LUND UNIVERSITY

School of Economics and Management

"Does education play a significant role in electric vehicle adoption rates in Sweden?"

Niclas Malmhagen

Bachelor Thesis

May 2018

Departement of Economics

Supervisor: Alexandros Rigos

Abstract:
This thesis examines if education as a channel for environmental awareness affects battery electric vehicle (BEV) adoption in Sweden. It discusses how the pollution from internal combustion engine vehicles (ICEV) lead to economic cost both to governments as well as citizens. It also analyzes different control variables that were aimed at capturing economic concerns, age and convenience in BEV adoption rates. The control variable was income, age, distance travelled and percentage of inhabitants living in houses. The analysis uses data from all municipalities in Sweden in order to get a diverse data set. Based on previous theory the paper makes motivated hypothesizes on how each variable will affect BEV adoption in Sweden. The results from a linear regression with robust standard errors shows that three of the variables have statistically significant results, being education, Age and distance travelled. The paper concludes that education as a proxy for environmental awareness does lead to increased adoption rates, as well as that municipalities with higher median ages have lower adoption rates. It also concludes that municipalities with inhabitants that travel further distances during a year also leads to increased BEV adoption rates. Different areas suitable for future research has also been suggested.

Keywords: Battery Electric Vehicles, Adoption, Sweden, Education

Table of Contents

1. Introduction

1.1 Background

Concerns about pollution and its negative effects on both the environment and health is one of the greatest issues that the world faces today. According to the World Health Organization, nine out of ten people breathe polluted air (W.H.O., 2018). One of the main contributors to air pollution in urban areas, is from road transport (Krzyzanowski, Kuna-Dibbert, & Schneider, 2005). The economic costs caused by pollution through health expenses alone are severe. A study from 2001 by Spadaro and Rabl (2001) showed that the cost in damages in the EU from cars built before 1997 was 2 to 41 euro cents per km, while cars produced after 1997 had a cost of from 1 to 9 cents per km. The study calculated this through looking at how specific pollutants from emissions impacted health, crops and man-made environments, followed by examining the costs resulted from these impacts. The cost that pollution had on health was calculated from the cost of having an actual illness, as well as the loss in productivity that the illness has on the individual. The damage pollution had on crops and on man-made environment was derived from the loss in crop yields and the damage caused to man-made surface areas that was caused from automotive pollution. (Spadaro & Rabl, 2001). Further studies in Beijing showed that the total economic cost for health impact caused by road transport air pollution was $298 million (0.58% of GDP) in 2008 (Guo, et al. 2010). While it may seem like a small percentage of Chinas GDP, it is still a large cost, that consumes a countries taxes.

The automotive industry has always been an innovative industry (Albers, Ili, & Miller, 2010), as for instance seen by the fact that cars being sold today are much safer compared to cars sold 20 years ago (Stewart, 2017). While innovation has among other things contributed to vehicles having a less negative effect on the environment, cars´ negative externalities on the environment and health are still substantial. Even though internal combustion engines vehicles (ICEV) are constantly improving, through fuel efficiency and reduced environmental impact, other solutions are being approached. This is demonstrated through many large automakers such as, GM, Ford, Jaguar Land Rover and Volvo announcing plans for future electric vehicles (Williams, 2017).

One of the proposed solutions to reduce air pollution at a local level is battery electric vehicles (BEV). On a global scale it is still debated whether BEVs are cleaner and better for the environment compared to traditional ICEVs (Holland, et al. 2016). The reason is the high environmental costs that occur during the total production cycle. The clear advantage that

BEVs have over ICEVS is that they don't pollute while driving. This means that a BEV's environmental impact on a local level is far less compared to ICEVs. BEVs as a solution to pollution abatement and as a factor to improve health is being greatly considered. This is seen through many government incentives across the world supporting the adoption of BEVs and hybrids. For example, in Sweden you can get different types of tax breaks as well as subsidies when purchasing an electric vehicle (Miljöfordon, u.d.). This paper will focus on BEVs instead of hybrids due to the significant difference between the vehicle types. There are two types of hybrids, plug-in hybrid electric vehicles (PHEV) and hybrid electric vehicles (HEV) (State of Indiana, u.d.) Both variants have an electric and combustion engine and charges its battery from their combustion engine as well as regenerative braking. The main difference is that HEVs can only charge its battery through its combustion engine whilst PHEVs can also charge by connecting to an electric power grid. This means that PHEVs can run on energy from electricity alone (State of Indiana, u.d.) Compared to BEVs, hybrids do not have the same issue of range as well as they do emit pollution on a local level. As local pollution has a direct economic impact on both health, in terms of healthcare cost, as well as crops and man-made surfaces, BEVs can be used to reduce these costs. This means that government spending can be used on other issues.

1.2 Scope

While adoption of BEVs is occurring on a global scale, it is not practical nor beneficial to examine BEV's globally. The reasoning behind this is both due to the vast amount of data that would be required to do this along with the variety of different factors for BEV adoption that exists in different countries. As it is probable that different countries consumers and governments have different reasons and incentives when it comes to adopting BEVs one regression explaining global adoption of BEVs would not be helpful. This paper focuses on how education levels, as a channel for environmental awareness, affects BEV adoption rates in Sweden, more specifically "Does education play a significant role in electric vehicle adoption rates in Sweden?", Sweden was chosen as the main focus for this paper as Sweden is a large country in terms of landmass. This means that even though if Sweden's overall population density is quite low compared to the world average, Sweden still has highly populated municipalities such as Stockholm and Gothenburg. I expect that this will result in many diverse municipalities making Sweden an appropriate region to study. In order to analyze adoption rates in Sweden I will be comparing data from municipalities to see what factors affect adoption rates across Sweden. Municipal data is used over individual data due to the lack of individual data

available. In order to look at BEV adoption in Sweden I will be using the amount of BEV's newly registered per 10,000 people in each municipality as a proxy for BEV adoption rates in Sweden. While I suspect that this will be a suitable proxy for adoption, there are details in the data that will have a small effect on the results, for example that the data is affected by people moving between municipalities.

