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– A fixed effects model

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Abstract

The emissions of greenhouse gases have for long been a big issue for the planet and the human wellbeing. A tax on fossil fuels and emitted greenhouse gases have been introduced in Sweden, among other countries. The tax is an attempt to decrease the use of fossil fuels along with the emissions. In this paper, the tax on fossil fuels and its effects on the demand for environmentally friendly cars have be estimated. The panel data with a time period from 2001 up until 2014 have be analyzed by means of a fixed effects model. The result from the study provides suggestive evidence of a positive relationship between the fuel taxes and demand for environmentally friendly cars.

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1. Introduction

The environment has for long been a frequent discussed topic in today's society and different possible solutions for the global warming are proposed. By this research, an examination of the Swedish taxes on fossil fuels will be done. The paper will look at the possible effects and changes of demand for private environmentally friendly cars in Sweden, due to a higher tax on gasoline and diesel. The purpose with this kind of study is to examine to what extent the fuel taxes are contributing to a more sustainable environment.

The United Nations (UN) outlined, in 2015, seventeen sustainable development goals for trying to solve the problems with global warming, among other issues (United Nation, 2017). By these goals, the UN want to transform the world by the year 2030 to a better and more equal world. This is called the 2030 agenda for sustainable development.

In Sweden the government has also set up goals for improving our world and, above all, the environment (Miljömål, 2016). These environmental objectives consist of three different parts. First of all, there is a generational goal. This is the overall goal of environmental policy in Sweden. This goal will work as a guide for every level in society towards environmental action. One of the key aims is that the improvement of Swedish environment must not become a cost for foreign environment and health.

Under this generational goal, sixteen environmental quality objectives are stated (Miljömål, 2016). These objectives will explain in what condition our environment will be in, after accomplishing the work towards a better environment. For example, there are “reduced climate impact”, “a safe radiation environment” and “sustainable forests”. These targets are to be fulfilled in one generation, i.e. by the year of 2020. For the climate objective, the deadline is 2050.

Also included in the generational goal, we have 24 different milestone targets (Miljömål, 2016). Managing these milestones will get Sweden closer to achieve the environmental quality objectives, and in turns, the generational goal.

The second environmental quality objective is clean air and states that “The air must be clean enough not to represent a risk to human health or to animals, plants or cultural assets.”

(Miljömål, 2016). On account of this, one of the most important challenges is to decrease the air pollution. A major source of air pollution in Sweden today is road traffic since the exhaust gas from all vehicles consists of different particles, organic compounds and nitrogen dioxide. All of this contributes to ground-level ozone.

In 1991 the Swedish government implemented a tax for carbon dioxide emissions (Naturskyddsföreningen 2012). The purpose was to reduce the use of fossil energy in Sweden, since that have a negative impact on the environment. From then to now there has been a notable decrease in the use of fossil fuels. Both gasoline and diesel cars are fueled with fossil fuels and contributes to the emissions of green house gases. More environmentally friendly cars would be favorable but the differences between these and the environmental destructive cars is subtle. The European Union (EU) have a classification system named Euro, which tells the maximum of emitted carbon dioxide per kilometer for different types of cars (Diesel Net, 2016). In this study, the environmentally friendly cars have only been classified according to type of fuel, irrespective to emissions.

According to an article in Dagens Nyheter, the three first ethanol cars came to Sweden in 1994 (Dagens Nyheter, 2008). Also in the early 90's, the first electric cars were purchased in Sweden (Ladda elbilen, n.d.). These two types of cars are both categorized as environmentally friendly cars. A brief definition of environmentally friendly cars is that they must have small impact on the environment and low amount of emitted greenhouse gases in comparison to more traditional means of transportation (Transportstyrelsen, 2015).

The hypothesis for this project is that the tax on gasoline and diesel, in combination with income, will have a positive effect on the demand for environmentally friendly cars. This kind of study can be helpful for the Swedish government in future decision making about the fuel taxes. With a satisfied hypothesis, the environment could also be improved and that benefits the general population.

One of the main limitations for this research is the time limit of the data. Finding all data that is needed for the examination over a longer time period is hard since not all data are either available or open to the public. The data for this project contain information from year 2001 up until 2014. This is a decent time period, but the results would be more reliable if data for a few more years could be included in the calculations.

There are still some variables that could be included in the model but were too hard to find data on for the demanded years. For example, prices for all kinds of fuel, like electric and biofuels have been hard to estimate. Also, the amount of fuel that is demanded for each type of car for every year would be favorable for the calculations. Furthermore, since it is possible to refuel an ethanol car with gasoline it makes it almost impossible to know which type of fuel has been used in those cases and that contributes to an uncertainty.

The demand for different types of cars is also influenced by a lot of other variables such as car models, extra equipment, prices and type of usage. In this study, none of this is included in the model, since that would be to extensive for this project. This too is an overall limitation for this project.

There are some studies and papers written on this topic. For example, a paper about an examination of to what extent car buyers undervalue the fuel costs in the future (Grigolon, Reynaert & Verboven, 2014). They also look at what this implies for an alternative tax in the future and its effectiveness. Their study shows that there is only a small undervaluation of the costs for fuel. The consequence with this is that fuel taxes are more effective in reducing the use of fuel, than the product taxes that are based on fuel economy. They explain this with a conclusion that the high mileage consumers are better targeted by the fuel tax.

Another study, published in the American Economic Journal, have examined how a tax can affect the carbon dioxide emissions of new cars (Klier & Linn, 2015). Based on their data, they found that the CO_2 tax reduces registrations. They made their study for three different countries, France, Germany and Sweden. The biggest effects were found in France and some evidence where found to suggest that the mix of new cars in France were affected by the domestic tax.

