**The Demand for Electric Cars in the United States in 2014**

*Research Question: Do the price of the electric cars and the availability of electric charging stations influence the demand for electric cars?*

**Alp Arhan Uguray**

**I. Introduction and Literature Review:**

An electric car is an [automobile](https://en.wikipedia.org/wiki/Automobile" \o "Automobile" \t "_blank) that is [propelled](https://en.wikipedia.org/wiki/Ground_propulsion" \o "Ground propulsion" \t "_blank) by one or more [electric motors](https://en.wikipedia.org/wiki/Electric_motor" \o "Electric motor" \t "_blank), using electrical energy stored in [rechargeable batteries](https://en.wikipedia.org/wiki/Rechargeable_battery" \o "Rechargeable battery" \t "_blank) or another [energy storage](https://en.wikipedia.org/wiki/Energy_storage" \o "Energy storage" \t "_blank) device. Electric motors as a clean energy resource decrease the carbon emissions released by cars provide cost-efficiency due to the low price of the electricity compared to the fossil fuels, and low maintenance costs together with an unmatched torque of acceleration. Electric cars offer substantial economic and environmental benefits, by substituting grid-based electricity for fossil fuels (Egbue and Long 2012).

Electric cars have key advantages compared to gasoline based conventional cars. Yet they also have downsides such as; their range is limited, their purchasing prices are very high and currently few charging stations are available. Hence, it is vital for car manufacturers to define the right pricing strategies and offer more locations for charging stations to understand their impact on individuals’ vehicle choices.

The purpose of this paper is to use OLS regression tools to determine whether the demand of electric cars in the United States is affected by the price of the electric cars and the availability of electric charging stations. For that reason, the following independent variables are chosen: the price of the electric cars, the price of electricity, the price of gasoline, the availability of the charging stations, and median income. This study aims to look at how these factors have a positive or a negative effect on buyer’s incentive to purchase an electric car, specifically EV (Electric-only Vehicle)’s by using cross-sectional data analysis on the average of sales of 13 brands in 2014 across 50 states. Since EVs started to commercialize by 2007, the economic viability of electric cars and thus possible adoption rates are still constrained. As a result, this research will focus on the factors that affect the demand of the electric cars by investigating the sales data.

**Literature Review:**

The consumption of petrol is considered problematic due to costs of oil, doubts about the security of oil supplies, and greenhouse gas (GHG) emissions. As the volatility of oil prices increased over time and greenhouse gas emission started to go high, the dominance of oil on the industry made us realize there can be a more cost-effective and efficient way to use energy resources on the way we think of transportation. To address this problem, electric cars are introduced as the perfect substitute, which are capable of improving both cost-efficiency for the user and urging re-allocation of natural resources as clean energy is adopted for the main source. This may ultimately change the infrastructure of entire energy and transportation industry. However, there are still some constraints that have to be addressed to increase the demand for the electric cars. The relevant agents in determining the demand for the electric cars include: vehicle price, fuel cost, driving range, the availability of charging stations, and charging time are among the important attributes used in consumer demand (Larson 2014).

Electricity has major advantages compared to gasoline or diesel. Nevertheless they also have drawbacks: their range is limited, a full charge of the battery requires up to 8 hours (before fast charges are available) and currently, few charging stations are available. It is therefore critical for car manufacturers to define the right pricing strategies and, most importantly, provide more locations for charging stations to understand their impact on individuals’ vehicle choices (Glerum 2013) EV purchase prices, which are heavily dependent on battery costs, have been identified as being the most significant obstacle to widespread EV diffusion (Brownstone 2000). After conducting surveys and studies to get a sense of reasons that impact the adoption of the electric cars, The Van Westendorp price sensitivity method (PSM) shows the acceptable price range for EVs to be $22,000–27,500 (Larson 2014). This range closely matches average price range for sales of conventional cars during the same period. The willingness-to-pay method reveals consumers are unwilling to pay large premiums for EVs, even when given information on future fuel savings (Larson 2014). This shows that income is a very important variable to consider while seeing the factors that influence the demand for the electric car.

In addition to that, EV adoption is seen as being very limited without stimulation from external factors such as stringent emissions regulations, rising fuel prices, or financial incentives (IEA 2014). Such factors include encouraging the public to purchase EVs through the incentives. For example; almost half of the states in the USA, have tax-exemptions on parking, using highway, monthly tax rate and more to promote the purchase of EVs. As new regulations and strategies on prices, regulations and the market should be implemented to allow the EV market to grow against 90% oil market (Eppstein 2011).

