Assessing Sociopolitical Changes on Mature Market Electric Vehicle Sales

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# TABLE OF CONTENTS

Introduction ................................................................................................................................. 2
Objectives .................................................................................................................................. 3
Methods ...................................................................................................................................... 3
  Market Identification ............................................................................................................. 3
  Data Analysis ......................................................................................................................... 4
  Content & Market Analysis ................................................................................................. 4
Results ....................................................................................................................................... 5
  European EV Market Shares ............................................................................................... 5
  Germany ................................................................................................................................ 6
  Netherlands ......................................................................................................................... 7
  Norway ............................................................................................................................... 8
  Sweden ............................................................................................................................... 9
  United States .................................................................................................................... 11
    California ....................................................................................................................... 11
    Georgia .......................................................................................................................... 12
Discussion ............................................................................................................................... 14
References .............................................................................................................................. 16
Introduction

As the threat of anthropogenic climate change becomes increasingly apparent, industrial and technological advancements and consumer behavior within the automotive industry have begun to adjust in an attempt to mediate and slow the emissions of harmful greenhouse gas. Electric vehicles (EVs) have emerged as a key development in the transportation sector that utilize electric power and rechargeable batteries. Plug-in hybrid electric vehicles (PHEVs) or battery electric vehicles (BEVs) can either reduce or fully eliminate gasoline consumption, respectively. Extensive studies have and are still being conducted to assess consumer response to EVs and their purchase motivations to optimize market growth (Sierzchula, Bakker, Maat, & van Wee, 2014; Hardman & Turrentine, 2017).

Key drivers of EV market growth and industry innovation are financial and non-financial incentives implemented primarily by the government and private utility companies (Field, 2017; McKinsey & Company, 2014; Tal & Nicholas, 2014; Jenn, Springel, & Gopal, 2017). The EV market both within the United States and across Europe shows general growth trends, especially over the course of the last couple of years as incentives have been introduced and infrastructure has been developed (Hartman, 2014). However, quarterly vehicle sales data reveals significant fluctuations beyond expected seasonal variation. Much of the observed volatility can be associated with the introductions and cancellations of a variety of EV policies within each regional jurisdiction (Tietge, 2017).

The EV market and accompanying policies have grown to the point of policy reviews for renewal or complete cancellations due to lack of funding or changes in political prioritization. Some entities have designed gradual reductions of EV incentives while other markets have experienced sharp changes—both intentionally and unintentionally, depending on the market (McKinsey & Company, 2014). The resulting fluctuations destabilize market growth, but may still support the steady development of a market.

This project identified mature markets, selected from the United States and Europe, based on consistency of available data from 2010 onward. Market selections were narrowed down based on known histories of sustainable transportation policies within the country or state and the last decade. Asian countries such as China and Japan were excluded due to a lack of resources for identifying and translating related policies however, both markets demonstrate a strong commitment to EV adoption and supportive policies.

Long-term policy and incentive changes were measured in select states and countries to identify and analyze the impact of ‘shocks’ to the electric vehicle market. Shocks were identified arbitrarily based on significant spikes in data outside of the expected margin of difference over a short period of time. Statistical models paired with a content analysis of policies and incentives were deployed to measure significant market changes and the potentially distributed impacts of isolated shocks to electric vehicle adoption. Collected data intends to inform policymakers and automakers about the influence of market changes and long-term coordination to support market development.
Objectives
The primary objective of this project is to provide aggregate data that supports a potential relationship between how EV incentives are implemented and market growth. Results should support that the actual implementation of the policies is just as important as the type and strength of policies.

In order to make this assertion, available data will be used to (1) determine the prevalence of shocks in the EV sales market using specifically identified markets of interest, (2) assess changes in the sociopolitical climate in relation to shifts in the EV market, and (3) determine any long term impacts that short term shocks have on market development and growth.

Methods

Market Identification
All market data has been collected from the website ev-sales.blogspot.com, an EV sales database organized by EV data analyst José Pontes. The consistency of available data provided the basis for choosing specific countries and states.