As they write in a report published by the Swedish Centre of Transport studies (CTS), the motor fuel tax has since long been a way to generate revenues from taxes in the transport sector (Proost, Van Dender & Eliasson, 2014). However, the taxes are nowadays also for decreasing emissions and improving air quality. They explain in the paper that there are a lot of debates about possibly reforming these taxes or even replacing them with a more effective solution. This is a topic that the paper by the CTS is discussing. Their report summarizes a few highlights from a symposium they created, by means of recent research about this topic and one of their conclusions is that not many alternatives to fuel tax are currently compiled, which could be problematic for a possible replacement.

In an article published in the Economic Letters, an analysis of panel data and common models are made (Judson & Owen, 1999). The authors have chosen the fixed effects model and explains that it is a common model to use for macroeconomists. It is also stated in the article that the fixed effects model is more suitable than the random effects for various reasons. For example, in this study of the fuel taxes and demand for environmentally friendly cars, all counties in Sweden are included, so a random effects model would not be useful since that requires a random sample from a larger area of counties. In the paper by Judson and Owen (1999), a comparison between balanced and unbalanced panel data is performed. According to their assumptions, the data is more likely to be unbalanced for larger time periods. In this study, the time period is relatively small, and the data can then be determined as balanced. This implies, according to the results in the article by Judson and Owen (1999), that a corrected least square dummy variable (LSDVC) is more efficient than a generalized method of moments (GMM).

This paper consists of six different chapters. First the introduction that gives a short presentation of the background and the purpose of this research. It also includes the hypothesis, limitations with the project and a short literature review. Later, in the methodology chapter an explanation of the fixed effects model is presented. This chapter also includes how the calculations have been carried out and how the data have been collected and arranged. Then the third chapter is to present all the results, followed by a discussion in the fourth section. Lastly, a conclusion of the calculations and the research is made in chapter five. The complete results and calculations can be found in appendix II.

2. Methodology

To be able to answer the research question of how the demand for environmentally friendly cars change by the fuel taxes, a fixed effects model will be applied. First, a brief explanation of the model is therefore presented in this chapter. To implement this regression model, an extensive amount of data for different variables is needed. That, along with a short review for all selected variables is therefore in order. Later in this chapter, an exposition of how the data is found and arranged is subsequent. Lastly some modifications for the data are done.

2.1 Fixed effects model

The fixed effects model is a statistical model that is used when an analyze of the impact of variables that vary over time is in interest (Torres-Reyna, 2007). Using the fixed effects model, the effect of price on demand for a certain product can be estimated. The fixed effects are also estimated using least square. The connection between outcome variables and predictor can be explored by the fixed effects model.

The general equation for a fixed effects model is shown below.

$$Y_{it} = \beta X_{it} + \alpha_i + d_t + u_{it}$$

Here, the Y is the dependent variable for i = entity and t = time (Torres-Reyna, 2007). The vector of independent variables is shown as X in the equation, here as well, the i and t stands for entity and time. The coefficient for X is β and it is an unknown intercept for each entity. The α_i and d_t represents the respectively county and year fixed effects. The u equals the error term.

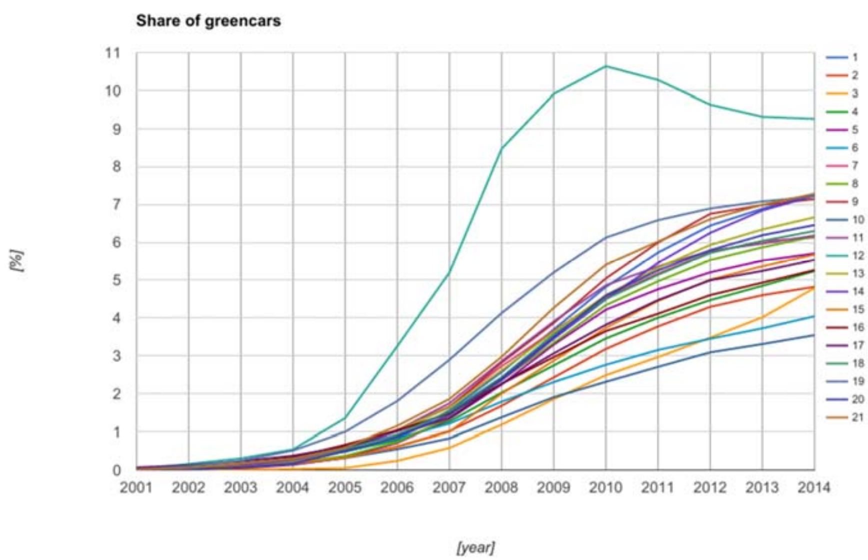
When running any kind of regression, the coefficients for all variables can be found. These values tell us how much an increase in the independent variables will affect the dependent variable. The sign in front of the values shows the slope of the coefficient, thus if it has a positive or negative impact on the dependent variable. The software that have been used for all regressions in this research is Gretl.

2.2 Variable selection

When conducting a fixed effects model for demand on environmentally friendly cars, a number of variables are essential to include. The chosen time period is momentous for the study, and the data is collected from 2001 up until 2014.