None of the surveyed literature explicitly analyzed the influence of the availability of charging stations, the electric car prices, median income, price of the gasoline and electricity across 50 states on the demand of the electric cars. Consequently, this provides further justification for research, as the topic is unique.

**II. Description of the Econometric Model:**

 A quantitative evaluation of the association between the demand of the electric cars and the variables; the price of the electric cars, price of electricity, price of gasoline, the number of electric charging stations, and median income is performed using an Ordinary Least Squares (OLS) regression. Since the model to estimate the demand of the electric cars uses cost functions, the use of quadratic function is used for the variable ecarprices. On the other hand, for the variables numstations, price\_electricity, price\_gasoline and median income linear functional forms are used. After evaluating the regression results, I have realized that the price\_electricity and price\_gasoline in fact, are in quadratic forms, however, their quadratic forms were statistically insignificant at 5% level based on the estimated model and out of 50 observations. As a result, using the linear forms for the price\_electricity and price\_gasoline provided better results. The only quadratic variable in the estimated model is the variable ecarprices.

**Table 1: Labeling the dependent and independent variables.**

|  |  |
| --- | --- |
| **Dependent Variable Name:** | **Label Titles:** |
| *ecarsales* | Electric Car Sales Across 50 States in 2014 |
| **Independent Variables Name:** | |
| *ecarprices* | Average of Electric Car Prices Across 13 Models After Tax and Incentives in 2014 |
| *price\_electricity* | Price of Electricity Converted to Per Gasoline Gallon Equivalent |
| *price\_gasoline* | Price of Gasoline per Gallon |
| *numstations* | The Number of Public Electric Fueling Stations |
| *medianincome* | Median Income (2014 Dollars) |

Equation 1 represents a linear regression model equation, where ,,,, , , and, represent the magnitude of the association between the Electric Car Sales Across 50 States in 2014 and the independent variables. The variable ecarprices is in quadratic form and the rest of the variables are in linear.

**Equation 1: The Estimated Model:**

The key variables that I am analyzing are ecarprices and numstations. In theory and according to the literature review, it is expected that the coefficients of the price of the electric cars should have a negative sign. As the price of the electric cars increases, fewer people will be able to afford it, and, as a result the demand for it should decrease. In addition to that, in theory, it expected that the price of the electricity and price of the gasoline should have opposite signs because they are substitutes. The expected sign for is negative. As the price of the electricity goes up, potential buyers are expected to choose the alternative cheaper gasoline. On the other hand, is expected to have a positive sign due to the intuition that an increase in gasoline prices would lead potential buyers to purchase electric cars, as a result, increase the sales of the electric cars. The literature review states that the price of the electricity is cheaper compared to the price of the gasoline. Furthermore, the availability of the charging stations, as the literature review states as the most important variable, is expected to have a positive sign. This is because, in theory, as there are more available locations to charge electric cars, the people are more likely to purchase an electric car.

My research question is; *do the price of the electric cars and the availability of charging stations influence the demand for electric cars?*

My hypothesis for this question is that the price of the electric cars and the availability of the charging stations should positively affect the demand for the electric cars, and they are expected to statistically explain the demand of the electric cars.

**III. Data and Methodology:**

***a. Data Sources and Methodology***

To begin with, the dependent variable; the demand of electric cars is estimated by using sales of electric cars data from Electric Vehicle Transportation Center’s Electric Vehicle Sales for 2014 and Future Projections Report for the USA Market, and Forbes Inc. Statista Study on Registered Electric Vehicles in the USA by Niall McCarthy. The data includes only the sales of EV’s, not Hybrid vehicles that use both electric and gasoline for fuel. For each variable, data is collected for 50 states in the USA in the year of 2014. The Electric Car Prices After Tax and Incentives variable estimated by using two different sources in which one of them stated the prices of electric cars across States before tax, and the data from U.S. Department of Energy’s Energy Efficiency & Renewable Energy, Alternative Fuels Data Center in 2014showed the special tax-exemptions and incentives each state offers for purchasing an electric car for an individual. The car models that are used to calculate the average price of EV’s are shown on Table 2 below. The data shows that there is a total of 26 states that offer special tax-exemption policies and incentives up until 2014 in which the incentives include from $1,000 to $7,500 reduction in price for an individual buyer. As a result, the price of the electric car is estimated by subtracting the average price of EVs in the State by the amount of special tax-reduction the state offers. In addition to that, I have included all types of electric cars as part of the variable.

