



# **Are Government-Subsidized Electric Vehicle Policies Effective at Increasing EV Market Share in Different Countries? A global review of the relationship between EV policies and the EV market**

**Nicholas Taormina and Rahul Ainpudi**

*University of Florida*

Faculty Mentor: Anne Donnelly, Center for Undergraduate Research

## **Abstract**

This paper examines the relationship between legal policy and the Electric Vehicle market in countries from around the world. As climate change has become an increasingly more important issue in modern society, heavy emphasis has been placed on environmentally conscious alternatives to many things used in daily life. Transportation, one of the largest and most polluting sectors of the economy, has seen many advances towards an eco-friendly future. Electric Vehicles, or EVs, have been lauded as the answer to heavily polluting Internal Combustion Engines (ICE) by governments around the world. They have dumped large amounts of money in the form of tax breaks and subsidies into the EV sector, but it is unclear if that is really having an effect on the market. This study finds no correlation between the amount of money a government is offering to subsidize the purchase of EVs and the EV market share of the country. While EV law structure varies heavily between countries, the general contribution to the sector by governments is largely the same around the world.

*Keywords:* electric vehicles, international EV policies, public policy

## **Introduction**

The effort to lead a zero-carbon emission, environmentally friendly life has become a global movement with the growing emphasis placed on the issue of climate change. The initial efforts of this international green movement are already evident in the transportation sector as electric vehicles begin to flood the market (Kieckhäfer et al., 2016). For instance, the sales of electric cars recorded a 40% year-on-year increase from 2018 to 2019 and electric vehicles also accounted for 2.6% of global car sales in 2019 (IEA, 2020). Traditional internal combustion engine (ICE) vehicles run on fossil fuels, a finite resource, and a 2016 study estimates that in 47 years, all oil reserves will be depleted (British Petroleum, 2016). On top of the dwindling supply of fuel, ICE vehicles produce very large amounts of pollution. According to the EPA, 28% of greenhouse gas emissions come from transportation, making it the least environmentally friendly out of all

industries (EPA, 2020). With 1.3 billion (and counting) vehicles on the road, it is clear to see that this planet's environmental future is not very bright (Wards Intelligence, 2017).

Electric vehicles (EVs) seem to be regarded as one of the solutions to this global transportation climate crisis (EPA, 2020). They produce no direct pollution and can be charged using electricity that is already being generated. Although some may argue that the electricity used to power electric vehicles is produced from non-renewable resources, such as the burning of fossil fuels, it does not change the fact that EVs will dramatically reduce the carbon emissions being released by the transportation industry (Ghosh, 2020). However, with only 2.6% of global car sales in 2019 being electric, humanity is obviously quite far away from this promised green future (IEA, 2020). This begs the question, what is preventing the switch from ICE to EVs? Most car buyers cite high initial purchase costs, limited battery range, and inadequate charging infrastructure as reasons to avoid EVs (Vassileva & Campillo 2016; Egbue, Long, & Samaranyake, 2017). Additionally, many consumers fear the complexity and unreliability that often accompany new technology (Krishna, 2021).

A large portion of these concerns can be alleviated through government subsidies. Because of this, governments around the world have created incentive systems to drive consumers towards EVs. Unfortunately, the effects of these incentive systems are unclear (Ma et al., 2019). Previous studies on the impact of incentives on EV market share have been limited to single countries or regions. Munzel et al. determined that purchase incentives provides a minimal increase in EV market share in the EU (2019). The study by Plötz, Gnann, and Sprei found a weak positive impact of incentives on absolute sales numbers in both the US and the EU (2016). However, the use of the number of EV sales means that yearly fluctuations in the total number of new car sales within a country are not considered. Because the true effects of the subsidies are difficult to determine and evaluate in the real world, it begs the question: could governments support the EV market in a more efficient way?