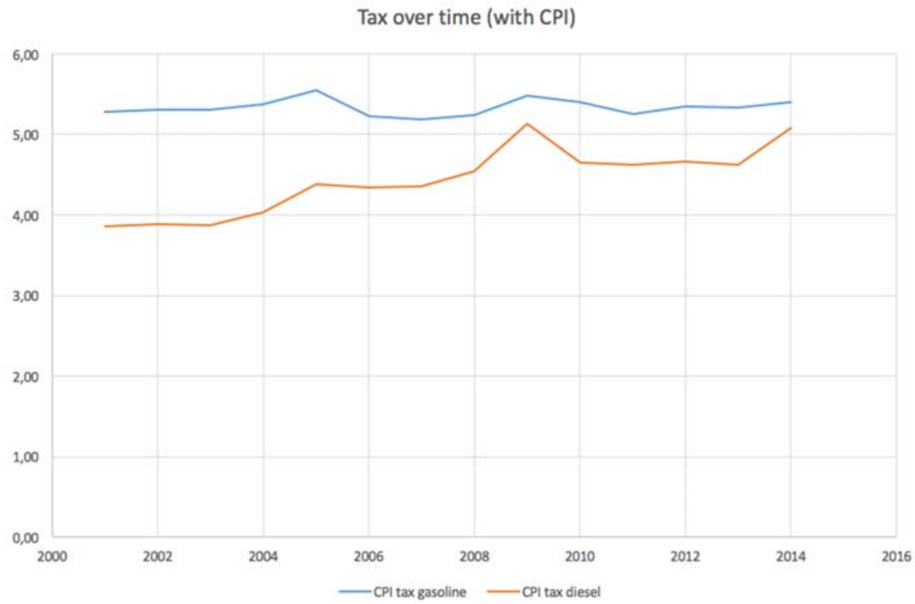
Since the calculations are made for the 21 different counties in Sweden, data on the quantity of different types of cars in all counties are needed. The cars that are included are gasoline and diesel, which are non-environmentally friendly cars. The environmentally friendly cars are powered by ethanol, electric, hybrid and biogas. A table of all cars for every county is presented in appendix I. The share of green cars over the chosen time period, divided between the different counties is shown in figure 1. A translation of the reference numbers for the counties can be found in appendix III.

Figure 1. Share of green cars over time, for every county in Sweden.



Both the taxes and the prices are presented in Swedish crowns and are necessary variables for this research. Since a price for fuel for electric, hybrid and biogas cars were hard to come across, only the price for gasoline, diesel and ethanol are presented in the data set. The total tax for gasoline and diesel are also presented in the data set. This tax includes both the energy tax and the carbon dioxide tax. The values for prices and taxes can be found in a table in appendix I. In figure 2, the values of the tax for gasoline and diesel, over time, is presented in a graph. These values are with respect to the consumer price index (CPI).

Figure 2. Tax for fuel over time, with respect to CPI, base year 2015.



Average income for every year in all 21 counties are also included in the study to increase the reliability for the results. Including the average income will help to tell possible variations between different economic conditions.

For this study, a function has been set up to be able to calculate the effects on demand for ecofriendly cars by a fuel tax, it is presented below.

$$\textit{Share of green cars} = \alpha + \beta_1 \textit{tax} + \beta_2 \textit{income} + \beta_3 \textit{price ethanol} + \beta_4 \textit{price gasoline} + \beta_5 \textit{price diesel} + \textit{year dummy}$$

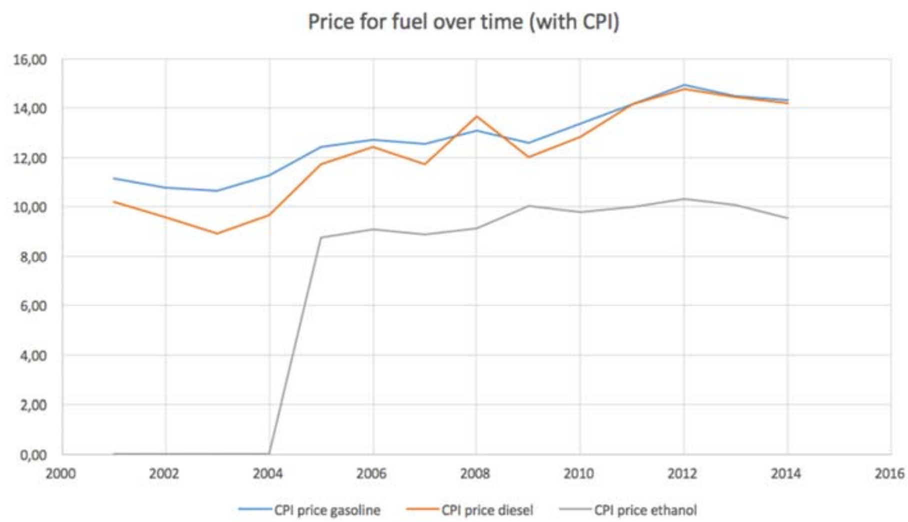
2.3 Data and data-sources

Most data are from the Swedish department for statistics (SCB) and the Swedish institute for petroleum and biofuels (SPBI). However, some modifications have been done to the prices, taxes and the income. Data for average income in all 21 counties are with respect to the CPI with the base year 2015. Since the prices on fuel and the taxes were not corrected for CPI, some calculations have been necessary to be able to compare all results.

The data for this study is panel data since it provides information on individual behavior, both across individuals and over time. The panel data have both cross-sectional and time-series dimensions and the fixed effects model is well suited for that, which is one of the declarations for why it is chosen as the model for this research. The time interval is necessary to avoid possible omitted variable bias. By examining the data, it is possible to see that for some of the variables there is both inter-county variation, which means that the values vary between the different counties and intra-county variation, that shows variation within each county over time.

A regression for ecofriendly cars, i.e. ethanol, electric, hybrid and biogas, will be conducted in this study. The dependent variable in this study will be the share of green cars which explains the demand for environmentally friendly cars. While running the fixed effects model, the time period will work as the dummy. In figure three the prices for gasoline, diesel and ethanol is shown over the time period 2001 up until 2014.

Figure 3. Price for fuel over time, with respect to CPI, base year 2015.