The number of fueling stations in each state in 2014 is determined by using the data from U.S. Department of Energy’s Energy Efficiency & Renewable Energy, Alternative Fuels Data Center. This data shows for each state the aggregated amount of electric vehicle fueling stations, including brands such as Tesla, BMW, and Ford. The price of the electricity for fueling data is collected from U.S. Energy Information Administration Annual Average Price per kWh by State data set in 2014. On the other hand, the price of the gasoline data is collected from Daily Gauge Gas Report 2014 Gasoline Prices per Gallon database. In order to have both of the independent variables have the same units, I have converted kWh to per Gasoline Gallon Equivalent by multiplying each value by the factor of 3.4.

The independent variables in the estimated model show the characteristics of quadratic functional forms. After running several regressions in which I included all the independent variables in quadratic functional forms except numstations, which had linear functional form, I have concluded that the respected t-values were lower than the critical t-values. As a result, I failed to reject the null hypothesis of the quadratic forms for the variables; price\_electricity, price\_gasoline and median income. This means that they were statistically insignificant at 5% level based on the estimated model where there are 50 observations. For that reason, I have dropped the quadratic functional forms for these variables and included only the linear forms in the estimated regression model.

|  |  |
| --- | --- |
| **Table 2: Type of Electric Vehicle's used in the estimation of Average Sales and Average Price of EVs** | |
| **Brands** | **Models** |
| Audi | A3 Sportback e-tron |
| BMW | I3 |
| Chevrolet | Soark EV |
| Fiat | 500e |
| Ford | Focus Electric |
| Honda | Accord EV |
| Kia | Soul EV |
| Mercedes | B-Class ED |
| Mitsubishi | iEV |
| Nissan | LEAF |
| Tesla | Model S |
| Toyota | RAV4 EV |
| Volkswagen | E-Golf |

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 3: Descriptive Statistics: The Factors that Influence the Demand of Electric Cars in the U.S. Across 50 States in 2014** | | | | | | | | | | | |
| **Variables** | **Total** | **Mean** | **Standard Deviation** | **Skewness** | **Kurtosis** | **Min** | **5th Percentile** | **25th Percentile** | **Median** | **75th Percentile** | **95th Percentile** | **Max** |
| **Electric Car Sales** | 146,399 | 2,927.98 | 4,677.08 | 4.02 | 22.17 | 110.00 | 177.00 | 526.00 | 1,396.50 | 3,101.00 | 10,482.00 | 29,471.00 |
| **Average Electric Car Prices Across 13 Models After Tax-Exemption and Incentives** | - | $49,985.29 | 4,774.7 | -$ .41 | 2.11 | $38,796.8 | $41,942.27 | $47,463.65 | $49,615.96 | $ 55,092.43 | $ 55,494 | $ 55,494 |
| **The Number of Electric Fueling Stations** | 13,044 | 260.88 | 464.12 | 5.18 | 32.95 | 2.00 | 11.00 | 44.00 | 158.00 | 323.00 | 698.00 | 3,186.00 |
| **Median Income (2014 Dollars)** | - | $54,962.54 | $9,109.32 | $0.23 | $2.61 | $35,521.00 | $42,278.00 | $48,060.00 | $54,613.00 | $60,708.00 | $71,223.00 | $76,165.00 |
| **Price of Electricity Converted to Per Gasoline Gallon Equivalent** | - | $4.03 | $1.38 | $2.89 | $14.84 | $2.67 | $2.74 | $3.14 | $3.69 | $4.58 | $6.05 | $11.09 |
| **Price of Gasoline per Gallon** | - | $2.23 | $0.21 | $1.07 | $4.75 | $1.92 | $1.97 | $2.11 | $2.21 | $2.35 | $2.71 | $2.88 |
| *Total Number of States with Special Tax-Exemption Policies and Incentives* | *26* |  |  |  |  |  |  |  |  |  |  |  |
| *Observations* | *50* |  |  |  |  |  |  |  |  |  |  |  |

***b. Descriptive Statistics***

Table 3 includes the descriptive statistics for all of the variables in the estimated model. Total electric car sales across 50 States in 2014 are 146,399. The average number of electric car sales is 2,927 units. The minimum and maximum amount of electric car sales are in Louisiana with 110 units sold, and California with 29,471 units sold, respectively. The median sales number is 1,396 units, which is below the average. The table reveals that the range between the maximum sales and minimum sales are 29,361 units. Since the range is very large, the electric car sales have a high variation between the different states, meaning that the dataset has outliers. The median, on the other hand, indicates the extent to which the central values within the data set is dispersed. As a result, median sales number of 1,396.50 gives a clearer picture of the variation of sales numbers across states by removing the outliers.