All European countries had monthly data available from January 2013 to present, allowing for data aggregations and manipulations. Chosen countries included Norway, Sweden, Germany, and the Netherlands [Figure 1]. While there was access to a variety of other potential markets, there were often substantial gaps of data missing or the sales numbers were too insignificant (i.e. fewer than 100 sales a month) to be considered relatively mature, established markets.

Figure 1: Map of chosen European countries
For the United States, state-level market information is generally less standardized and many states have such low EV adoption rates that data is unreliable in establishing any patterns. The two states selected were deliberately chosen because of their unique EV histories. California remains the leader in domestic EV sales, though market share for 2016 was only 3.29 percent, and has a strong track record of supporting environmentally-conscious policies for electric technology (Nikolewski, 2017) [Figure 10]. Georgia is a less conventional market for alternative technology, but experienced drastic changes in EV sales as a result of incentive changes and uncertainty (Jin, Searle, & Lutsey, 2014).

Data Analysis
Initially, statistical modelling was conducted using RStudio and Microsoft Excel, producing scatterplot visualizations of EV sales over time. More complex analyses were conducted, but due to the relative brevity of the project, the statistical analysis shifted away from analyzing in-depth correlations and focused more on basic linear modeling to display general trends of the EV market and the responses to sociopolitical changes.

Content & Market Analysis
Content analysis relied on the research database of LexisNexis Academic and Crimson Hexagon insights of social media analytics pertaining to EVs. The content analysis was generalized and limited in nature, due to funding and accessibility constraints. The intent of the content analysis was to determine if there is any correlation between consumer adoption and exposure to public dialogue surrounding EVs.

Crimson Hexagon published analytics with insight as to the social value differences held by consumers of hybrids and EVs in relation to one another. LexisNexis predominately returned newspapers, and industry press publications that were used as a direct proxy of relative exposure to EV narratives. Search terms included “location AND electric vehicle,” or “location AND electric car” to try to capture the widest, generalized references to EVs in relation to the specified locations.
Results
In terms of general market trends, there is an overall increase in EV adoption rates, as expected in markets that are relatively mature but still in development. The exception to overall increasing EV adoption rates is the Netherlands where the market is highly responsive to the loss of incentives but generally maintains steady and comparatively low quarterly rates of adoption.

The content analysis proved to be inconclusive in making generalizations about the relationship between media and the EV market. The key conclusion that can be taken from the content analysis is that there is public awareness of EV policies, incentives, and the market in general. The movement of media mentions either before or after a shift to the EV market is highly variant and does not follow a single pattern; whether the awareness reflected and measured by the content analysis is reactionary or anticipatory varies by location. There is a reciprocal relationship between media and consumer behavior, but not necessarily any predictive links beyond that.

In comparing European market patterns with US state patterns, an identifiable similarity was the immediacy of the market responses in the Netherlands and the state of Georgia. Both experienced significant spikes in market sales in response to impending expirations of electric vehicles, as detailed in the following sections.

Germany
The most significant barrier against EVs in the German automotive market is the strength of the automakers themselves, and their resistance to change. As the top auto manufacturing output in Europe, German car manufacturers have a high level of influence in the political and social responses to change. With the force of international consumers and an export industry valued at US$151.9 billion in 2016, German automakers including BMW, Mercedes-Benz, Audi, and Volkswagen, have been able to generally resist a countrywide transition from internal gas combustion engines to EVs due to the existing success of the automotive market (Workman, 2017).

The linear model of Germany’s market is relatively slow and steady growth [Figure 6]. While there is EV sales growth, the overall market share of EVs remains far lower than other European mature market counterparts [Figure 2]. The sharp decrease in BEVs at the end of the year 2015 can be attributed to a combination of seasonal fluctuations and anticipation of the government incentive that delayed consumer purchases. The German market does not reflect extreme variation in response to their limited incentives; the slope of growth trajectory is steeper following the incentive introduction, however, the market still follows a relatively steady linear growth pattern.
The content analysis component of the German market is generally anticipatory. In both instances of significant incentive changes, there were spikes in media coverage and publications surrounding EVs and Germany just before changes were implemented. Of all European markets, Germany appears to have the highest level of conversations around EVs, which is not unexpected given the automotive production levels from Germany. More recently, the pattern of media content parallels the uptick in EV sales, reflecting a positive relationship for social and industry conversations and the market.