Many experts believe that research funding is the best way for governments to help their respective EV markets grow (Beijing Capital Energy Technology Company, 2017). However, there is insufficient data to determine whether research funding or any monetary incentive significantly affects EV adoption (Plötz, Gnann, & Sprei, 2016; Munzel et al., 2019; Beijing Capital Energy Technology Company, 2017). Consumer purchase incentives considerably reduce the cost of adoption for EVs, making them more accessible to a broader range of people.

Common sense would lead one to believe that these incentives would cause an increase in EV market share. However, that may not be the case.

Completing this study will identify which country's EV legal policies are the most effective at promoting electric vehicles through statistical tests. This information can be used to improve the EV legislative environment worldwide in order to encourage further growth of the EV market.

### **Methods**

In order to answer a plethora of questions, a deep qualitative and quantitative analysis of the EV-related legal policy of a variety of governments around the world was conducted. Data gathered from this analysis can determine how legal policy affects EV adoption and any notable patterns in that legal policy. This study's approach differs from that of the Beijing Capital Energy Technology Company because this study uses statistics rather than expert opinion to determine the effects of legal policy on the EV market. The market share data comes from an early 2020 study by [ev-volumes.com](http://ev-volumes.com), a global EV sales database.

The findings of this study are based on extensive document analysis and statistics. The EV-related legal policy of a selection of 20 countries was analyzed to determine the different types of laws that currently exist. These 20 countries were selected for their significance in the EV industry and for the availability of information. After a substantial amount of research, the laws can be organized into two specific categories: (1) Vehicle Purchase Incentives, (2) Infrastructure Development Subsidies. Data for each of the 20 countries were collected and quantified for Categories 1 and 2. All values were converted to USD, using conversion rates from Morningstar at the time of writing (March 2021). Due to the considerable diversity in EV law structure, a few exceptions had to be made to standardize the data. Those exceptions will be detailed as follows.

It is a common practice for countries to scale consumer purchase subsidies with the cost of the vehicle, placing a hard limit after a certain price. For countries where this was the case, the maximum possible value was used. The reasoning behind this is that the average purchase cost of an electric vehicle, \$55,600, often exceeded the upper limit of a country's incentive (Hearst Autos Research 2020). Given that the average EV buyer would receive the full benefit in most countries, it is far simpler to assume the maximum bonus for all countries. In countries where EV owners receive a discount on annual road or vehicle taxes, the savings over five years were included in the final subsidy amount. Company car benefits were ignored.

**Table 1.** Raw data that includes the values used in regression tests.

Countries	Vehicle Purchase Incentives (USD)	Infrastructure Development Subsidies (USD)	Market Share (%)
Norway	\$11,258	\$72,000	56.000%
Finland	\$2,400	\$25,200	16.000%
Netherlands	\$4,700	\$27,920	15.000%
Sweden	\$7,100	\$36,000	11.000%
China	\$4,200	\$12,000	5.200%
UK	\$3,550	\$2,500	3.200%
Germany	\$8,880	\$22,000	2.900%
France	\$8,300	\$28,800	2.800%
Canada	\$3,900	\$30,000	2.670%
South Korea	\$8,500	\$72,000	1.950%
US	\$7,500	\$30,000	1.900%
Spain	\$6,500	\$28,800	1.400%
Japan	\$7,350	\$48,000	0.900%
Italy	\$7,100	\$3,550	0.900%
Brazil	\$1,750	\$12,000	0.400%
Mexico	\$6,000	\$3,600	0.002%
Colombia	\$400	\$0	0.002%
India	\$2,058	\$0	0.001%
Chile	\$0	\$0	0.001%
Peru	\$400	\$0	0.000%

For Category 2, data was manipulated to fit an “ideal station” model. An “ideal station” consists of six Level 2 charging points, each capable of delivering roughly 20 miles of range in an hour. These charging points are optimal for installation at places of work and shopping centers. Countries that provide subsidies per charger had their maximum subsidy multiplied by 6. In a few cases, a country’s government is offering to cover the entire cost of a charging station. In these instances, the average cost of a Level 2 charger, \$12,000 per charging point, was used (U.S. Department of Energy, 2015). As there are six charging points in one ideal station, the final subsidy would total \$72,000.