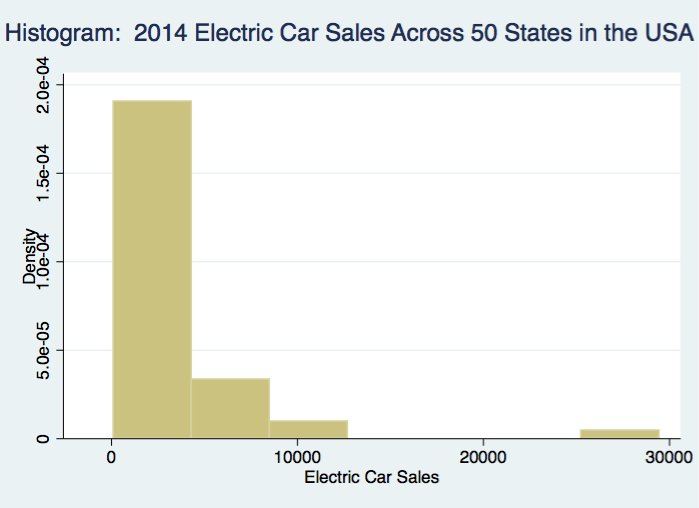
The total number of states that offers tax-exemption and incentives policies is 26. Since, each state has different tax-exemption policies and incentives, the price of electric cars vary depending on the amount of incentives that a state offers. Average electric car prices across 13 models after tax-exemptions and incentives’ mean is $49,985.29 and the median is $49,615.96. The minimum price of the electric car is $38,796.8 in Washington, where the highest tax-exemption and incentive of $7,500 reduction applies. The maximum price is $55,494.00, where there are no tax-exemptions and incentives on purchasing an electric car. The intuition behind this is that if a state offers a large amount of incentive of price reduction on purchasing an electric car, the people should be more inclined towards purchasing one, as the price will be cheaper. The acceptable price range for the EV’s is stated in the literature review as between $22,000–27,500 (Larson 2014). The estimated mean of the average price of the electric car across 13 models after the tax incentives is $22,485.29 larger than the maximum of the range stated by Larson. As a result, it is expected that due to high electric car prices, a potential buyer would purchase the substitute, gasoline-based car.

Table 3 further indicates that the number of electric fueling stations varies across 50 states in 2014. The average number of electric fueling stations is 260, and the median number is 158. The minimum number is 2 in Alaska, and the maximum number is 3,186 in California. Since the range is very high, Table 3 reveals that there are outliers in the dataset. In terms of the relationship between the electric car sales and the number of electric charging stations, it is expected that the potential electric car owners would want to have more locations to charge their cars in a state before they purchase it. The number of fueling stations and the number of sales of electric cars are highest in California.

Examining the table 3 further shows that median income across 50 states in 2014 calculated by using 2014 dollars has a mean of $54,962.54, and median of $54,613.00. The minimum median income is $35,521.00 in Mississippi. And the maximum median income is $76,165.00 in Maryland. The range between the lowest and highest median income is $40,644.00, which shows that there is a large income gap between the states. In theory, the willingness-to-pay method reveals that consumers are unwilling to pay large premiums for EVs, even when given information on future fuel savings (Larson 2014). As the median income of a state increases, the people would be able to afford more expensive cars. That being said, the median income of a state may positively or negatively impact the number of electric car sales depending on the consumer choices. As the income increases, more people will be able to afford electric cars. This assumption should expect an increase in the demand of electric cars in the states where the median income is high. On the other hand, as people’s income increases, it can be also expected that they will buy luxury gasoline cars instead of non-luxury electric cars.