**Netherlands**

The Dutch market is responsive to the loss of incentives but not necessarily motivated by them. PHEV purchases in the Netherlands have a much higher baseline average than most European markets and is primarily supported by massive spikes in response to the losses of incentives and seasonal increases at the end of fiscal years. The Dutch market heavily favors PHEVs over BEVs—likely a testament to the level of ease in integrating a plug-in hybrid as opposed to full electric vehicle into existing travel patterns and lifestyles.

The distribution of the quarterly shocks and subsequent drops is a nearly flat line, indicating minimal market growth [Figure 7]. The linear model of the Dutch market reflects the dispersed effects of the sales spikes in essentially flattening out the fluctuations. The spikes in sales are not necessarily driving market growth beyond equalizing and maintaining steady market levels; the market share of PEVs compared to ICEs remains low [Figure 3]. The Netherlands automotive industry is primarily import-driven with fewer than 100,000 vehicles produced in the country itself. As such, the resistance and pushback from automakers is far less influential than the German or Swedish market, giving the EV market the capacity to grow and develop with limited
disruptions outside of the usual political and social spheres. While growth in the Netherlands is not as upward sloping as other European markets, quarterly sales have still leveled out to around 5,000 vehicles, though individual quarter data is far lower.

![Figure 7: Dutch EV sales](image)

National conversations surrounding EVs is generally consistent with changes in EV sales levels. The relationship is not particularly anticipatory or reactionary; media presence appears to correspond directly to the timing of changes to the sociopolitical realm but with varying strength.

**Norway**

Norway’s automotive market has the highest market share level of EVs in the world at around 25 percent (Ayre, 2017) [Figure 4]. A key factor supporting the massive expansion of the Norwegian market is the lack of any traditional automotive industry in the nation. Norway almost exclusively imports their vehicles and as a result, moderates imports through taxing schemes. The primary form of Norwegian EV incentives is reduced or adjusted taxation on EV imports. Since 1990, there have been no purchase taxes on BEVs or fuel cell electric vehicles (FCEVs), and reduced taxes for PHEVs (European Alternative Fuels Observatory, 2016). Norway has much broader incentives that are less dependent on make and model specifications than other countries.

The Norwegian market can be characterized by steady increases with seasonal variability that is definitely incentive driven but does not seem to be highly variable in relation to said financial incentives [Figure 8]. Because Norway’s incentives are considerably more long-term than most other markets, the consumer response is not as reactive to changes in incentives. There are seasonal variations that are emphasized differently but the general trend is positive.
Figure 8: Norway EV Sales

The media content of EVs in Norway varies unrelatedly to the actual market. The lack of relationship is likely a testament to the length of EV support in Norway and the ubiquity of sociopolitical engagement with alternative fuels and sustainable transportation. The widespread government, social, and political support for EVs leaves little necessity for controversy and media coverage surrounding changes in policy or incentive.

Sweden

The growth of Sweden’s EV market has been plagued by inconsistent political support and incentives paired with inadequate funding allocation to support existing programs. Of all markets, the link between policy and behavior is most apparent in Sweden’s EV market; consumer response to the inconsistencies is reflected in the measurable variations of vehicle sales (Tietge, 2017). Sweden is similar to the Netherlands in that neither country has a particularly strong internal market for automotive production and rely more on importing their vehicles than exporting them.