1.3 Literature Review

Many different aspects of BEVs as well as hybrids have been studied. Some of the main aspects that have be studied are looking at consumers willing to pay for different types of vehicles, current incentives and if these incentives work differently between markets and analyzing reasons why the markets differ.

1.3.1 International studies

The adoption and increasing availability of BEVs in the automotive industry has received a lot of attention through both the media as well as academic papers. Many different aspects of this change have been analyzed, for example in a paper discussing spillover effects from purchasing EVs and their use in Norway showed that EVs are mainly purchased as second vehicles and used mainly for everyday use (Klöckner, Nayum, & Mehmetoglu, 2013). Consumers willingness to pay for electric vehicles has also been explored. The researchers looked at consumer's willingness to pay for electric vehicles through their different attributes. They approached the issue by looking at consumer's choices when offered three different version of one model, one ICEV and two BEV's. The paper concluded that consumers' willingness to pay for a BEV's was affected by different electric vehicle attributes. Specifically driving range, charging time, fuel cost saving, pollution reduction and performance (Hidrue et al. 2011).

Previous studies have also looked and analyzed at many different factors that affect adoption rates of both BEVs and hybrids. Sierzchula, et al. (2014) conducted a study investigating electric vehicles adoption rates in 30 different countries using 13 different variables. Their results showed that three of the variables had significant results being financial incentives, charging infrastructure and presence of production facilities had significant and positive correlation with that countries BEV market share. The other variables they also analyzed were urban density, education level, an environmentalism indicator, fuel price, EV price, vehicles per capita, model availability, introduction date and electricity price. The majority of countries that were included in this study were in Europe with the exception of Australia, China, Israel, Japan, New Zealand, and the US. The study also explains that their

descriptive analysis did however not show that financial incentives or charging infrastructure ensured high electric vehicle adoption rates. (Sierzchula, et al. 2014)

A study by Helveston et. al, conducted in China and the US showed that gasoline vehicles were still preferred instead of BEVs in both countries. The results also concluded that American consumers have lower willingness to pay for BEV technology compared to consumers in China. The main reasoning for the differences between the countries is due to the differences between consumer needs and expectations in both markets. Factors that make Chinese consumers more willing to adapt BEVs is that Chinese consumers lack experience from both BEVs as well as ICEVs, meaning that consumers have less expectations from both vehicle types. Furthermore, Chinese consumers are also familiar with charging routines through use of electric bicycles, an issue that also resides with BEV ownership. The conclusion also states that compared to the US, China also has major intercity trains which provide access between cities reducing need for vehicles. The study as well mentions that less oil dependency is a national security benefit for China, meaning that the government also has incentives towards BEV adoption (Helveston, et al. 2015).

Government incentives effects on hybrids have also been studied. A study conducted by Diamond looked at hybrid adoption over time in specific states that had recently changed their incentive policies and compared it to the average US adoption rate. The studies results indicated that gasoline prices played a greater role in hybrid adoption rates compared to incentive policies. It also concluded that incentives with upfront payments were most effective (Diamond, 2009).

A survey study by Bjerkan, Noerbech and Nortoemme (2016) in Norway looked at BEV incentives among almost 3400 BEV owners. The results showed that up-front price reduction such as exemption from VAT and purchase tax were most essential factors for consumer in their BEV purchase. Less critical incentives for BEV adoption was exempt from road tolls and license fee reduction. The study also looked at other available incentives in Norway such as, free parking, bus lane access & free ferry tickets, but concluded that these were only essential for smaller groups of consumers (Bjerkan, Noerbech, & Nordtoemme, 2016).

1.3.2 Connection to literature

Previous literature has looked at how consumers and their willingness to pay for different attributes of electric vehicles. They have also looked at how different factors such as, financial incentives, pollution, fuel saving, etc., affect electric vehicle adoption in different

countries. Many of the different studies have also used surveys in order to get a view on how different consumers value different features of electric vehicles. Some of the aspects that this paper will focus on and analyze does have similarities with other previous research, but this paper differs for two main reasons. The first is that this paper focuses on how education as a channel for environmental awareness affect BEV adoption, the second difference is that as this paper will only focus on Sweden.

2. Theory

In order to get a wide grasp on the effects on BEV adoption rates in Sweden I've chosen different variables that attempt to examine the different concerns that consumer have when it comes to BEV adoption. These variables try to explain most of the aspects of decision making when it comes to purchasing a BEV. The different main factors I have chosen to investigate, attempt to see the effects on adoption of BEVs through capturing consumers´ environmental concerns, economic concerns (both initial and running), willingness to adopt new technology through consumers age, and the convenience of owning a BEV. In order to capture consumers environmental concern, I will be using consumers average education levels on municipal level. Consumers´ economic concern is captured through data of municipal median incomes and total distance travelled of all cars in a municipality, divided per inhabitant around Sweden. Data concerning income will take into account the initial cost of purchasing a BEV while data from municipal travelling distances will be used to see how running costs impact BEV adoption. Driving distance is also affected by another important aspect which is that BEVs have a limited range meaning that consumers who travel far distances might not be able to own a BEV. In order to see if age plays a significant role in BEV adoption rates municipal median age level will be compared to their adoption level in Sweden. Convenience of owning a BEV is also included in this analysis as it is a one of the main unique aspects of owning a BEV's and will be analyzed by using data on municipal living accommodations.