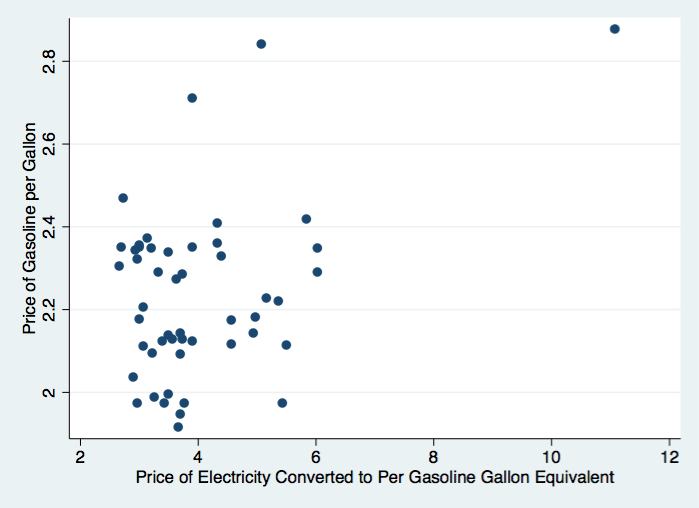
The price of electricity converted to per gasoline gallon equivalent across 50 states in 2014 has a mean of $4.03 and median of $3.69. It has a minimum of $2.67 in Idaho and has a maximum value of $11.09 in Hawaii. The price of the gasoline per gallon has a mean of $2.23 and median of $2.11. The minimum price is $1.92 in South Carolina and the maximum is $2.88 in Hawaii. The range in the price of the electricity and the price of gasoline is $8.42 and $0.96, respectively. There is a very large variation in prices of the electricity across 50 states compared to the variation in the prices of the gasoline. Since the average price of the electricity compared to the average price of the gasoline is larger, it’s more efficient and convenient for a car owner to use gasoline as fuel. Intuitively, it is expected that a car owner would choose the cheaper price option for fuel; as a result, the demand of the electric cars should decrease if the price of the gasoline is cheaper than the price of the electricity. The literature review states that the electric prices should be cheaper than gasoline prices, and argues that it is one of the ways where the electric car becomes cost-effective. In 2014, however, the gasoline prices are cheaper than the electricity prices.

**Graph 1: Histogram: 2014 Electric Car Sales Across 50 States in the USA.**

****

The distribution in the histogram for the dependent variable electric car sales across 50 states is not a normal distribution. The histogram is right-skewed around the mean 2,927.98. There are outliers in the histogram between 10,000 and 30,000.

**Graph 3: Scatter Plot: 2014 Price of the Gasoline Per Gallon vs. Price of Electricity Converted to Per Gasoline Gallon Equivalent in 50 States in the USA**

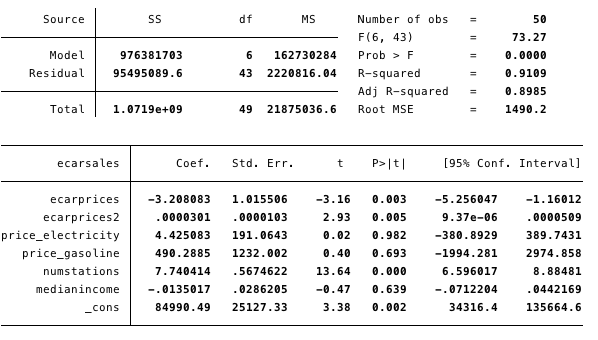
****

The importance of the scatter plot is that it provides insight into the comparison between the price of the gasoline and the price of electricity. The price of electricity is always more expensive than the price of gasoline in all of the states. This argues the statement the literature review makes. If the electricity prices are more expensive than the gasoline, then choosing an electric car is not cost-effective in terms of the fuel-cost savings.

**IV. Estimation Results:**

This section first considers the determinants of the demand of the electric cars by analyzing the estimated regression model, and then examines related T and F tests.

**Table 4: The Results of the Estimated Regression Model**



The results of the estimated regression model in Table 4 reveal the magnitudes and the signs of the coefficients of the independent variables. To begin with, all the other variables held constant, 1 unit increase in the electric car prices leads to 3.208083 units decrease in the sales of the electric cars. The sign and the magnitude meet my expectations and support my original hypothesis, since, in theory, an increase in the electric car prices should decrease the demand of the electric cars as the price will be more expensive and fewer people will be able to afford it. In addition to that, 1 unit increase in ecarprices2 leads to 0.0000301 units of increase in the ecarsales.