Quarterly variation in Sweden is significant, however overall trends do indicate increasing market adoption; market share is still low, but growing [Figure 5]. The PHEV market is especially responsive to variation in incentives and consumer uncertainty, whereas BEVs experienced more steady growth due to fewer changes to incentives specifically targeting BEVs [Figure 9].
Figure 9: Sweden EV Sales

The volatility of the EV market is matched by social and media engagement levels. There is significant variation in measured media mentions that vary beyond the capacity of establishing an association between media and sales.
United States
The United States EV market study focused solely on California and Georgia. As previously introduced, California has a strong history of EV adoption and Georgia experienced significant shifts in its statewide policies and incentives. While the federal EV incentive is significant at US$7,500, Georgia and California supplemented the federal incentive with generous state incentives. Both markets are unique and can be considered outliers in terms of EV adoption within the US.

Figure 10: United States EV market share

California
California has an extensive history of EV-supporting policies that are rooted in widespread air quality issues from the 1980s and the subsequent stages of solutions to mediate the negative health and environmental effects (Garas & Turrentine, 2014). The presence of incentives has been a relatively constant presence; the US$2,500 state rebate was originally introduced in 2010 and has been renewed regularly, with minimal changes. The only significant change was a renewed commitment to infrastructure and the addition of an income cap on consumer qualification of rebates (California Air Resources Board, 2016).

Another unique quality of California’s involvement with EV market development is the extensive regional incentives that supplement both state and federal incentives. Regional utility districts offer a variety of incentives ranging from EVSE rebates, tax and purchase rebates, on-road...
benefits, to utility discounts (California Air Resources Board, n.d.). This widespread support provides and added layer of benefits to local consumers and has made the integration of EVs much more appealing to potential buyers.

California is currently the leader in EV adoption in the US and there is consumer interest in both BEVs and PHEVs [Figure 10]. Similar to Norway, a certain degree of variability of EV sales is likely attributable to regular seasonal variation rather than responsiveness to any sociopolitical changes. There are not any explicitly identifiable shocks to the market that are measurable outliers from the linear model. The linearization of BEV and PHEV sales indicate steady increasing growth with BEVs taking over PHEVs in mid-2014 [Figure 11]. BEVs are supported by the presence of Tesla Motors, both as a popular PEV option and a regionally produced vehicle.

**Figure 11: California EV Sales**

California engagement with EVs is high—as expected given the history of social, environmental, and political commitments made in the state. However, again similar to Norway, there is insufficient variability and specific measurements to directly link media mentions with and level of influence to the actual market. Especially because there are not any major market shocks, an associative pattern cannot be established.

**Georgia**

Georgia’s EV market is incredibly responsive to incentives, making it both a domestic leader and straggler in EV market share within the span of five years. In 2010, Georgia established policies that provided EV buyers with a US$5,000 tax rebate on the vehicle purchase and up to US$2,500 towards the cost of installing electric vehicle supply equipment (EVSE) (Young, 2014). In 2013,
the introduction of domestic BEV production operations in nearby Tennessee supported significant growth of BEVs regionally. Discussions to discontinue the state incentives began in late 2014 and early 2015 with no actual changes until the incentives were abruptly cancelled in July 2015 and replaced with a US$200 registration fee (Gould Sheinin, 2016) [Figure 12]. The massive growth of the market was followed almost immediately by an equally massive drop due to confusion surrounding the cancellation of the incentives.

The significant shifts in EV policy are mirrored directly by the trajectory of market growth. Of all markets, Georgia has the most direct relationship between the measured shocks and changes to sociopolitical conditions; each time there is a significant change in the direction of market growth, there is an associated shift in policy. Throughout the entirety of BEV market variability, the PHEV market remained stagnant. From the relationship, Georgia is an example of a market whose growth is entirely reliant on consumer financial motivations rather than environmental or technological interests.

![Figure 12: Georgia EV Sales](image)

Especially during the period of confusion surrounding the renewal of the EV rebate, there is a loosely inverse relationship between literature mentions and EV sales reflecting higher levels of conversation. However, much like the other markets, there is not necessarily a direct link between the content analysis and the actual market behavior.
Discussion
As the viability of EVs as primary vehicles grows, political support and consumer engagement is more important than ever. Countries such as Germany and the United States have pledged funding for research and development of EV technology and market growth, but so far, all have missed their marks or are far off the necessary trajectory of growth.