2.1 Environmental Concern

One of the main reasons for why educated consumers are looking at adopting BEVs instead of ICEVs is due to electric vehicles not emitting any pollution while they drive. Education plays a noteworthy part in shaping Sweden, as education is compulsory and therefore its effects are population wide. As education effect a majority of the population I expect that it will play a significant role in adoption rates. The main focus in this paper is the impact that education has on consumers environmental awareness. A paper by A. Meyer (2015) showed

through survey´s that education did have an effect on individuals concern for their social welfare prompting them to be more environmentally friendly. The idea of education as a solution to the world environmental issue is further reinforced by the adoption of environmental education. A recent paper found that environmental education was in fact significant in inducing green behavior among citizens (Varela-Candamio, Novo-Corti, & García-Álvarez, 2018). Environmental education also aids in increasing the environmental knowledge among students. (Zsóka, et al. 2013). Environmental education in Sweden can be traced back to 1968 when the Swedish National Agency for Education started an investigation called SMIL (School Fostering of Environmental Protection) which resulted in a new environmentally aware curriculum (Breiting & Wickenberg, 2010). Breiting and Wickenberg also stated that some authors argued that environmental education has existed in Sweden since 1919 when the National School Plan was adopted which contained aspects of environmental awareness. The fact that environmental education has been part of the education system for at least 50 years tells us that a majority of the population that have higher levels of education have forgone some sort of environmental education. (Breiting & Wickenberg, 2010)

Using the mentioned theories from earlier I expect that more educated citizens in Sweden will be more environmentally aware, meaning that municipalities with higher levels of education will have higher rates of BEV adoption.

2.2 Economic Concern

Consumers economic concerns are also being analyzed in this study. The intention of including economic concerns in the regression is in order to take into account any economic benefits that come with higher levels of education. Consumers economic concerns include both, economic availability and affordability as well as economic incentives that coincide with BEV adoption such as running costs. As mentioned previously higher education usually leads to higher incomes as higher levels of education tend to lead to better payed jobs (Debusmann, 2011).

Economic availability and affordability will be measured from data on median income levels on a municipal level. I expect that income will have a significant impact on adoption rates as BEV's have in general a higher purchasing price compared to ICEVs. This means that if consumers incomes are greater, there is a greater chance that the consumer will adopt a BEV as they are less bound by borrowing constraints. To clarify, with borrowing constraint it is meant to signify the constraint that low-income consumers have when it comes to purchasing a BEV due to the high upfront cost. While consumers with high levels on income

would be able to purchase a BEV without having the same level of borrowing constraint as well as economic burden. In the Netherlands the average purchasing price of a BEV is around €79,000 while a petrol and diesel vehicles cost around €25,000 and €43,000 respectively (Pas, 2017). The same effect where BEVs have a higher initial cost compared to similar ICEVs can also be seen in the US (Kiley, 2016). The main reason for this extra cost is the cost of the battery (Bjornstad, 2016). As this initial cost is paid by the consumer when they are purchasing their car this is seen as an additional cost to consumers. This additional cost of battery production only exists on BEV´s rather ICEV´s and doesn't lead to any direct benefit for the consumer. If a consumer only wanted and needed a vehicle that can take them from point A to point B, then your typical consumer would choose the cheapest option. This means that BEVs have an additional barrier not only through BEVs being more expensive but also the fact that some consumer simply cannot afford this extra cost. Due to this I believe that higher income will have a positive effect with the BEV adoption rates. An important circumstance to mention is that the additional cost of BEVs is being counteracted by governments through subsidies but since this study is only looking at Sweden where BEVs subsidies and tax exemption are the same across a national level, government incentive will not be analyzed in this paper.

As mentioned earlier the other aspect of economic concerns that will be analyzed is the running costs. Running costs will work as a proxy for consumers concern regarding fuels costs as BEVs have lower running costs. This will be done by using data containing the distance the average inhabitant travel under one year. One of the main selling points for BEVs is that they have lower running cost then ICEVs. This means that consumer who travel and drive a lot will see greater economic benefits in the long run. While BEVs are cheaper if consumers drive a lot, these economic benefits do come at a cost. One of biggest concerns with BEV adoption is the concern of the limited range that BEVs have. Compared to ICEVs, BEV drivers cannot simply stop and refuel in minutes, instead they need to find a charging station and wait on average of around 30 minutes for 80% charge (FAQ om Elbilar, u.d.). Distance as a variable has two opposite effects on adoption rates, making it difficult to predict the result that distance will have on adoption rate at a municipal level**.** Based on the results from Klöckner et al. (2013) I expect that running costs will be the dominating factor. The main reason for this is that as this study concluded, that consumers used their electric vehicles for everyday mobility. While its doesn't specify exact distance, it's probable that everyday travel consists mainly of multiple short trips, for example they mentioned picking up kids (Klöckner et al. 2013).

2.3 Age

Even though electric vehicles have existed for some time they haven't been used conventionally in the automotive industry. As BEVs are being considered as a new form of technology I will be looking at how age of consumers affect BEV adoption rates. A study on hybrids showed that for every year older a respondent was, their interest in adopting a hybrid decreased by 0.42%. (Carley et al. 2013). While as mentioned previously, hybrids and BEVs have many differences when it comes to their features but, they still both share some of the same concerns such as range and a higher markup cost. Due to this, the results from this study are relevant to BEVs. Other studies aimed towards BEVs suggested that adoption rates for BEVs are more likely for middle aged men with technical profession (Plötz et al. 2014).

Due to data restrictions this study will not look at adoption difference between gender but will focus more on age. I expect that young and middle-aged adults are typically being early adopters, and that we will see a negative effect between age and BEV adoption levels in Sweden.

2.4 Convenience to own a BEV

Living accommodation plays an important role when it comes to convenience for owning a BEV and charging a BEV. The variable that will be used to measure convenience is the percentage of the population that live in houses. This variable is relevant towards convenience as people living in houses can install charging stations at home, a solution not as easily available to people living in apartments. While BEV owners do not need to install a charging station at home, it greatly increases charging speeds. Charging a BEV from a regular outlet adds about 2-5 miles of range per hour, while a charging station add 10 to 60 miles of range per hours (Department of Energy, u.d.). People living in houses will be able to install charging stations at home whilst people living in apartments are less likely to have personal parking spots and may depend on public parking that may or may not have a charging station. I expect that living accommodations, more specifically the proportion of the population that lives in houses compared to people living in apartments will have a large effect on BEV adoption. As with ICEVs, BEV owners cannot simply and easily recharge their car on the way to or from work but would preferably recharge their vehicle when it is not at use. A study by Skippon and Garwood also shows that most BEV owners will charge at home overnight (Skippon & Garwood, 2011). Due to this I expect that municipalities with a high proportion of the population living in houses will have higher rates of adoption of BEVs.