For the variable price\_electricity, 1 unit increase in the price of the electricity per gallon equivalent leads to 4.425083 unit increase in the demand of the electric cars. This does not meet my expectations since if the price of the electricity for fuel goes up; the demand of the electric cars should decrease. As more people will look for alternatives for substitution, such as cheaper gasoline-based conventional cars, people will more likely to purchase conventional cars than the electric cars. On the other hand, 1 unit increase in the price\_gasoline variable will lead to a 490.2885 units increase in the demand of the electric cars. This meets my expectations. As the price of the gasoline per gallon goes up, people would choose a substitute for it, as a result, will increase the demand for the electric cars. Since both of the variables were expected to have different signs due to the fact that they are substitutes, I can say that price\_electricity doesn’t meet my expectations. Both price\_electricity and price\_gasoline have very large standard errors, which causes their t-values to decrease.

Furthermore, the sign and the magnitude of the variable numstations meet my expectations and support my original hypothesis. 1 unit increases in the numstations lead to 7.740414 units of increase in the demand of the electric cars. Since, as the number of Public Fueling Stations in a state increases, the availability of access and options for charging will increase as well. As a result, an increase in the number of charging stations will lead to an increase the demand of the electric cars.

The sign of the median income does not meet my expectations. 1 unit increase in the medianincome variable leads to 0.0135017 units of a decrease in the demand of the electric cars. In theory, as people’s income increases more people will be able to afford the electric cars, consequently sales of the electric cars should increase.

The magnitudes of the coefficients of the independent variables further indicate that 1 unit increase in the price of the gasoline per gallon leads to the largest increase in the demand of the electric cars in comparison to the number of public fueling stations and the median income. 1 unit increase in the median income has the lowest amount of increase in the demand of the electric cars. On the contrary, the literature review states that the income is one of the most important variables in determining the demand of the electric cars. However, the estimated regression results show that it has the lowest impact on the demand of the electric cars compared to the other independent variables.

In order to test the individual statistical significance of each variable based on this regression model, I have run one-tailed t-tests for each of the independent variables at 5% level of significance. The decision of using one-tailed t-tests is derived from the shape of the histograms for each variable, where the distributions are not normal and either right and left-skewed. Out of 50 observations, 7 independent variables, degrees of freedom are calculated as 42. The T-Distribution Table indicates that the critical t-value is 1.684.

**Table 5: T-Tests and hypothesis testing for the independent variables**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Hypothesis Testing** | **Variable** | **Estimated T-Value (** | **Critical T-Value** | **Result** |
|  | Ecarprices2 | | 2.93| | 1.684 | Reject |
|  | Price\_electricity | | 0.02 | | Fail to reject |
|  | Price\_gasoline | | 0.40 | | Fail to reject |
|  | Numstations | | 13.64 | | Reject |
|  | Medianincome | | -0.47 | | Fail to reject |
|  |  |  |  |

The results of the t-tests of individual independent variables show that I reject the null hypothesis for ecarprices2 and numstations, meaning that the two independent variables are statistically significant at 5% level of significance based on the results of the estimated regression model where there are 50 observations. Since I rejected the null hypothesis for the quadratic functional form of ecarprices2, I did not perform a t-test on the linear model. These two results support my hypothesis that electric car prices and the availability of charging stations influence the demand of the electric cars positively due to their signs, and are statistically significant due to the results of the t-tests. The estimated t-value of the numstations is the greatest among all of the independent variables; as a result it is the most significant independent variable in the regression.

On the other hand, I fail to reject the null hypothesis for price\_electricity, price\_gasoline and medianincome meaning that the three independent variables are statistically insignificant at 5% level of significance based on the results of the estimated regression model where there are 50 observations.

For the variable price\_electricity, I have failed to reject the null hypothesis as a result, concluded that the price\_electricity is statistically insignificant. However, in theory and literature review, the expected sign of the coefficient for price\_electricity was negative. By failing to reject a null hypothesis when it is false, Type II error has occurred. In addition to that, the null hypothesis for the medianincome is . In the literature review, it is expected that an increase in the medianincome should lead to an increase in the demand of the electric cars. The regression results show that the sign of the coefficient is negative and that does not meet my expectations. Since I failed to reject the null hypothesis when it is false Type II error has occurred for this independent variable.