2.4 Logarithmic data

The prices on fuel, the average tax and average income have been turned into logarithmic variables. This is because the logarithmic form makes it easier to read and compare all results, since the differences between the values becomes smaller.

The logarithmic for number of green cars, fuel prices, taxes and average income have been calculated in Excel. It is possible to do these calculations directly in Gretl, but since there is a lack of data for the price of ethanol, the calculations have been modified in Excel. The explanation for natural logarithmic is shown below.

$$e^{ln(x)} = x$$

When inserting x equal to zero, the natural logarithmic heads toward negative infinity. This will make the model harder to run and understand. Therefore, the model is adjusted in such a way that the logarithmic values are calculated by ln(1+x). This will facilitate the calculations in the fixed effects model.

Now, the function for share of green cars, with the logarithmic values instead, can be written as follows.

$$Share\ of\ green\ cars = \alpha + \beta_1 ln(tax) + \beta_2 ln(income) + \beta_3 ln(price\ ethanol) + \beta_4 ln(price\ gasoline) + \beta_5 ln(price\ diesel) + year\ dummy$$

3. Results

This chapter is for presenting the results from the calculations and examinations of this research. Only a demonstration of all results will be executed in this section, and further explanations and discussions are left for the next chapters.

All variables have a so called p-value. This is an indicator for the probability for the statistical model. The p-value should be as small as possible for the value to be the most reliable (Blom et al. 2013, p. 324). The stars indicate the size of the confidential level for the model, three stars indicates a 1% level of significance (the more stars the better certainty).

3.1 Empirical results

The fixed effects model has been accomplished in a various of ways. In all models, the robust standard errors and the time dummies are included. First, the share of green cars was set as the dependent variables and the logarithmic of prices for fuel, average income and average tax were set as independent variables.

Table 1. Fixed effects for share of green cars and average tax as an independent variable.

	coefficient	std. error	t-ratio	p-value	
const	-2,48927	0,237004	-10,50	1,38e-09	***
Logofgasolinepri~	0,164373	0,0372161	4,417	0,0003	***
Logofdieselprice	0,0308267	0,0279282	1,104	0,2828	
Logofethanolprice	-0,0127098	0,00149091	-8,525	4,31e-08	***
Logofaverageinco~	0,139783	0,0214652	6,512	2,39e-06	***
Logofaveragetax	0,173916	0,0317710	5,474	2,33e-05	***
dt_2	-0,00484184	0,00438504	-1,104	0,2826	
dt_3	-0,00844973	0,00357524	-2,363	0,0283	**
dt_4	-0,000472327	0,00440789	-0,1072	0,9157	
dt_5	-0,00305281	0,00446597	-0,6836	0,5021	
dt_6	-0,00124933	0,00529308	-0,2360	0,8158	
dt_7	-0,00521724	0,00433647	-1,203	0,2430	
dt_8	-0,00778563	0,00409758	-1,900	0,0719	*
dt_9	-0,000748312	0,00316393	-0,2365	0,8154	
dt_10	0,00223479	0,00558868	0,3999	0,6935	
dt_11	-0,00494725	0,00460010	-1,075	0,2950	
dt_12	-0,00752011	0,00358117	-2,100	0,0486	**
dt_13	-0,00425801	0,00408943	-1,041	0,3102	
dt_14	-0,00330750	0,00584028	-0,5663	0,5775	

Mean dependent var	0,026250	S.D. dependent var	0,025437
Sum squared resid	0,028957	S.E. of regression	0,010656
LSDV R-squared	0,847261	Within R-squared	0,840662
Log-likelihood	938,9858	Akaike criterion	-1799,972
Schwarz criterion	-1656,312	Hannan-Quinn	-1742,440
rho	-0,108181	Durbin-Watson	1,890599

In figure 2, the results for the coefficients that were calculated were intuitive and lined up with expectations. It is shown that both the price for gasoline and the price for diesel has a positive impact on the demand for green cars. In all the models, the diesel price do not show any level of significance, a possible explanation for this can be found in the discussion. This is a level-log model so the output should be interpreted as $Y=\alpha+\beta_n*\ln(x)$, with α being a constant and β_n being the coefficient. If the change in demanded green cars were to be calculated, the function for the new level of demand would look like $Y_{new}=\alpha+\beta_n*\ln(x+\Delta x)$. The derived function for change in Y will then look like, $\Delta Y=\beta_n *\ln(1+\Delta)$. This means that a change of 1% in price for e.g. gasoline will be calculated as $\Delta Y=0{,}164373*\ln(1{,}01) \Rightarrow \Delta Y\approx 0{,}0016$. This implies an increase by 0,16% in demand for share of green cars, which might not seem like a great increase. A more draught explanation of this can be found in the discussion. Also, the average income has a positive impact on the demand for eco-friendly cars. This is too, an expected result since frequently, people with higher income have a higher purchasing power when it comes to more expensive and newer car models. The price for ethanol has a negative impact on the demand for green cars, which is easy to understand by implementing the demand theory. Since ethanol is among the fuels for green cars, rising the price for ethanol will imply high operating costs for green car users, hence demand is likely to fall. The average tax has a positive affect on the demand for environmentally friendly cars which confirms our hypothesis. The average tax is here the proxy for taxes on fossil fuels like gasoline and diesel. Higher taxes imply a higher opportunity cost for using non-green cars, hence, forward-looking consumers are likely to shift away from cars running on fossil fuels that are heavily taxed to green cars, ceteris paribus. The p-values in this model shows high significance for all variables except the price for diesel.

The same regression was made with the same variable, except from the average tax. Now only the gasoline tax was included in the model.

