Impact of Green Mobility EU Announcements on Stock Returns of Major Automotive Manufacturers: An Event Study Using Cumulative Abnormal Returns (CAR)

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1 Abstract

The EU commission mandated every car to be sold after 2035 to be emission free. This study examines the effect of this and other recent EU policies on incumbent automobile manufacturers using Cumulative Abnormal Returns (CAR) in an event study setting. Abnormal returns in proximity of the announcement were found to be predominantly negative, indicating investor pessimism. A second analysis using Ordinary Least Squares seeks explanation for this pessimism. For that purpose, a unique dataset containing dozens of firm-specific variables was constructed. The second analysis finds that multiple firm-specific variables affect Cumulative Abnormal Returns significantly. Drivers of investor sentiment are exposure to EU policies, timing of entry into the EV market, technological advancement of the product and success of current EVs. This study helps to understand the mechanisms behind the restructuring of the automobile industry and provides information to develop strategies for survival for both incumbent car manufacturers and nations that depend on these industries.

2 Introduction

The 27th of October 2022 marked a turning point for the automotive industry.

On that day, the European Commission passed a law that effectively prohibits the production and sale of internal combustion engine cars after 2035. As to be expected, this harsh decision triggered a lot of reactions. Organizations like Greenpeace claim, the set target is too late, to reach the goal of keeping global warming below 1.5 degrees Celsius (Greenpeace, 2022). But the law was also heavily criticized by the opposing parties. Lobbyists claim that this law is too harsh, and that the EU is harming one of their strongest economies – the automobile industry (Politico, 2024). This comes as no surprise, as a recent report by BCG shows, that US car manufacturers lose about 6,000 USD on every 50,000 USD Electric Vehicle (EV) they sell (BCG, 2024). While, this report concerns the North American market, it is to be expected that European car makers exhibit similar numbers, because most of the critical EV infrastructure is still produced by Asian, mostly Chinese firms (The Diplomat, 2023). This high dependency on Chinese suppliers, coupled with receding EV Sales, led the European Commission to reconsider their ambitious targets for 2035 (Forbes, 2024). Already back in 2023, German car manufacturers ran a successful campaign to spare e-fuels from the planned ICE ban (Euronews, 2023). So, it is evident that reaching climate neutrality is a major Eu goal, however lawmakers are also concerned with not harming one of their strongest industries. Therefore, the following research question shall be examined in this paper:

How do investors think about the future performance of incumbent automobile manufacturers, considering the upcoming shift towards greener mobility?

It is important to anticipate, how incumbent firms will do in a future towards more sustainability in the automotive industry. Capital markets act as a good proxy for how well car makers are equipped for such a shift in mobility.

Sustainability has been on the forefront of political and social discussions. This paper adds social value by introducing a framework that allows to take micro-economic factors of pro-sustainability policies into account, which can be integrated into future discussions.

Research in this field is scarce. There is a growing realm of literature that explores the relationships between green policies and micro-economic data like stock prices or revenue.

There is however only little literature concerned with the effects of the internal combustion engine ban, as announced in 2022. While this law has substantial effects on incumbent car makers and on of the biggest global industries, academic literature has hardly covered this event and its effects. This paper will therefore contribute to the scientific landscape by exploring the effects of a novel event in a researching field that is rapidly growing.

3 Literature Review

This paper is part of an emerging and growing study field that examines the effect of climate-change related news on economic outcomes, which in the context of this research take on the form of daily stock returns. This section will introduce a selection of relevant literature published in this study field.

Disclaimer: Green and Brown Stocks

A widely used practice for characterizing the environmental sustainability of firms, is allocating them into “green firm” and “brown firm” buckets. Often these 2 terms are stretched beyond the aspect of environmental sustainability and find use among the whole ESG spectrum, also declaring badly managed or for example tobacco-producing firms as “brown” (Pástor et al., 2021). As the focus lays solely on the environmental aspect of sustainability in this research, the concepts of brown and green will only be used in this context.

3.1 Traditional Capital Market Theories

As outlined in the introduction, the demand for sustainable solutions has soared in the past years. It is therefore to be expected that this demand exceeds common consumer goods and also affects capital markets. Standard economic theory, following the CAPM-model of Sharpe (1964) predicts that investors will only pick stocks based on their anticipated pay-off. This theory entails that individual preferences of the investor (towards sustainability for example) do not affect stock prices. Fama & French (2017) argue that this assumption is unrealistic, and they suggest a significant impact of the investors taste on stock selection. An investor could for example have preferences towards growth stocks or towards domestic stocks. They argue that there is additional utility connected to holding a stock that is not captured by the CAPM model that only takes stock returns into consideration. In the same context, it is therefore likely that an increased global awareness for sustainability also leads to an increased demand of stocks that reflect these values.