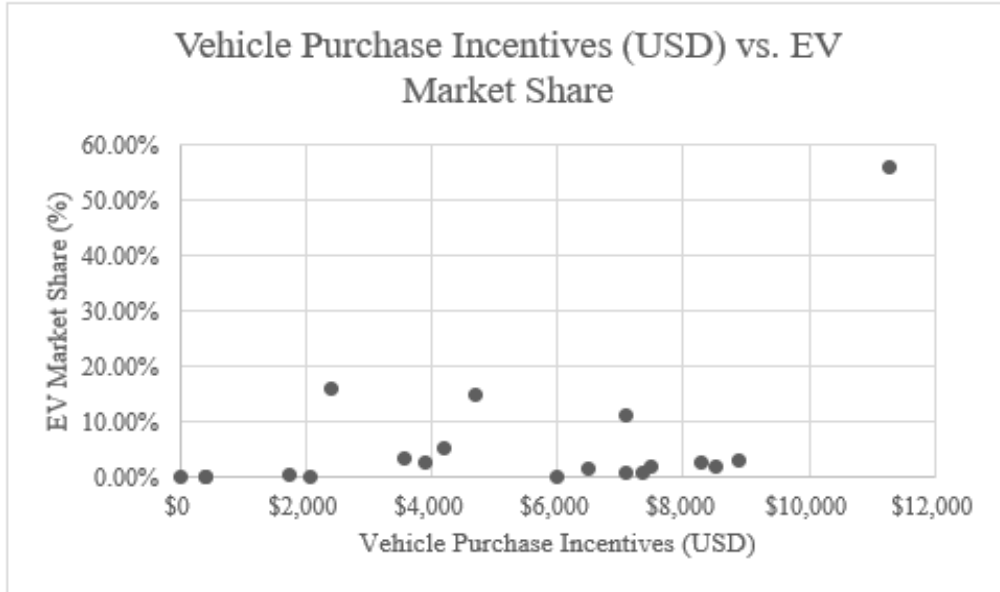
In addition to legal categorization, the countries were grouped into four regions in order to determine any patterns. These regions are: North America, Western Europe, Eastern Asia, and Latin America. Africa was excluded from this study due to a lack of data. Using a T-Test, the regional average of each category was compared to the calculated global average for each. This demonstrates whether some regions of the world promote EV growth through legal policy more than others. If this is true, further study may be needed to determine the reasons for these

patterns. A significance level of 0.05 was used for all tests based on the sample size and the amount of data available. A p-value above 0.05 for this test would indicate that there is not enough evidence to show a statistically significant difference between each continent's legal policy.