2.5 Environmental Party

In order to further check and confirm my hypothesis that education can be used as a proxy to channel environmental awareness I will be running an additional regression. The regression will have the percentage of the population that voted for the environmental party in the 2014 election as the dependent variable and education as the independent variable.

Even though political parties have many agendas and Miljöpartiet (MP), the Swedish environmental party, have specific views on subjects that do not regard the environment, for example immigration policies, I suspect that the majority of the voters consist of consumers feeling strongly for the environment and want to support environmental protection. As this is a more controversial variable it does have weaknesses such as a political party‘s diverse views will lead to consumers not basing their vote solely on one aspect of the party’s view. Voters will most likely base their vote on the consumer’s opinion of the party as a whole. I expect this will lead to a few environmentally concerned consumers to choose other parties that better support their whole agenda. I imagine also that this will also lead to non-environmentally concerned consumers choosing to vote for MP for reasons not related to their environmental views and goals. Even though this is the case I expect that it shows environmental awareness.

Table 1: Results from Regression where Education is run against Environmental party

VARIABLES	(1) Environmental Party
Education2016	0.324***
	(0.030)
Constant	1.346***
	(0.305)
Observations	290
R-squared	0.608

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1 shows that when education levels in a municipality increases by 1%, the amount of inhabitants in the municipality that voted for the environmental party increases by 0,324, a statically significant result. While this result may seem small it does show that education and percentage of voters for the environmental party are related. This also shows us that education has a positive impact on environmental awareness as seen by the positive coefficient.

3. Data

The goal of this paper is to see how education affects BEV adoption rates in Sweden. Data from specific individuals was preferred but due to lack of availability data municipal data was used instead. The data consists from all 290 municipalities in Sweden giving a wide geographical sample. All regressions have been run using robust standard error in order to take in account any heteroscedasticity.

3.1 Dependent Variables

In order to proxy for adoption levels in Sweden I will be using data from Statistiska Centralbyrån (SCB) consisting of data showing the amount of newly registered BEV´s per municipality (SCB, 2018a). This data is proxy towards BEV adoption rates as the data consists of all the newly registered BEVs in the municipality. This means that the data also includes consumers that already have a BEV as well as consumers that have moved between municipalities, resulting in the data not showing exact adoption levels. To account for the difference between population levels leading to high populated municipalities having more newly registered BEVs the data was transformed to per 10,000 inhabitants. This was calculated from the amount of newly registered BEV's per municipality and the population of each municipality. The data for municipal population in 2017 was also gathered from SCB (SCB, 2018b). Changing the data to BEV's per 10.000 gives a more accurate view of how the independent variables affect the dependent variable.

Table 2 Summary Statistics for Municipality Population and Newly Registered BEV's

Variable	Mean	Standard Deviation	Observations	Median
Population (2017)	34466,04	71178,9	290	15689
Newly Registered BEVs (2017)	2.78	2.89	290	2.12

Table 3 shows the summary statistics for BEVs adoption rates in 2017. The results show that the mean BEV adoption rates is 2.78 per 10,000 inhabitants. The results also show that the standard deviation of adoption is 2.89 meaning that the spread of the data is large among municipalities.

Table 3 Summary Statistics for Newly registered BEV's per 10,000

Variable	Mean	Standard Deviation	Observations	Median
BEV Adoption Rate	2.78	2.89	290	2.12

3.2 Independent Variables

3.2.1 Education

The data chosen to represented education as a variable was collected from SCB and included statistics from two different levels of education from 2016 (SCB, 2018c). The first is "The proportion of the population that has at least 3 years extra education after high school (population between 25-65 years of age)" and second "Post graduate education". The municipal data from both variables were first added together and then transformed from total amount of inhabitants with higher levels of education, to percentage of the municipal inhabitants using population data from 2016 (SCB, 2018b). This data is portrayed in the "Education" variable.

Table 4 shows that the mean percentage of inhabitants with higher levels of education in municipalities is 11.13% while the median percentage is 9.80%. Overall the data supports that there is a variety in additional education levels across municipalities in Sweden as seen by the standard deviation being 4.62.

Table 4 Summary statistics for Education

Variable	Mean	Standard Deviation	Observations	Median
Education (2016)	11.13	4.62	290	9.80

Table 5 shows the results when estimating a linear model using OLS, education against BEV adoption in a linear regression. The results show that for every percentage increase in population with higher education, the amount of BEVs adopted in a municipality increases by 0.352 per 10,000 inhabitants, a statistically significant result. The regression also shows that there are other factors that are affecting the results as shown by the statistically significant

constant. R^2, a measurement of how much the model explains that data is 0.315 (Dougherty, 2011).

This result falls in line with the theory and hypothesis that consumer that have higher levels of education are more likely to adopt a BEV due to higher environmental awareness. Whilst this result is statistically significant, it is not possible to exactly identify whether this is due to only environmental concern or other factors such as higher educated consumers have higher levels of income. A linear regression including control variables will be run in section 4: Results.

Table 5 One Variable Regression with Education

VARIABLES	(1) BEV Adoption Rate
Education (2016)	0.352***
	(0.048)
Constant	-1.140**
	(0.474)
Observations	290
R-squared	0.315

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

3.2.2 Income

The data for median annual income was collected by ekonomiefakta and is data from 2016 (Ekonomifakta, u.d.). The data included data from inhabitants that were 20 years or older. The data was transformed from total Swedish krona, into per 100,000Sek. This data is portrayed in the "Income" variable. Table 6 shows that the differences in median income between municipalities is small as seen by the standard deviation being 0.27. The data shows that mean and median, average income in municipalities is 2.61 and 2.56 respectfully. The data doesn't support that there is a large difference in income within Sweden, but this is mainly due to the data for each municipality is already in averages meaning that the data doesn't portray high- and low-income consumers but instead the average inhabitant in each municipality.