Table 2. Fixed effects for share of green cars and the gasoline tax as an independent variable.

	coefficient	std. error	t-ratio	p-value	
const	-2,69371	0,249718	-10,79	8,72e-10	***
Logofgasolinepri~	0,180876	0,0359689	5,029	6,43e-05	***
Logofdieselprice	0,0261903	0,0255766	1,024	0,3181	
Logofethanolprice	-0,00978454	0,000973943	-10,05	2,93e-09	***
Logofaverageinco~	0,162040	0,0210015	7,716	2,03e-07	***
Logofgasolinetax	0,109127	0,0544561	2,004	0,0588	*
dt_2	-0,00401798	0,00450927	-0,8910	0,3835	
dt_3	-0,00779180	0,00337051	-2,312	0,0316	**
dt_4	-8,57485e-05	0,00447590	-0,01916	0,9849	
dt_5	-0,00227851	0,00471916	-0,4828	0,6345	
dt_6	-0,00106617	0,00546521	-0,1951	0,8473	
dt_7	-0,00459824	0,00431714	-1,065	0,2995	
dt_8	-0,00711478	0,00417363	-1,705	0,1037	
dt_9	-0,000241014	0,00303828	-0,07933	0,9376	
dt_10	0,00235015	0,00552426	0,4254	0,6751	
dt_11	-0,00427081	0,00469929	-0,9088	0,3743	
dt_12	-0,00659782	0,00376255	-1,754	0,0948	*
dt_13	-0,00356478	0,00419085	-0,8506	0,4051	
dt_14	-0,00321184	0,00572590	-0,5609	0,5811	

Mean dependent var	0,026250	S.D. dependent var	0,025437
Sum squared resid	0,032056	S.E. of regression	0,011212
LSDV R-squared	0,830912	Within R-squared	0,823606
Log-likelihood	924,0368	Akaike criterion	-1770,074
Schwarz criterion	-1626,414	Hannan-Quinn	-1712,542
rho	-0,173333	Durbin-Watson	2,048261

In this model, the results look very much like the results in the first model. The main difference is the impact on demand for green cars by the gasoline tax. It is still positive but smaller than before. The level of significance has also decreased which means that it is not as certain. The time dummies in these models have all, except time period 10, a negative impact on the dependent variable. The time fixed effects allows to control shocks because their impact is restricted to a certain time period. Time period one is excluded in these models because of the time dummy and to enable comparisons.

Lastly, the model was carried out with the diesel tax included, ceteris paribus. In this model, all results were similar to the first two models.

Additional models were estimated by replacing the prices and taxes with their lagged values. The intuition behind this is to an extent, for identification purposes. In the real world one would expect that consumers to adjust to policy changes slowly, rather than instantaneous, so therefore price and tax changes will take some time before the impact is reflected on the demand for cars. The regression was done for both the average tax, the diesel tax and the gasoline tax as independent variables.

Table 3. Fixed effects with lagged variables, average tax set as an independent variable.

	coefficient	std. error	t-ratio	p-value	
const	−2,96609	0,256194	−11,58	2,55e-10	***
Logofgasolinep~_1	0,120537	0,0312857	3,853	0,0010	***
Logofdieselpri~_1	−0,00270838	0,0173416	−0,1562	0,8775	
Logofethanolpr~_1	−0,0198919	0,00195267	−10,19	2,31e-09	***
Logofaverageinco~	0,213188	0,0222745	9,571	6,58e-09	***
Logofaveragetax_1	0,0513427	0,0276745	1,855	0,0784	*
dt_2	−0,00230368	0,00306968	−0,7505	0,4617	
dt_3	−0,00724081	0,00345621	−2,095	0,0491	**
dt_4	0,00185467	0,00376907	0,4921	0,6280	
dt_5	−0,000552318	0,00514104	−0,1074	0,9155	
dt_6	0,000519028	0,00373855	0,1388	0,8910	
dt_7	−0,00455667	0,00358011	−1,273	0,2177	
dt_8	−0,00616319	0,00272521	−2,262	0,0350	**
dt_9	0,00178168	0,00441599	0,4035	0,6909	
dt_10	0,00458978	0,00540111	0,8498	0,4055	
dt_11	−0,00195214	0,00323216	−0,6040	0,5527	
dt_12	−0,00571376	0,00344752	−1,657	0,1131	
dt_13	−0,00323045	0,00373834	−0,8641	0,3978	

Mean dependent var	0,025968	S.D. dependent var	0,024882
Sum squared resid	0,030739	S.E. of regression	0,011437
LSDV R-squared	0,817467	Within R-squared	0,812182
Log-likelihood	853,6462	Akaike criterion	−1631,292
Schwarz criterion	−1494,132	Hannan-Quinn	−1576,234
rho	−0,063279	Durbin-Watson	1,960313

The results from the regressions with lags included differs some from the ordinary fixed effects models. Here, the price of gasoline has a positive impact on the demand for green cars, in contrast to the price for diesel and ethanol that both have a negative impact on the dependent variable. The average income and average tax still has positive effects on the demand for green cars. The time dummies are included here as well and the first period is excluded like before. Time period fourteen is here omitted because of exact collinearity.

The Akaike information criterion has a negative relationship to the likelihood and is positively related to the number of parameters (Hu, 2007). One seeks an AIC at its minimum. As shown in the figures, all estimated models in this research has a small value for AIC, even below zero.

An alternative to the AIC, that selects more parsimonious models, is the Hannan-Quinn. The calculation of Hannan-Quinn is based on the “law of log of the log” of the sample size (Claeskens, 2011). Here, as well, a minimum value is desired and all models for this study fulfils this.

The R-squared shows the percentage variation in the dependent variable across time, explained by our model. The Least square dummy variables (LSDV) presents a type of R-squared that usually is higher than normal ($R^2 > 0,9$). This is it not as reliable as the regular R^2 since the dummies are included in this regression and by those means the LSDV R^2 naturally gets higher.