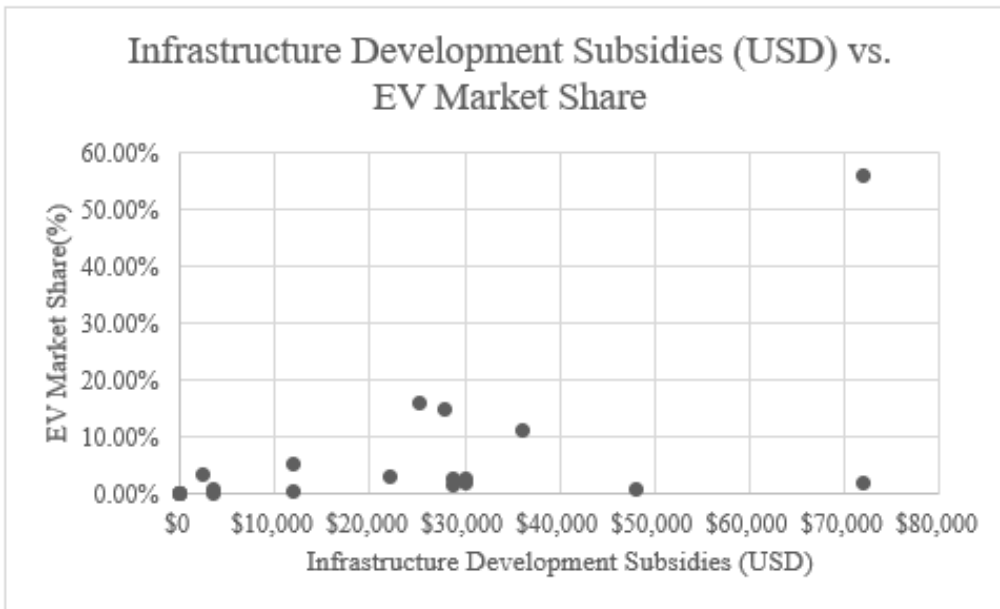
Along with the regional comparisons, this study aims to analyze the EV market on a global scale. Regression analyses were performed to determine the relationship between each category and the market share of EVs. The null hypothesis for this regression test will be that "there is not sufficient statistical evidence that shows a correlation between the category and the EV market share of a country", while the alternative hypothesis is that "there is sufficient statistical evidence that shows a correlation between the category and the EV market share of a country." An alpha of 0.05 was used to determine if the achieved p-value is enough to confidently reject the null hypothesis. If the p-value is between 0.1 and 0.05, then there is some statistical evidence to reject the null hypothesis and accept the alternative. If the p-value is less than 0.05, then there is strong statistical evidence to reject the null hypothesis and accept the alternative. If the p-value is greater than 0.1, then the null hypothesis must fail to reject and conclude that there is no sufficient statistical evidence that shows a correlation between a specific category and EV market share.

### **Results**

The two regression tests aimed to determine if any statistical evidence proves a correlation between a country's EV Purchase Incentives and its EV market share, and a correlation between a country's Infrastructure Subsidies and its EV market share. According to the regression test results, the R square value for the test between a country's Purchase Incentives and its EV market share was 0.004, and the R square value for the test between a country's Infrastructure Subsidies and its EV market share was 0.07. Both of these values are very close to zero and, therefore, must fail to reject the null hypothesis and conclude that there is no correlation between the variables assessed in the regression tests.



**Figure 2A.** Scatter plot of Vehicle Purchase Incentives (USD) vs. EV Market Share



**Figure 2B.** Scatter plot of Infrastructure Development Subsidies vs. Market Share

**Table 2A.** Regression analysis of Vehicle Purchase Incentives vs. EV market share

Regression Statistics	Value
Multiple R	0.0660585
R Square	0.0043637
Adjusted R Square	-0.0542031
Standard Error	0.0509347
Observations	20

**Table 2B.** Regression analysis of Infrastructure Development Subsidies vs. EV Market Share

Regression Statistics	Value
Multiple R	0.2709421
R Square	0.0734096
Adjusted R Square	0.0189043
Standard Error	0.0491368
Observations	20

The goal of the T-Tests was to determine if certain regions contributed significantly more or less to the EV industry than others. This could indicate an influence that one country's EV-related laws may have on its neighbors. The tests showed that, for the most part, there was little variation between each region of the world.

The global mean for Vehicle Purchase Incentives was \$5,092, with a standard deviation of \$3,149. Latin America showed a significantly lower mean, \$1,710, compared to the rest of the world. The other three regions produced a similar mean to each other, with very similar standard deviations across all four regions.

**Table 3A.** The T-Test values for Purchase Incentives

Region	Average	Standard Deviation	P-value
North America	\$5,700.00	\$2,500.00	0.795
Latin America	\$1,710.00	\$2,490.00	0.034
Asia	\$5,527.00	\$2,900.00	0.8
Europe	\$6,640.00	\$2,757.00	0.2
Global	\$5,092.30	\$3,149.36	N/A

For Infrastructure Development Subsidies, the global mean was \$22,719, with a standard deviation of \$21,590. Latin America's mean of \$3,120 was significantly lower than that of the other regions. There was a wide variance in means and standard deviations in each region.