3.2 Empirical Evidence

There are several economic papers that try to find empirical evidence, capturing this relation. Donadelli et al. (2019), for example, examine this relationship by exploiting news announcements on more stringent environmental policies in an event study setting. They show that the stock prices of companies operating in the oil industry exhibit lower Cumulative Abnormal Returns than other more sustainable industries. Effectively, this means that there is a relative decline in the valuation of fossil fuel firms, after these announcements.
Borghesi et al. (2022) also compare returns in green and brown industries after green policy plans have been announced and find similar results. Their research shows an increase in returns for both types of industries with the brown industries, however, exhibiting less growth, which ultimately leads to a relative devaluation of brown industry firms. They ran additional analyses on the type of policy announcement and found that policies of the type "climate mitigation" had the most significant effect. They explain this with the fact that these policies on average receive 70% of a countries "green recovery" budget.
Another seminal paper by Barnett (2019) makes use of a concept called "Climate Policy Risk Exposure". This metric captures, how strong the negative effects of additional climate policies would be for a firm. He finds that firms with high risk-exposure tend to have negative cumulative abnormal returns, after the likelihood of additional climate policies increases.
All these papers provide empirical evidence to support the assumption that the investors' perception of a firm's sustainability affects asset prices.

3.3 Theory Expansions

New theoretical models have hence been developed to accommodate this information. Pástor et al. (2021) for example use the CAPM framework developed by Sharpe (1964) to reason for a stock selection based on sustainability. They argue that green stocks mostly have a negative alpha which means that their baseline constantly does worse than the market benchmark. It would therefore not be profitable for investors to buy these assets. However, Pástor et al. (1964) claim that in the case of a sudden shock, green stocks outperform their brown counterparts in terms of market returns. Ardia et al. (2020) conducted empirical research to test this theoretical model. To quantify "sudden shocks" they constructed a daily "Media Climate Change Concerns Index" that captures news about climate change published by major US newspapers. Using a panel data fixed effects regression, they found that when climate change concerns increase unexpectedly, green firms' stock prices increase, and brown firms' stock prices decrease. This proves again, that trivial models like conventional CAPM do not suffice to predict buying decisions accurately.

3.4 Theoretical Framework

This section is used to develop a framework for answering the researched question formulated in the introduction. Existing theories and past research will be used to develop hypotheses that shall be tested in this paper.

How do investors think about the future performance of incumbent automobile manufacturers, considering the upcoming shift towards greener mobility?

The first step towards answering this research question is to conceptualize the investors' perception. A possible approach could be to have a sample of investors fill out surveys, ranking different stocks on a scale of 1 to 10. This solution is, however, very labor and time intensive and also has a handful of shortcomings if the sample size is not big enough. In this research, the investors' optimism of a firm's future performance will be conceptualized by the daily stock returns of that given stock.

Information and Stock Prices

Ultimately, this mechanism works because of the so-called Efficient Market Hypothesis, as popularized by Fama (1970). The main argument of this hypothesis is that asset prices (like stock prices) reflect all information available on the market. In this state, market efficiency is reached. As soon as new information emerges, prices adjust rapidly to reflect these news. The paper also argues, that in all markets, the strongest form of market efficiency can never be reached, which is also supported by Grossman & Stiglitz (1980). This is due to asymmetric information amongst investors. Some information might be confidential and kept in private for example, which allows for abnormal returns in insider-trading. Fama (1970) also presents, however, empirical evidence supporting a semi-strong market efficiency. In this market condition, prices contain all publicly available information, including historical information. This is supported by event studies showing quick adjustment to newly available information (Jensen, 1968). Following this line of argumentation, the first hypothesis can be formulated:

I. The EU's recent zero-emission mobility policies affect investor expectations, leading to measurable changes in the stock returns of major automobile manufacturers.

Firm-specific Variables & Investors' Expectations

It is plausible to expect that different firms are affected in a different matter by expansive climate policies, like the EU's ambitions towards greener mobility. This is also supported by the earlier introduced "Climate Policy Risk Exposure" metric, used by Barnett (2019). Observing and analyzing firm-specific characteristics can therefore be indicative of how investors' expectations change with the announcement of new green policies:

II. There exists a correlation between firm-specific variables and investors' expectations about that firm's future performance.

Timing of Entry

The first factor that might play a role in the investor's perception of a firm's potential during the mobility shift is their timing of entry into the EV-market.

A concept that is often mentioned in the context of market entry are first mover advantages, as popularized by Lieberman & Montgomery (1988). They argue that firms entering early will do better than others simply by being the first on the market. This is for example due to these companies being ahead on the learning curve, or being able to control input factors that are crucial to the production. Having these advantages will allow early entrants to produce at a lower cost and gain a competitive advantage. Klepper & Simons (2000) provide empirical evidence for this theory, showcasing how the US-American tire industry is still dominated by a few early entrants.

