on the proportion of newly registered electric cars and the exclusion of the control variables can thus be assumed to overestimate the malus effect.

The coefficient for A*verage yearly Income* has a positive effect on the proportion of newly registered BEVs. The variable represents the average annual income per county for the age group 30 - 59 years. That income influences the proportion of newly registered cars is a result that we have expected, as electric cars are usually relatively expensive in relation to alternative cars. As mentioned earlier in the essay, previous research has often shown that income is positive related to the adoption of a new electric car. Borenstein and Davis '(2016) study which showed that the adoption of American electric cars differs between individuals' income levels, as the richest are those who own the largest share of electric cars. The study by Lucas W. Davis (2018) has also shown the same results, where the relationship between the adoption of electric cars and the income differences between American households were studied. In addition to the income coefficient in our study being significant in all regressions, the effect is of little importance compared with the income variable in Trosvik and Egnér (2017). Our coefficient shows a value of 0.000096, which means that if the variable Average yearly Income increases one unit, the proportion of newly registered electric cars would increase by 0.0096 percent. This is much less value than the income variable in the Trosvik and Egnér (2017) study. What can be assumed is that caused such small value is that we used data for region level which could not capture the true affect that income could have on share of newly registered BEV. Despite that, if we used data from the municipality level instead, the probability that the coefficients would have shown much larger value than the one displayed or in line with previous research values.

The coefficient for *GreenpartyVotes*, which represents the proportion of votes that goes to the Green Party in county council election in Sweden, has been shown to have a negative and insignificant effect on the proportion newly registered electric cars. This is not the result we expected, as the Trosvik and Egnér (2017) study showed that the green part votes have a significant effect on the share of newly registered electric cars and that they have a positive relationship. Meaning that areas or regions where green parties get higher votes were expected that electric vehicle adoption be larger than regions that green parties get smaller votes. It assumed that environmental awareness of environmental problems has a direct effect on the intention to buy EV, as green cars reduce emissions. As previously mentioned, Okada et al. (2019) found that there is a connection between individuals' environmental awareness and purchase intentions with electric cars in Japan. It is important to point out that we used in our theses data for the proportion of votes in the county council election that goes to the *Miljöpartiet* for each individual county council. Thus, the variable can be misleading, as individuals do not necessarily need to vote for the *Miljöpartiet* to be environmentally conscious or to buy an electric car. Overall, there is no clear conclusion that could be drawn to the of proportion green votes that have a decisive impact on the proportion of newly registered electric cars.

Furthermore, the variable *Fuel Price* is significant, but it showed that it has a negative relationship with the proportion of newly registered electric cars. Meaning one unit increase in fuel price reduces the proportion of newly registered electric cars. Another result we did not expected. This is a result that is against what most previous research on the subject has proven, as the price of petrol has a positive effect on the adoption of electric cars, which indicates that rising petroleum prices will lead to more consumers using BEV and PHEV. Adepetu et al. (2016) found almost similar results as this thesis where they found no evidence to suggest that gas prices were effective in promoting PHEV sales in the United States.
The sharp rise in petrol prices in recent years should have increased the incentives to acquire an electric car. Unfortunately, it is difficult to find data at municipality or regionally level, as prices in particular change over time and not between municipalities or regions. Then we used yearly average gasoline price in Sweden for all regions. Possibly this may have affected the real effect of the variable on the proportion of newly registered electric cars. Because we assumed that if we were to used data for municipality or regional level, results would be proven differently. When the price of petrol is pushed up, it will be more expensive to drive a gasoline car, which in line with the utility function developed by Berry, Levinsohn & Pakes (1995), should reduce an individual's benefit from driving a gasoline car. This would lead to the consumer choose to buy an electric car instead of a gasoline car.

The limitation in this essay was made to study only the proportion of newly registered electric cars, thus not studying the entire passenger car fleet. This limitation is based on only new car sales and newly registered passenger cars that covered by the bonus-malus system. Thus, no conclusions can be drawn about the development of the electric car seen to the entire passenger car fleet in this essay. The result will be the share of newly registered electric cars increased during the studied period. Statistics from power circle (2020) show that the share of newly registered rechargeable passenger cars in July 2020 was 26.5% compared to just around 11% in the same month in 2019. Furthermore, the share of BEV and plug-in hybrids of new registrations in March 2021 was 37% and this is an increase of just by 70% compared with March in 2020 (Power circle, 2021). Despite this development electric cars are only a small percentage of the total passenger car fleet. Rechargeable cars make up about 3 percent of the total vehicle fleet, of which 34 percent are electric cars and 66 percent charging hybrids. It is important to point out that the share of electric cars in the total vehicle fleet is still small, thus, it is important for politicians to evaluate their policy incentives more often to be able to apply the best and most efficient policy measures.

8 CONCLUSION

In this essay, the effect of malus, from the Swedish political reform bonus-malus system has on the share of newly registered battery electric vehicle (BEV) have been studied and analyzed. The reform is tax system that encourage low-emission vehicles and penalizes cars with high emission, one of many measures that taken with the aim of reducing emissions from the transport sector and tackling the climate change. Our main objective is to examine if the Malus part influenced the demand for the BEV. Our results shows that Malus is a variable with a large effect on the share of newly registered electric car and display a significance influence. The result confirms the findings from previous literature on tax system, nevertheless supporting our assumption. Implying that the tax system has indeed impacted the demand for BEVs and boosted the expansion for eco-friendly car fleet. The regression points out a positive correlation between Malus variable with dependable variable, indicating a significant impact on share of BEV. While other variables suggesting a decent impact, except the fuel price, which disclose a negative association. Specific recommendation for policy change is beyond the scope of this paper, however may the policy makers benefit for the basic insights discussed throughout the study.

9 APPENDIX

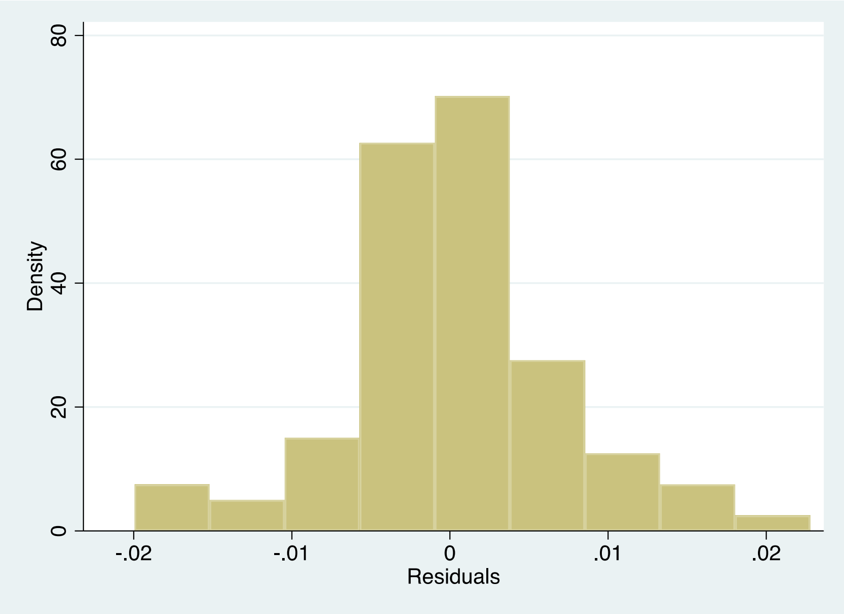

Figure 5: *Histogram of the distribution of the residual*

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