**Table 3B.** The T-Test values for Infrastructure Development Subsidies

Region	Average	Standard Deviation	P-Value
North America	\$30,000.00	\$0.00	0.158
Latin America	\$3,120.00	\$4,653.77	0.00158
Asia	\$33,000.00	\$28,618.18	0.587
Europe	\$27,418.89	\$19,119.91	0.582
Global	\$22,718.50	\$21,590.11	N/A

### Discussion

Based on these tests, it is unclear if legal policy directly impacts EV market share. Neither of the regression analyses produced conclusive results. There are likely external factors, such as culture or economic status, that are more influential on a country's adoption of EVs. Further research on this topic would be needed to determine how various socioeconomic factors are affecting EV adoption.

In regards to regional differences in legal policy, the T-Tests produced some conclusive results. Latin America demonstrated a statistically significant lower average Purchase Incentive than the rest of the world, at roughly 34% of the global average. This is likely due to economic factors, as the average purchase price of an EV is over two times the average cost of a mid-sized car in many Latin American countries (Alves, 2021). Latin America also demonstrated a significantly lower average Infrastructure Subsidy than the rest of the world. This is again likely due to economic factors. Additionally, governments may not want to invest much money into developing infrastructure that very few people will be able to use.

Despite their high contributions to infrastructure development, the United States and Canada both have relatively low EV market share values. In a large country like the U.S., a far more expansive charging network is needed to make up for the limited range of EVs. This may explain why the North American governments are more willing to subsidize infrastructure development than many others. In fact, as a part of his new Bipartisan Infrastructure Framework, President Biden plans to pump \$7.5 billion over the next eight years into further developing EV infrastructure in the United States in an effort to make electric vehicles more practical for everyday drivers. The majority of this money will be spent on President Biden's goal of building 500,000 EV chargers across the nation (The White House, 2021).

In addition to the discussed external factors, a lack of awareness may also be inhibiting the effectiveness of these government subsidies. It is critical to consider that many of the policies



included in this study and the EV market as a whole are relatively new and may need more time to develop and have a more definitive impact. For this reason, many potential buyers may not know of the incentives that have been established to reduce the financial demand of purchasing an EV. Therefore, these policies and subsidies are not able to perform their intended purpose as people fail to even consider EVs because of their price. Consequently, it would be advisable to conduct this same study or one similar in a few years when the policies are more well-known and the EV market has grown.

### **Conclusion**

This study explored the relationship that EV legal policies have with the EV market. No significant correlation was discovered between consumer purchase incentives or infrastructure subsidies and EV market share. Additionally, while purchase incentives were essentially the same, government spending on EV infrastructure varied greatly by location. Most governments seem to be on board with subsidizing the purchase of EVs, but not necessarily with developing the charging network needed to make them practical. This study highlighted the general uncertainty associated with the EV market and EV technology as a whole. While governments are attempting to make EVs more mainstream, a number of external factors are unfortunately interfering with their efforts.

The results of this study seem contradictory to what is generally expected from government subsidization. It could be the case that governments are not subsidizing EVs enough to make any real difference in EV market share. If they are subsidized enough, then it is likely that many consumers are unaware of the bonuses given to them by the government. Future studies on consumer opinion of EV policies would be needed to determine the reasons for their ineffectiveness. Additionally, EVs may simply be far less attractive to consumers than ICE vehicles because of the technological limitations discussed earlier, therefore making the purchase price largely irrelevant. In large countries such as the United States, for example, an EV may currently be impractical for most people due to the great distances between places. As shown by the Beijing Capital Energy Technology Company's study, experts in the field believe that R&D is the best way for governments to contribute to the EV industry (2017). The results of this study seem to support that idea, given the lack of correlation between subsidies and market share.

As EV technology continues to evolve and the EV market continues to grow, it remains paramount that governments do all that they can to ease the transition from ICE vehicles.

Continued monitoring of both the EV market and legal policy can ensure that aid is given to the industry in the most effective manner.

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