Since only the time dummies are included in this study, the LSDV R-squared should not be too misleading. Yet, in the models ran in this study, all LSDV R^2 can be found between 0,83 to 0,88, which are still pretty high results. A value for R^2 as close to one as possible is desired.

The value for Within R-squared resembles the R-square that is found while running an Ordinary least square regression. A 100% R^2 indicates that, around the mean, all the variability of the response data is explained by the model.

4. Discussion

This chapter is dedicated for discussions. First, a short explanation of the results that were presented in the previous chapter will be made. Then some potential reasons explaining the outcome and why. Lastly, some ideas for further research will be stated and discussed.

4.1 Result discussion

The purpose with this research was to examine the effects of a higher tax on gasoline and diesel on the demand for environmentally friendly cars. The results that were found during this study, confirm our hypothesis and show that there is connection between the dependent variable, share of green cars, and some of the independent variables, such as prices and income. These results were more or less as expected and they also show a high level of significance which suggests that they are trustworthy.

Also, the purpose was to find a true relationship between the demand and the fuel taxes. According to the calculations in the fixed effects model, there is a positive relationship between the taxes on gasoline and diesel and the demand for environmentally friendly cars. The results show us that a 1% increase in the tax will lead to an increase in demanded cars by approximately 0,17%. A 1% increase in taxes may not make that much of a difference, but imagine a 100% increase in taxes, this would imply that the tax today (approximately 5 Swedish crowns) will increase to 10 Swedish crowns. This will make the price on gasoline go from around 15 Swedish crowns to 20 Swedish crowns per liter. By doing this, the share of green cars will increase from around 6% to 18%, which is a significant change.

The model with lagged variables show us similar results except that the diesel price now has a negative correlation with the dependent variable. A fully explanation for this is yet hard to estimate.

4.2 Issues and potential explanations

When executing a research, there are always some issues that can emerge and can be improved in further studies. Firstly, the lack of included variables is an important factor for why all the results are not as expected or wanted. As earlier mentioned, the demand for environmentally friendly cars depends on a large number of different factors, such as car models and extra equipment. If prices on all cars and fuels, along with information on how much of each type of fuel is demanded was possible to include in the study, the research would provide better, more reliable results.

Another issue to have in mind, if comparison around the county was favourable, is the number of counties. It would be a good idea to go deeper and collect data for every municipality instead. This would help the study to better see variation around the country. For example, the average income would be more explaining if the statistics were kept for smaller areas than whole counties.

One issue with the results is that the diesel price does not show any significance in either of the models. It is hard to do a fully explanation on this, but there are some possible reasons for why the diesel price is not significant. First of all, the issues with included variables is one of the main problems with the model. For example, the price for oil has a great impact on the prices for diesel and gasoline. Except from that, there are other factors that need to be listed. Cars that are fuelled with diesel has normally a lower fuel economy than gasoline cars. This imply that the demand for diesel is less influenced by price changes. A possible outcome of this, is that the movement in demand is bigger between gasoline and diesel cars than for example gasoline and electric cars. This can partly explain the lack of significance in diesel price. The demand for different fuels are also affected by the tax on cars. A lower tax on diesel cars contributes to a shift in demand from gasoline to diesel. The taxes improve the demand for the most environmentally friendly cars and deteriorates for the least environmentally friendly cars. But since some diesel cars can be classified as environmentally friendly cars, according to the EU classifications, these cars land somewhere in between, and it is therefore hard to estimate the shifts in demand between different car types. In this study, the environmentally friendly cars have only been divided by means of their fuel type. To improve the study, and get more reliable results, the classification for environmentally friendly cars made by the European Union would be favourable.

Another aspect to look at is the development of electric cars. Looking back a few years, the electric car where not as requested since it did not provide as good appliance as other cars. Nowadays, the batteries in electric cars are highly improved as well as the prices for refuelling an electric car has decreased. This implies that the demand for electric cars have increased only the last few years. The taxes and prices on fossil fuels have most definite a positive impact on the car industry and their development of environmentally friendly cars and that in turn increases the demand for these types of cars.

4.3 Further research

This research concerns an important issue that should be discussed more often. It is necessary that more studies and other research are made on this topic so that all benefits with fuel taxes can be listed and explained in a reliable way. If other studies were made on this subject, and similar results were found, the government would have a good reason for increasing the taxes for fossil fuels so that the emissions of carbon dioxide in Sweden could decrease. Or, if other studies would show that the fuel taxes do not have a positive impact on the demand for environmentally friendly cars, another solution would be necessary. That could encourage the government to work harder on other possible settlements for the issues with carbon dioxide emissions.

It is important to include more variables for further studies to indemnify the research even more. A longer period of time would also be a great improvement when looking at the long term effects of fuel taxes. Studies on other countries with resembling fuel taxes could also be a good way to compare and analyse the actual effects of higher taxes.

5. Conclusion

This research is an attempt for analysing the effects of the taxes on fossil fuels on environmentally friendly cars and investigate how it contributes to reach the environmental quality objectives. The results that were found by introducing the fixed effects model on the collected data is that prices and income have a positive impact on the demand for environmentally friendly cars, which could be expected. The calculations also confirm the hypothesis that the tax on fossil fuels would have a positive impact on the demand for environmentally friendly cars.

If the environmental goals, with an improved environment, are to be reached by the year of 2020, more research is necessary so that a solution for the emissions of greenhouse gases could be found. A higher tax on fossil fuels, according to this study, could be a good contribution for reaching our environmental targets.

Although, a more circumstantial research for this topic might be necessary to get more exact results on the impact. This study will more act as a guideline for what direction the taxes are affecting the demand for green cars.