I conducted F-test to test the combined statistical significance of all independent variables on the dependent variable. The hypothesis testing for the null is; , at 5% level of significance based on the estimated model when N = 50.   
Since the p-value (0.05) >0.0000 (Prob > F), I reject the null hypothesis and conclude that the estimated regression is statistically significant, and there is a jointly strong impact of the independent variables on the dependent variable.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Table 6. Regression results for the Factors that Influence the Demand of Electric Cars** | | | | |
| **Models** | **(1)** | **(2)** | **(3)** |
|  | **Electric Car Sales** | **Electric Car Sales** | **Electric Car Sales** |
|  |  |  |  |
| **Average Electric Car Prices Across 13 Models After Tax-Exemption and Incentives** | -3.208\*\* |  | -3.215\*\* |
|  | (1.422) |  | (1.325) |
|  |  |  |  |
| **ecarprices2** | 0.0000301\*\* |  | 0.0000302\*\* |
|  | (0.0000138) |  | (0.0000129) |
|  |  |  |  |
| **Price of Electricity Converted to Per Gasoline Gallon Equivalent** | 4.425 | -147.0 |  |
|  | (163.3) | (132.2) |  |
|  |  |  |  |
| **Price of Gasoline per Gallon** | 490.3 | -86.21 | 278.8 |
|  | (1313.2) | (1482.8) | (1073.5) |
|  |  |  |  |
| **The Number of Public Electric Fueling Stations** | 7.740\*\*\* | 9.290\*\*\* | 7.772\*\*\* |
|  | (0.497) | (0.417) | (0.488) |
|  |  |  |  |
| **Median Income (2014 Dollars)** | -0.0135 | 0.0236 |  |
|  | (0.0183) | (0.0288) |  |
|  |  |  |  |
| **Constant** | 84990.5\*\* | -7.293 | 84725.2\*\* |
|  | (36907.6) | (2798.8) | (34369.2) |
|  |  |  |  |
| ***Observations*** | 50 | 50 | 50 |
| ***R-squared*** | 0.911 | 0.848 | 0.910 |
| ***Adjusted R-squared*** | 0.898 | 0.835 | 0.902 |
| ***F*** | 168.2 | 99.62 | 164.08 |
| ***rmse*** | 1490.2 | 1901.9 | 1461.2 |
|  |  |  |  |  |
| Note 1: Robust standard errors are displayed in parenthesis. |  |  |  |  |
| Note 2: [Number of Observations are 50] |  |  |  |  |
| Significance levels: \* p<0.10; \*\* p<0.05; \*\*\* p<0.01 |  |  |  |  |

In order to test the joint statistical significance of each independent variable, I ran 3 different regression models that can be seen above in Table 6. The model 1 is the unrestricted model, where all of the independent variables are included in the regression. The model 2 is the restricted model that excludes the variables ecarprices and ecarprices2; and Model 3 excludes the two independent variables; price\_electricity, and medianincome that I have concluded during hypothesis testing that they have Type II errors.

In the restricted Model 2, I have taken out the electric car prices out of the equation and ran the regression to see if this is going to cause an omitted variable bias. In the absence of the electric car prices variable, F-value in the model 2 decreased to 99.62 from 168.2 in Model 1. This shows that the independent variables joint impact on the dependent variable decreased in Model 2. The adjusted R-squared decreased from 0.898 to 0.835. Also, the coefficients and the signs of price\_electricity, price\_gasoline and medianincome changed dramatically. The standard errors for these variables have shown an increase as well, which means that individual t-values will increase, meaning I will more likely to fail to reject the null, and that they will become statistically insignificant. As a result, Model 2 causes omitted variable bias due to removing the key variable the price of the electric cars. In theory, it is expected that the demand function should include price function as a variable. After the F-test, I have concluded that the price of the electric cars variable is relevant in the demand function, which meets my expectations.

In the restricted Model 3, I have omitted the variables; price\_electricity and medianincome that have Type II errors due to unexpected signs of the coefficients. The F-value decreased in a small amount from 168.2 in Model 1 to 164.08 in Model 2, this shows that the joint impact of the independent variables on the dependent variable did not change much. In addition to that, the coefficients of ecarprices and numstations increased, making them explain the dependent variable more, which supports my original hypothesis. The standard errors of the all independent variables are decreased, increasing the t-values of individual independent variables. This means that I am more likely to reject the null hypothesis, and conclude that the independent variables explain the dependent variable better, and their statistical significance increased at 5% level based on the Model 3. Consequently, omitting the price\_electricity and medianincome variables do not cause omitted variable bias; instead, I qualify the Model 3 as a better model than the unrestricted Model 1.