Table 6 Summary Statistics for "Income"

Variable	Mean	Standard Deviation	Observations	Median
Income (in 100.000kr)	2.61	0.27	290	2.56

Table 7 shows the results when running a linear regression with income as the independent variable. The results show that when the median income in a municipality increases by 100,000kr, the amount of BEVs adopted in the municipality increases by 5.015, a statistically significant result. The results also show that the constant is -10.312 meaning that there are other factors affecting adoption rates. R^2 in this regression is 0.223 further proving this point.

The results in table 7 supports the theory that income has a positive impact on BEV adoption. The results also seem logical as consumers who have lower levels of income would have a much harder time being able to afford the extra initial cost the comes with purchasing a BEV.

Table 7 One Variable Regression with "Income"

VARIABLES	(1) BEV Adoption Rate
Income in 100000kr	5.015***
	(0.836)
Constant	-10.312***
	(2.103)
Observations	290
R-squared	0.223

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

3.2.3 Age

The data for median age at a municipal level was collected from SCB and is data from 2016 (SCB, 2017). This data is portrayed in the "Age" variable. Table 8 shows that there is a low variety in median age levels in municipalities. The table shows that the mean and median average age for municipalities is 43,24 and 43.51 respectfully. Furthermore, the table also shows the standard deviation is 2.56 meaning that the variety in median age among municipalities is small. This data doesn't portray that there is a large variety in age between municipalities which might have an effect on the variables impact on the independent variable. This is due to the same reason as mentioned earlier, being that the data used is the average inhabitant in a municipality. Even though there is only a small difference between municipalities I expect this variable to still have a notable effect on the independent variable.

Table 8 Summary Statistics for "Age"

Variable	Mean	Standard Deviation	Observations	Median
Age	43.24	2.56	290	43.51

Table 9 shows the results when running a linear regression with median age as the independent variable. The results show that when the median age in a municipality increases by one year the amount of BEVs adoption rate decreases by 0.462, a statistically significant result. The regression also shows that there are other factors that affect BEV adoption as seen by R^2 being 0.167.

Even though the data used in this regression is in median age levels for different municipalities in Sweden rather than specific individuals the results from the regression supports the results from Carley, et al. (2013) I suspect that this has to do with that age plays a strong role in BEV adoption levels and that if the data used in this regression were to be data from specific individuals the coefficient would be greater and the results more intriguing.

Table 9 One Variable Regression with "Age"

VARIABLES	(1) BEV Adoption Rate
Age	-0.462***
	(0.079)
Constant	22.742***
	(3.511)
Observations	290
R-squared	0.167

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.

3.2.5 Distance

The data for distance travelled per inhabitant per 10km was collected from Länstyrelsen and is total distance travelled in 2016 per inhabitant (Länstyrelsen, 2017). The data is calculated by adding to total kilometer driven by all cars in the municipalities and dividing this total by the number of inhabitants, giving averages per inhabitant. The data was transformed from being in 10kms to 1,000km. The consequence of the data being total distance driven for the average inhabitant is that the data for all the municipalities are more similar and doesn't take into account inhabitants that travel short and long distances. This data is portrayed

in the “Distance” variable. Table 10 shows that the mean and median values of the variable “Distance” is 7.72 and 7.83 respectfully. The standard deviation of 1.04 shows that there is a low variety between municipalities when it comes to total distance travelled under a year.

Table 10 Summary statistics of “Distance”

Variable	Mean	Standard Deviation	N	Median
Distance (in person, in 1,000km)	7.72	1.04	290	7.83

Table 11 show the results from a linear regression where distance is the independent variable. The results show that when the distance travelled during one year increases by 1,000km, the BEV adoption rate decreases by 0.562, a statistically significant result. The table also shows that there are other factors that affect BEV adoption. This is seen through the statistically significant constant as well as the low R^2. The results from this regression does not fall in line with the theory that expected that the distance variable would have a positive impact on BEV adoption.

Table 11 One Variable Regression with “Distance”

VARIABLES	(1) BEV Adoption Rate
Distance	-0.562***
	(0.177)
Constant	7.112***
	(1.418)
Observations	290
R-squared	0.041

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

3.2.7 Residence

The data concerning inhabitants living locations was collected from SCB statistics website and is from 2016 (SCB, 2018d). The data was compiled from the percentage of the population that lived in houses with proprietorship, housing cooperative and living with a tenancy right. The data also had certain data points which did not show a percentage of inhabitants living in that form of household. This was due to there was either less then 5 households or 5 people in one of the three categories due to privacy reason. These data points were altered to zero when compiling the data. SCB also mentioned that a few households are

missing from the data as not everyone is registered in a household. The definition used for "house" by SCB included detached single and two-family houses, semidetached houses, terraced houses and townhouses. The value represents the percentage of inhabitants that live in houses rather than for example an apartment. This data falls under the "Residence" variable.

Table 12 shows that the mean and median percentage of inhabitants living in houses is 61.83 and 64.95 respectfully. The table also shows that there is a variance between municipalities, as seen by 14.48 standard deviation but that the data is quite centered towards the mean.

Table 12 Summary statistics of "Residence"

Variable	Mean	Standard Deviation	N	Median
Residence	61.83	14.48	290	64.95

Table 13 shows the results from a regression where Residence is the independent variable. The results show that when the amount of inhabitants increases by 1% adoption rates in the municipality decreases by 0,039, a statically significant result. While this result is not in line with the theory I believe this is because this independent variable only explains 0.038 of the data. The results shows us that there are other factors that play a much greater role in BEV adoption rates. I believe that in a multivariable regression with education and the other control variables mentioned previously in this section, percentage of inhabitants living in houses will show a result more in line with the theory.