6. Summary

1) Using Panel data from 2001 to 2014 this study has investigated the effects from fuel taxes on demand for environmental friendly cars.

2) The Fixed effects model were used for this study.

3) The results by this study show some positive relationship between taxes and demand. Positive relationships between demand for green cars and fuel prices are also found.

4) Lack of data is the main weakness for this research.

5) Further research is necessary if more trustworthy results should be found.

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Appendix I: Descriptive statistics

Table 4. Total amount of cars divided by type of car, for each county every year.

County	Blekinge		Dalarna		Gotland		Gävleborg		Halland		Jämtland		Jönköping	
Year	non green	green	non green	green	non green	green	non green	green	non green	green	non green	green	non green	green
2001	73987	18	142804	18	30117	5	134630	18	136170	23	65019	8	153411	19
2002	74228	21	143052	38	30409	4	134596	28	137317	31	65052	25	153935	60
2003	74821	100	144113	110	30867	5	135177	168	139465	68	65249	68	155418	201
2004	75137	216	144588	222	31196	8	135979	335	141641	192	65251	125	156808	367
2005	75508	364	145233	465	31342	16	136562	681	143736	467	65343	327	158113	838
2006	75787	619	145680	909	31551	76	136988	1076	145232	1043	65857	551	159501	1686
2007	76338	1210	146608	1502	31691	185	137662	1767	146283	1975	66280	814	160800	2716
2008	75415	1988	146131	2499	31599	379	136828	2831	145566	3341	66111	1203	159556	4467
2009	74794	2873	145731	3628	31798	601	136079	3843	145773	4968	66140	1562	158289	6016
2010	74175	3756	145485	4783	31618	807	135148	4843	146146	6438	65830	1871	158312	7549
2011	74222	4511	146288	5741	31822	973	135305	5647	148272	7408	66196	2156	159596	8713
2012	73991	5094	147313	6609	31787	1146	135374	6336	149248	8198	66485	2376	160384	9758
2013	74106	5483	148451	7161	31971	1338	136164	6939	150623	8790	66883	2589	161584	10365
2014	74920	5885	151441	7674	32289	1624	137805	7618	153722	9302	67751	2856	165171	10780

Table 5. Total amount of cars divided by type of car, for each county every year.

County	Kalmar		Kronoberg		Norrbotten		Skåne		Stockholm		Södermanland		Uppsala	
Year	non green	green	non green	green	non green	green	non green	green	non green	green	non green	green	non green	green
2001	113488	8	85703	7	127293	9	512535	71	729335	150	119421	13	126237	10
2002	113944	15	85947	33	127450	18	517184	269	737122	1176	120534	25	132271	45
2003	114680	85	86176	131	128120	87	521841	675	744240	2290	121786	141	129095	153
2004	115447	219	86985	290	128571	203	527530	1409	750071	4079	122580	308	130315	348
2005	116235	433	87668	522	129042	405	534792	2861	748761	10291	123479	706	131956	756
2006	116728	864	88371	919	129694	712	543120	5705	743908	25046	124062	1302	131848	1343
2007	117188	1611	88890	1483	129735	1084	549609	9786	742678	40735	124785	2072	139974	2125
2008	116606	2812	88195	2556	129342	1807	547140	16104	724039	67024	123593	3320	138500	3338
2009	115793	4006	87839	3532	129703	2521	546943	22256	714041	78538	122859	4624	138355	4943
2010	115315	5230	87184	4634	130055	3080	546177	27927	715363	85166	122615	5916	138774	6531
2011	116009	6068	87557	5583	131106	3650	550010	31164	733520	84002	124120	6982	139354	8045
2012	116178	6802	87876	6364	131925	4209	552956	33893	749543	79892	124827	7869	140467	9364
2013	116894	7287	88724	6664	133216	4562	559410	35491	763506	78417	125983	8528	139966	10283
2014	118509	7774	90333	6949	134841	4957	567332	37377	783911	79992	127981	9135	142394	11097

Table 6. Total amount of cars divided by type of car, for each county every year.

County	Värmland		Västerbotten		Västernorrland		Västmanland		Västra Götaland		Örebro		Östergötland	
Year	non green	green	non green	green	non green	green	non green	green	non green	green	non green	green	non green	green
2001	137487	16	116228	42	120895	82	118545	17	666942	145	125836	16	180851	11
2002	137523	37	116643	71	120629	152	118936	33	663765	682	126257	23	182338	74
2003	138433	117	117018	198	121167	281	120221	194	669111	1667	126784	89	183724	295
2004	139168	238	118095	386	121908	461	121385	359	674328	3472	126910	215	184793	548
2005	139494	455	118754	793	122228	759	122171	680	679000	6837	127458	634	186123	1098
2006	140220	854	119242	1249	122486	1123	122981	1147	682248	12553	128082	1116	186752	2171
2007	140942	1422	119885	1796	122919	1701	116345	1804	682057	20332	128154	1868	188044	3561
2008	139836	2855	118963	2754	122194	2826	115786	2890	674037	29030	127672	3126	186489	5708
2009	138861	4106	118734	3629	121910	3853	114746	4245	668252	36688	126527	4588	185573	8273
2010	138281	5370	118587	4496	121024	4808	114440	5396	667723	43579	128677	6194	185221	10587
2011	138857	6467	119886	5141	121433	5688	116117	6293	674537	47556	129900	7209	186082	11913
2012	139359	7354	120762	5828	121086	6368	117398	7121	676190	50074	130823	8044	187000	13228
2013	139519	7911	121619	6311	121813	6741	118757	7631	678173	51669	132274	8724	188501	14152
2014	140740	8467	123445	6861	123474	7233	120811	8122	689988	53653	131860	9102	191997	15039

Table 7. Prices for gasoline, diesel and ethanol over time with respect to CPI with base year 2015.