Content analysis and social analytics confirm the divergence between level of discussion and perceptions around EVs. The findings support the slow uptake and market stagnation of EVs; in the realm of alternative fuel vehicles, while EVs are frequently discussed, they are perceived with limited positivity and resistance [Figure 13, Figure 14] (Crimson Hexagon, 2017). All locations experienced a consistent media presence with regular fluctuations much like the market itself. However, the media engagement levels are not necessarily a predictor of market movement nor do they represent the positive or negative perceptions of EVs.

![Electric Cars vs Hybrid Cars Share of Voice Trend](chart1)

**Figure 13: Share of discussions involving electric cars versus hybrid cars**

![Electric Cars vs Hybrid Cars Sentiment Trend](chart2)

**Figure 14: Consumer sentiment towards hybrid vehicles versus electric vehicles**

As incentives expire and phase out, their replacement is key in supporting continued expansion and full maturation of the markets. Governments must remain willing to invest and commit to the viability of EVs; the market itself and overcoming technological constraints remain dependent on said willingness, otherwise EV markets will continue to struggle (Green, Skerlos, & Winebrake, 2013). Policy incentives miss the key components of identity and social theory; lifestyle symbology and product imaging are often a significant motivator beyond purely financial
incentives (Rezvani, Jansson, & Bodin, 2015). Georgia contradicts that belief to some extent, but a significant motivator for BEV adoption in Georgia was the regional output, financial incentives, and support of the associated job market at the nearby Nissan EV production plant.

The most apparent conclusion identified is that almost all major shocks in EV markets can be associated with some sort of change to the sociopolitical climate surrounding EVs. Especially in the less mature markets where the EV market has yet to be fully independent, any form of change in the policy sphere invariably shifts the direction of EV sales. While the incentives themselves are important, the way in which they are implemented must be deliberate and intentional.

In California and Norway—arguably the longest sustained supporters of EV policies—the markets are notably more stable in reaction to policy changes. Their stability points to the eventuality of a market with a lower likelihood of shocks and that is less reactive to sociopolitical shifts. The market shocks and associated sociopolitical changes in Georgia and the Netherlands indicate that an abrupt elimination of EV incentives destabilizes the market in the long-run. In both instances, the linear growth of the markets is essentially nonexistent, despite significant periods of growth that are balanced by significant drops in sales. Studies recommend a gradual expiration of incentives, similar to Norway’s reductions in taxes, as a means of preventing absolute market dependence on government intervention while still maintaining growth (Slowik & Lutsey, 2017). The shocks that pair with sociopolitical shifts generally do not distribute out well in the overall market. Together, the case studies demonstrate what other studies corroborate: incentives are an important driver of the EV market and must remain until EVs have gained enough traction to be self-sustaining; premature removal can drastically reduce the likelihood of sales and be damaging to the market (Hardman & Turrentine, 2017).

In addition to political support, social and industry engagement has fallen short. In order to prevent the stagnation of the EV market and move beyond the still-low market share held by EVs, consumer education efforts have the potential to generate and increase positive consumer incentives (Hardman & Turrentine, 2017). Incentives alone are insufficient; in many cases, the incentives are there, but consumer reactivity is low. The barrier of uncertainty or unfamiliarity is a continued roadblock to EV adoption; a paradigm shift in consumer attitudes and marketing output paired with sustained incentives is necessary when considering the development of a viable transportation alternative (Plug In America, 2015).

To prevent destabilizing ‘shocks’ to EV markets, governments and industry must continue to deliberately coordinate in ways that supports the growth and acceptance of alternative fuel vehicles. By maintaining incentives to sufficiently establish sustained EV markets and focusing media and marketing efforts to consumers, electric vehicles have a chance at persisting as a solution to global climate change driven by transportation usage. Such coordination between policymakers and automakers is required if EVs are to remain a legitimate tool in combating fossil fuel emissions and unsustainable transportation development.
References


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