Table 13 One Variable Regression with "Residence"

VARIABLES	(1) BEV Adoption Rate
Residence	-0.039***
	(0.015)
Constant	5.172***
	(0.939)
Observations	290
R-squared	0.038

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

3.3 Regression

The data collected will be put into a linear regression. The regression will be as follows:

$$BEVAdoption = \alpha + \beta_1 Education + \beta_2 Income + \beta_3 Age + \beta_4 Distance + \beta_5 Residence + \varepsilon$$

Each coefficient will show how the individual variables effect BEV adoption rates. While the education variable will be my main focus, the other variable have been added as control variables in order to see educations effect on BEV adoption due to environmental concern.

3.4 Data Limitations

The major limitation with the data is that the data is from municipalities. While I still believe that the results will be interesting, and I suspect that the true strength of the variables cannot be seen. This is because to many of the data points are formed by the average inhabitant in a municipality. The consequence of this is that the data does not take into account inhabitants that lie below or above the average, meaning that the results will only show what factors affect the average inhabitant. For example, the results will not portray whether an inhabitant with a low level of income but living in a house and a municipality with a high number of houses will adopt a BEV.

4. Results/Analysis

Table 14 shows the results from five different linear regressions. The first regression is a single variable regression with "Education" as discussed in the previous section.

In order to single out educations impact on BEV adoption as a channel for environmental awareness, income is added to the second regression as a control variable. The second regression shows that income has an effect on BEV adoption rates. When the average income in a municipality increases by 100,000SEK, the adoption rates increase by 1.540. The P value of this result below 0.05 meaning that the result is statistically significant at the 5% level. Adding Income into the regression did have an impact on educations effect on BEV adoption rates. In the second regression, when the percentage of inhabitants that have a higher level of education increases by 1%, then the amount of BEV's adopted in the municipality increases by 0.287 per 10,000 inhabitants, a statistically significant result. Adding "Income" as a variable in the regression did increase R^2 to 0.325 meaning that the regression did improve as a result and that educations effect on BEV adoption is more isolated.

The third regression adds "Age" as an additional variable in order to see if BEV adoption rates are affected by typical early adopters. The regression shows that age has a negative effect on BEV adoption rates. When the average age in a municipality increases by one year the adoption rate decreases by 0.07 per 10,000 inhabitants. This result is although not statistically significant. Adding "Age" as a control variable showed decreased the effect that income had on BEV adoption. Income was also no longer statistically significant in the third regression. I suspect this has to do with that in general, older consumers have more money as they have worked for more years then younger consumers. This could mean that age has a greater effect on BEV adoption compared to income levels. Table 16 shows that education still has a statically significant effect on BEV adoption. Adding "Age" also improved the regression R^2 to 0.327.

The fourth regression takes into account distance. Adding "Distance Travelled" into the regression lead to significant improvement. Prior to adding distance into the regression only education had a statistically significant result on the BEV adoption rates. When the distance control variable was added, age became statistically significant. I believe that adding distance signaled out the effect that age has on BEV adoption. The fourth regression shows that educations effect on BEV has become greater and has a statistically significant positive effect on BEV adoption. The coefficient has increased from 0.275 to 0.339 meaning that municipalities with higher percentage of its inhabitants with higher levels of education lead to greater BEV adoption levels. The results also show that distance travelled has a positive effect on BEV adoption and is statistically significant. This means that for every 10,000 kilometers more the average inhabitant travels in a municipality, the BEV adoption rates increase by 0.812 per 10,000 inhabitants. R^2 has now also improved to 0.371 meaning that the regression explains more of the data set.

The fifth regression adds the control variable for convenience, specifically convenience behind owning a BEV into account. This is done by analyzing inhabitant's types of residence, more specifically the proportion of the population that lives in houses. Residence has a small positive effect but statistically insignificant effect on BEV adoption rates. The final regression shows that education and distance travelled have a positive effect on BEV adoption rates while age has a negative effect. Income still has no statistically significant effect on BEV adoption rates. R^2 was slightly improved after adding "Residence" to the regression.

Table 14: Multivariable Linear Regression with Education

VARIABLES	(1) BEV Adoption Rate	(2) BEV Adoption Rate	(3) BEV Adoption Rate	(4) BEV Adoption Rate	(5) BEV Adoption Rate
Education (2016)	0.352***	0.287***	0.275***	0.339***	0.351***
	(0.048)	(0.044)	(0.046)	(0.046)	(0.049)
Income in 100000kr		1.540**	1.263*	0.897	0.684
		(0.724)	(0.749)	(0.752)	(0.714)
Age			-0.070	-0.241***	-0.250***
			(0.061)	(0.070)	(0.075)
Distance Travelled				0.812***	0.728***
				(0.166)	(0.206)
Residence					0.010
					(0.016)
Constant	-1.140**	-4.437**	-0.544	0.811	1.645
	(0.474)	(1.768)	(3.743)	(3.617)	(3.823)
Observations	290	290	290	290	290
R-squared	0.315	0.325	0.327	0.371	0.372

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5. Discussion

The final result showed that three of the five independent variables were statistically significant. The three significant variables were education, age and distance travelled.

Education was used to proxy the environmental awareness among consumers. The final regression show that education has a positive impact on BEV adoption rates in Sweden. This is aligned to the theory section which predicted that consumers with higher levels of education would be more willing to adopt a BEV. These results correspond with Meyer, Varela-Candamio et al. (2018) and Zsóka et al (2013) that had results showing that higher education, as well as environmental education lead to increased environmental awareness and there for greener behavior. Even though β_1 is as hypothesized I suspect that the coefficient is greater than in reality. I suspect this is due to the Income control variable used municipal averages instead of individual data. This means that the data doesn't include individuals with above or below average income meaning that the data is not a diverse as income levels are in reality and as a result the barrier on initial cost may have been neglected. While this may have affected the

results, the results do show that education as a channel for environmental awareness does have a positive impact on BEV adoption rates.

Income and distance were used as proxies to see consumers economic concerns with BEV adoption. Income, with support from the theory, was expected to have a positive impact on BEV adoption rates which the results did show. However, the results were not statistically significant. I suspect this has to do with, as mentioned earlier, that the data for income is in median income for different municipalities in Sweden. I suspect that the results from the regression would be different if the data used was from specific individuals.