**V. Discussion:**

In this paper, I have investigated *if the price of the electric cars and the availability of charging stations influence the demand for electric cars.* My results helped me to conclude that both of the key variables in my hypothesis are statistically significant in explaining the demand of the electric cars, as a result, the results of the key variables supports my expectations, literature review, theory and my hypothesis.

The most significant implication was collecting reliable data on the average prices of gasoline-based cars across 50 states. The absence of this data in the regression produces an omitted variable bias. This bias can affect the coefficients of the independent variables and influence the signs and magnitudes of two variables that Type II error occurred. For that reason, not including the price of the conventional cars as an independent variable while including the price of the electric cars, affected my estimated model, and resulted a bias. The presence of both of the variables in the estimated regression would have created a better model.

I determined that there are Type II errors for the variables; price\_electricity and medianincome. After running side-by-side regressions, I have concluded that both of these variables do not improve the estimated regression and they were statistically insignificant in all of the models at 5% level in 50 observations. Therefore, omitting them creates a better model for my hypothesis.

The literature review’s and my expectations from the price\_electricity was that when the price of electricity gets more expensive, the demand of the electric cars should decrease. Even though I expected a negative sign, the results of my regression analysis showed that the sign is positive. This might be due to the fact that average oil prices in 2014 were in decline and were cheaper than the electricity prices. For this reason, the gas can be very low only in 2014. If I were to pick another year for regression, I would get different statistical significance, sign and coefficients for the price of the gasoline.

The literature review’s and my expectations from median income were that it should have a positive relationship with the demand of the electric cars. However, results showed otherwise. The reason why is that, the average price of the electric cars is two times more expensive than an average price of the gasoline cars, which is mentioned in the literature review. This shows that electric cars are not in the same competitive market with the gasoline cars. Instead, electric cars are in the market of luxury cars. For that reason, when median income in a state increases, people are more likely to choose the substitute gasoline luxury car rather than a non-luxury electric car. This is an implication I faced. If the market of the electric cars were fully defined, I could have used different models of electric cars, and consequently get different sales and price numbers.

**VI. References**

David Block, Dr. "Electric Vehicle Sales for 2014 and Future Projections - Transport Research International Documentation - TRID." *Electric Vehicle Sales for 2014 and Future Projections - Transport Research International Documentation - TRID*. Electric Vehicle Transportation Center, n.d. Web.

Eppstein. "Energy Policies of IEA Countries: The United States 2014." *Energy Policies of IEA Countries* (2014): n. pag. Web.

Egbue, Ona, and Suzanna Long. "Barriers to Widespread Adoption of Electric Vehicles: An Analysis of Consumer Attitudes and Perceptions." *Energy Policy* 48 (2012): 717-29. Web.

Glerum, Aurélie, Lidija Stankovikj, Michaël Thémans, and Michel Bierlaire. "Forecasting the Demand for Electric Vehicles: Accounting for Attitudes and Perceptions." *Transportation Science* 48.4 (2014): 483-99. Web.

Kihm, Alexander, and Stefan Trommer. "The New Car Market for Electric Vehicles and the Potential for Fuel Substitution." *Energy Policy* 73 (2014): 147-57. Web

United States. U.S. Department of Energy’s Energy. Energy Efficiency & Renewable Energy. *Alternative Fuels Data Center in 2014*. N.p., n.d. Web.

United States. U.S. Energy Information Administration. *Annual Average Price per KWh by State 2014*. N.p.: n.p., n.d. *U.S. Energy Information Administration*. Web

Sierzchula, William, Sjoerd Bakker, Kees Maat, and Bert Van Wee. "The Influence of Financial Incentives and Other Socio-economic Factors on Electric Vehicle Adoption." *Energy Policy* 68 (2014): 183-94. Web.

Vivanco, David Font, Jaume Freire-González, René Kemp, and Ester Van Der Voet. "The Remarkable Environmental Rebound Effect of Electric Cars: A Microeconomic Approach." *Environmental Science & Technology Environ. Sci. Technol.* 48.20 (2014): 12063-2072. Web.

"Gasoline Prices per Gallon." *AAAs Daily Fuel Gauge Report*. N.p., n.d. Web.