	Price Gasoline	Price Diesel	Price Ethanol
2001	11,17	10,19	0,00
2002	10,76	9,60	0,00
2003	10,66	8,92	0,00
2004	11,28	9,66	0,00
2005	12,44	11,71	8,75
2006	12,73	12,43	9,07
2007	12,57	11,74	8,89
2008	13,07	13,68	9,13
2009	12,61	12,00	10,05
2010	13,39	12,82	9,79
2011	14,18	14,18	10,00
2012	14,94	14,77	10,31
2013	14,50	14,45	10,07
2014	14,32	14,19	9,54

Table 8. Taxes for gasoline, diesel and ethanol over time with respect to CPI with base year 2015.

	Tax Gasoline	Tax Diesel
2001	5,28	3,86
2002	5,31	3,88
2003	5,31	3,88
2004	5,38	4,04
2005	5,54	4,38
2006	5,23	4,34
2007	5,18	4,35
2008	5,24	4,54
2009	5,48	5,13
2010	5,40	4,65
2011	5,26	4,62
2012	5,35	4,67
2013	5,34	4,63
2014	5,40	5,07

Appendix II: Fixed Effects model

Table 9. Fixed Effects model with lagged variables, gasoline tax set as independent variables

	coefficient	std. error	t-ratio	p-value	
const	-3,07964	0,274799	-11,21	4,51e-10	***
Logofgasolinep~_1	0,109437	0,0360808	3,033	0,0066	***
Logofdieselpri~_1	0,00954106	0,0212264	0,4495	0,6579	
Logofethanolpr~_1	-0,0191892	0,00172305	-11,14	5,03e-10	***
Logofaverageinco~	0,215845	0,0221023	9,766	4,71e-09	***
Logofgasolinet~_1	0,0910751	0,0282202	3,227	0,0042	***
dt_2	-0,00232886	0,00304099	-0,7658	0,4527	
dt_3	-0,00716523	0,00337430	-2,123	0,0464	**
dt_4	0,00202364	0,00377700	0,5358	0,5980	
dt_5	-0,000526306	0,00517049	-0,1018	0,9199	
dt_6	0,000658617	0,00360128	0,1829	0,8567	
dt_7	-0,00465398	0,00350397	-1,328	0,1991	
dt_8	-0,00591861	0,00261708	-2,262	0,0350	**
dt_9	0,00183138	0,00441262	0,4150	0,6825	
dt_10	0,00453084	0,00540931	0,8376	0,4122	
dt_11	-0,00192773	0,00319877	-0,6026	0,5535	
dt_12	-0,00565718	0,00334187	-1,693	0,1060	
dt_13	-0,00304538	0,00366716	-0,8304	0,4161	

Mean dependent var	0,025968	S.D. dependent var	0,024882
Sum squared resid	0,030690	S.E. of regression	0,011428
LSDV R-squared	0,817757	Within R-squared	0,812480
Log-likelihood	853,8632	Akaike criterion	-1631,726
Schwarz criterion	-1494,566	Hannan-Quinn	-1576,668
rho	-0,064003	Durbin-Watson	1,963363

Table 10. Fixed Effects model with lagged variables, diesel tax set as independent variables

	coefficient	std. error	t-ratio	p-value	
const	-2,92416	0,252341	-11,59	2,51e-10	***
Logofgasolinep~_1	0,129540	0,0304216	4,258	0,0004	***
Logofdieselpri~_1	-0,0102225	0,0169840	-0,6019	0,5540	
Logofethanolpr~_1	-0,0196756	0,00221026	-8,902	2,15e-08	***
Logofaverageinco~	0,213488	0,0224167	9,524	7,14e-09	***
Logofdieseltax_1	0,0241239	0,0203288	1,187	0,2493	
dt_2	-0,00234044	0,00310482	-0,7538	0,4597	
dt_3	-0,00735193	0,00345745	-2,126	0,0461	**
dt_4	0,00176904	0,00377305	0,4689	0,6442	
dt_5	-0,000620768	0,00515761	-0,1204	0,9054	
dt_6	0,000424328	0,00375829	0,1129	0,9112	
dt_7	-0,00461028	0,00358504	-1,286	0,2131	
dt_8	-0,00631759	0,00271208	-2,329	0,0304	**
dt_9	0,00172847	0,00443011	0,3902	0,7005	
dt_10	0,00455271	0,00541412	0,8409	0,4103	
dt_11	-0,00200742	0,00325078	-0,6175	0,5439	
dt_12	-0,00580188	0,00347282	-1,671	0,1104	
dt_13	-0,00334783	0,00375470	-0,8916	0,3832	

Mean dependent var	0,025968	S.D. dependent var	0,024882
Sum squared resid	0,030866	S.E. of regression	0,011461
LSDV R-squared	0,816711	Within R-squared	0,811404
Log-likelihood	853,0819	Akaike criterion	-1630,164
Schwarz criterion	-1493,004	Hannan-Quinn	-1575,105
rho	-0,061122	Durbin-Watson	1,955233

Appendix III: Counties

Table 11. Reference numbers for the 21 counties in Sweden.

1	Blekinge
2	Dalarna
3	Gotland
4	Gävleborg
5	Halland
6	Jämtland
7	Jönköping
8	Kalmar
9	Kronoberg
10	Norrbotten
11	Skåne
12	Stockholm
13	Södermanland
14	Uppsala
15	Värmland
16	Västerbotten
17	Västernorrland
18	Västmanland
19	Västra Götaland
20	Örebro
21	Östergötland