The results showed that distance has a positive effect on BEV adoption. Although this is in line with the hypothesis, the results differ from the single variable regression that was run in section 3.2.5. The results show that the economic gain consumers get from cheaper running costs outweighs the fear of lack of range. This is supported with results from Klöckner, Nayum, & Mehmetoglu, as mentioned prevously.

The regression also shows that age has as predicted a negative effect on BEV adoption which complies with Kennedy and Funks (2016) results that younger adults are more willing to adopt new forms of technology. The results do coincide with Plötz, et al. (2014).

The regression also concluded that residence had a positive effect on BEV adoption, although the result is statistically insignificant. This coincides with the theory that showed that the majority of BEV owners do charge at home. I speculate that the reason why this result was not significant is that municipalities that have low percentages of inhabitants living in houses are most likely cities. This could mean that a large proportion of the inhabitants don't own any form of vehicle weakening this variable. I suspect that if this variable was transformed to consider proportion of inhabitants that own vehicles the variable would give a more interesting result.

6. Conclusion

This study concludes that education as a channel for environmental awareness does play a significant role on BEV adoption. The main reason behind this is that higher levels of education in Sweden leads to greater environmental awareness and therefor increasing BEV adoption levels. The results also showed that age negatively impacted BEV adoption while consumers who drove more during the year were more likely to adopt a BEV. While the data has some constraints that shouldn't be disregarded the results still have implications. As air pollution is a dominant issue in many cities across the world, BEVs should be considered as a potential solution, at least at a local level. In order for Sweden and other similar countries to

increase the amount of BEVs present they should focus on conveying forward BEVs as a solution towards local environmental air pollution as well as continue with environmental education. Governments should also focus on making BEVs more available to youths and young adults as studies show that municipalities with a higher median age among inhabitants tend to have lower adoption levels. This could be done through subsidies specifically aimed at younger adults that can afford an ICEV but not a BEV. Governments should also focus on showing consumers the benefits of owning a BEV for daily commuting not only through economic incentives but also for environmental reasons. Decreasing local pollution from vehicles in cities through electric vehicles would benefit countries expenditures on related health care as well as the loss in human capital. This means that BEVs would not only benefit governments but also taxpayers.

Further study should be done in Sweden to see what effect individual data would have on the regression. It would be interesting to analyze if there is a connection between age and distance, as the results from this paper showed that age became statistically significant when distance was added to the regression. Furthermore, a study comparing two countries with different financial incentives in order to see if income has an significant effect on BEV adoption would also be an interesting area to research.

References

Albers, A., Ili, S., & Miller, S. (2010, June). Open innovation in the automotive industry. *R and D Management*, 246-255.

Bjerkan, K. Y., Noerbech, T. E., & Nordtoemme, M. E. (2016). Incentives for promoting Battery Electric Vehicle (BEV) adoption in Norway. *Transportation Reasearch Part D: Transport and Environment, 43*, 169-180.

Bjornstad, E. (2016, 01 21). *Electric Cars: Great Idea, But Why So Expensive?* Retrieved 05 13, 2018, from Bellperformance: https://www.bellperformance.com/blog/electric-cars-great-idea-but-why-so-expensive

Breiting, S., & Wickenberg, P. (2010). The progressive development of environmental education in Sweden and Denmark. *Environmental Education Research, 16*(1), 9-37.

Carley, S., Krause, R. M., Lane, B. W., & Graham, J. D. (2013). Intent to purchase a plug-in electric vehicle: A survey of early impressions in large US cites. *Transportation Research Part D: Transport and Environment, 18*, 39-45.

Debusmann, B. (2011, 08 05). *Education pays off in better jobs, higher salaries*. Retrieved 05 09, 2018, from Reuters: https://www.reuters.com/article/us-education-earnings/education-pays-off-in-better-jobs-higher-salaries-idUSTRE7746CW20110805?feedType=RSS

Department of Energy. (n.d.). *Charging at home*. Retrieved 05 23, 2018, from Department of Energy: https://www.energy.gov/eere/electricvehicles/charging-home

Diamond, D. (2009). The impact of government incentives for hybrid-electric vehicles: Evidence from US states. *Energy Policy, 37*(3), 972-983.

Dougherty, C. (2011). *Introduction to Econometrics* (Vol. 4). New York: Oxford University Press.

Ekonomifakta. (n.d.). *Nyckeltal för alla regioner*. Retrieved 04 22, 2018, from Ekonomifakta: https://www.ekonomifakta.se/Fakta/Regional-statistik/Din-kommun-i-siffror/Nyckeltal-for-regioner/?var=17249,17251

FAQ om Elbilar. (n.d.). Retrieved 05 09, 2018, from Ladda Elbilen: http://www.laddaelbilen.se/elbilar/fakta-om-elbilar/faq-om-elbilar-6407563

Guo, X. R., Cheng, S. Y., Chen, D. S., Zhou, Y., & Wang, H. Y. (2010). Estimation of economic costs of particulate air pollution from road transport in China. *Atmospheric Environment, 44*(28), 3369-3377.

Helveston, J. P., Liu, Y., Feit , E. M., Fuchs, E., Klampfl, E., & Michalek, J. J. (2015). Will subsidies drive electric vehicle adoption? Measuring consumer preferences in the U.S. and China. *Transportation Research Part A: Policy and Practise, 73*, 96-112.

Hidrue, M. K., Parsons, G. R., Kempton, W., & Gardner, M. P. (2011). Willingness to pay for electric vehicles and their attributes. *Resource and Energy Economics , 33*(3), 686-705.

Holland, S. P., Mansur, E. T., Muller, N. Z., & Yates, A. J. (2016). Are There Environmental Benefits from Driving Electric Vehicles? The Importance of Local Factors. *American Economic Review, 106*(12), 3700-3729.

Kiley, D. (2016, 02 29). *Report: Cost Of Electric Vehicles Falling Fast, Will Drive Demand*. Retrieved 05 09, 2018, from Forbes: https://www.forbes.com/sites/davidkiley5/2016/02/29/report-cost-of-electric-vehicles-falling-fast-will-drive-demand/#5525c7983ea9

Klöckner, C. A., Nayum, A., & Mehmetoglu, M. (2013). Positive and negative spillover effects from electric car purchase to car use. *Transportation Research Part D: Transport and Environment*, 32-38.

Krzyzanowski, M., Kuna-Dibbert, B., & Schneider, J. (2005). *Health effects of transport-related air pollution.* Copenhagen, Denmark: World Health Organization. Regional Office for Europe.

Länstyrelsen. (2017, 05). *Körsträckedata.* Retrieved from RUS: http://extra.lansstyrelsen.se/rus/Sv/statistik-och-data/korstrackor-och-bransleforbrukning/Pages/default.aspx

Meyer, A. (2015). Does education increase pro-environmental behavior? Evidence from Europe. *Ecological Economics*, 108-121.

Miljöfordon. (n.d.). *Rökna På Utgifterna*. Retrieved April 2018, from miljofordon: www.miljofordon.se/ekonomi/

Pas, B. v. (2017, 10 04). *Buying an Electric Car the Most Expensive [Digital image]*. Retrieved 05 09, 2018, from Statista: https://www.statista.com/chart/11341/buying-an-electric-car-the-most-expensive/

Plötz, P., Schneider, U., Globisch , J., & Dütschke, E. (2014). Who will buy electric vehicles? Identifying early adopters in Germany. *Transportation Research Part A: Policy and Practice, 67*, 96-109.

SCB. (2017, 02 21). *Sveriges befolkning kommunala jamforelsetal 31 december 2016.* Retrieved from SCB: http://www.scb.se/hitta-statistik/statistik-efter-amne/befolkning/befolkningens-sammansattning/befolkningsstatistik/pong/tabell-och-diagram/helarsstatistik--kommun-lan-och-riket/sveriges-befolkning-kommunala-jamforelsetal-31-december-2016/

SCB. (2018a, 02 15). *Fordon i län och kommuner 2017.* Retrieved 05 13, 2018, from SCB: https://www.scb.se/hitta-statistik/statistik-efter-amne/transporter-och-kommunikationer/vagtrafik/fordonsstatistik/pong/publikationer/fordon-i-lan-och-kommuner-2017/

SCB. (2018b, 02 21). *Folkmängd i riket, län och kommuner 31 december 2017 och befolkningsförändringar 1 oktober–31 december 2017. Totalt.* Retrieved 04 22, 2018, from SCB: https://www.scb.se/hitta-statistik/statistik-efter-amne/befolkning/befolkningens-sammansattning/befolkningsstatistik/pong/tabell-och-diagram/kvartals--och-halvarsstatistik--kommun-lan-och-riket/kvartal-4-2017/

SCB. (2018c, 04 19). *Statistical Database - Select Variables and Value.* Retrieved from Statistiska Centralbyrån: http://www.statistikdatabasen.scb.se/pxweb/en/ssd/START__UF__UF0506/Utbildning/?rxid=f45f90b6-7345-4877-ba25-9b43e6c6e299

SCB. (2018d, 04 19). *Statistikdatabasen Välj variabler och värden.* Retrieved 05 08, 2018, from Statistikdatabasen: http://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__HE__HE0111/HushallT22/?rxid=7433c394-09af-4663-8ffd-7f7bf478c2d6

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

Skippon, S., & Garwood, M. (2011). Responses to battery electric vehicles: UK consumer attitudes and attributions of symbolic meaning following direct experience to reduce

psychological distance. *Transportation Research Part D: Transport and Environment, 16*(7), 525-531.

Spadaro, J. V., & Rabl, A. (2001). Damage costs due to automotive air pollution and the influence of street canyons. *Atmospheric Environment, 35*(28), 4763-4775.

State of Indiana. (n.d.). *OED: Electric Vehicles (EVs, HEVs, PHEVs)*. Retrieved 05 22, 2018, from State of Indiana: https://www.in.gov/oed/2675.htm

Statistiska Centralbyrån. (2018, Febuary 15). *Fordon i Län och Kommuner 2017.* Retrieved April 2018, from SCB: www.scb.se/hitta-statistik/statistik-efter-amne/transporter-och-kommunikationer/vagtrafik/fordonsstatistik/pong/publikationer/fordon-i-lan-och-kommuner-2017/.

Stewart, J. (2017, Febuary 3). *Watch How Terrifyingly Bad Car Safety Was Just 20 Years Ago*. Retrieved May 2018, from Wired: https://www.wired.com/2017/02/watch-terrifyingly-bad-car-safety-just-20-years-ago/

W.H.O. (2018, 05 02). *9 out of 10 people worldwide breathe polluted air, but more countries are taking action*. Retrieved from World Health Organisation: http://www.who.int/news-room/detail/02-05-2018-9-out-of-10-people-worldwide-breathe-polluted-air-but-more-countries-are-taking-action

Valmyndigheten. (2014, 10 02). *Röster Val 2014.* Retrieved 05 08, 2018, from data val: https://data.val.se/val/val2014/slutresultat/R/rike/index.html

Varela-Candamio, L., Novo-Corti, I., & García-Álvarez, M. (2018). The importance of environmental education in the determinants of green behavior: A meta-analysis approach. *Journal of Cleaner Production*, 1565-1578.

Williams, B. (2017, 10 03). *Here's how every major automaker plans to go electric*. Retrieved 05 17, 2018, from Mashable: https://mashable.com/2017/10/03/electric-car-development-plans-ford-gm/#Wguh1NUBPiqP

Zsóka, Á., Szerényi, Z. M., Széchy, A., & Kocsis, T. (2013, June). Greening due to environmental education? Environmental knowledge, attitudes, consumer behavior and everyday pro-environmental activities of Hungarian high school and university students. *Journal of Cleaner Production, 48*, 126-138.