Christensen et al. (1998) however argue that the early accumulation of knowledge can not only be an asset in favor, but also a liability. They build upon the "dominant design" framework by Utterback and Suarez (1993), that states that every product will at some point establish a dominant design that will become the industry standard. In the case of the automobile industry, this used to be a closed-body, steel-frame car, powered by an internal combustion engine. They argue that a firm's success is not only dependent on them entering the market early, but also on the adoption of the dominant design. Conversely to the first mover advantage theory, Christensen et al. (1998) find that firms entering just before the emergence of a dominant design had increased survival chances in the following years.

The EV era marks a new lifecycle for the automobile industry and market shares are reshuffled. A new dominant design for cars in the form of electricity powered vehicles is expected to emerge. Following the reviewed theories, it is therefore plausible to expect investors to take a car manufacturer's time of entry into this new market into account:

II.I The timing of entry of automobile manufacturers into the EV market relates to investors' expectations about that firm's future performance.

Technological Advancement

A Staple in economic theory is the "Rational Choice Theory". With its basic concepts being found in works of Adam Smith (1776), this theory suggests that every individual's goal is the maximization of their own utility (Scott, 2000). Consumers obtain utility in numerous ways, with a significant share being generated by product attributes. These attributes can take on different forms like performance, quality or also price of the product. Empirical research of the German market shows that consumers care about performance and range of EVs when faced with a buying-decision (Lieven et al., 2011). The same study also found that the range of a car affects consumer choices more when faced with electric compared to conventional cars. Similar findings were presented by Zhang et al. (2016), who in their empirical study of the Norwegian EV-market found that "vehicle technology" is a main driver for utility.

These findings can be used to motivate the following hypothesis:

II.II The degree of technological advancement of a car manufacturer's EVs relates to investors' expectations about that firm's future performance.

Success of Current EVs

Another determinant of future success of a car manufacturer's EVs is the perception of their current products. A positive reputation can create favorable momentum for firm performance. In this context, a concept capturing a brands perception is "brand equity". The concept of brand equity, popularized by Aaker (1991) refers to the additional premium, a company can ask for selling branded, compared to unbranded products. This equity can be developed through advertising, among others. Furthermore, Simon & Sullivan (1993) also find that the perceived quality of a product is a main determinant and driver of brand equity. This is especially relevant for this research, as Baltas & Saridakis (2010) found that some car manufacturers and even models are priced at a premium, when controlling for actual differences of the product. This comes as no surprise, considering that cars are not just items of use but are also regarded as a form of status symbol (Gartman, 2004). It can therefore be hypothesized that brand equity and the perception of their current products will affect expectations about future firm performance:

II.III The consumer's perception of a car manufacturer's current EVs relates to investors' expectations about that firm's future performance.

Policy Exposure

Lastly. It is also to be expected that some car manufacturers are more exposed to these policies than others. While EU-policies are often adopted by other markets as well, manufacturers with higher dependency on EU-markets will most likely be hit harder by the EU-policies in question. It can therefore be hypothesized that:

II.IV The car manufacturer's exposure to the EU green mobility policies relates to investors' expectations about that firm's future performance

4 Methodology

The data analysis of this paper is twofold. In the first part, an event study using Cumulative Abnormal Returns (CAR) will be conducted. Subsequently, OLS will be used to explain part of the CAR results.

4.1 Event Study (CAR)

An event study is a methodology designed to analyze how certain events or public announcements shape the expectations of investors on the stock market. In the case of this research, interest lies on the expectation of investors towards how companies are going to perform in the "green mobility" era. To do so, two distinct events, shaping the automotive industry were identified and exploited for this analysis. These events will be explained in detail in the Data section of this paper.

As mentioned earlier, economic theories claim that stock prices already contain all the information that is available on the free market (Fama, 1970). If a new piece of information is released to the public, the theory suggests that this leads to change in investors' expectations and therefore also change in stock price immediately. An event study, using CAR, measures these updated expectations of investors by using stock returns close to the announcement. This methodology works, because the stock returns ultimately reflect, if the majority of investors has sold or bought the stock on that particular day. If investors expect companies to do well in the future, they will buy the stock. Otherwise, investors will sell. By the laws of supply and demand, this simple framework leads to fluctuations in stock price, raising prices for stocks that are in higher demand. Ultimately, an increase in stock price compared to the day prior leads to positive stock return. The expectation of an investor is therefore related to the return of a given stock, which is crucial, as this paper will use stock returns as a proxy for investors' expectations.

Industry Benchmark

Stock returns are however subject to a lot of other factors like market fluctuations and cannot always be solely attributed to the investor's expectation about that specific company. To combat this issue, the daily stock returns of a car manufacturer will be compared to a benchmark to get so called “Abnormal Returns”, which are essentially returns that cannot be explained by regular market movements.

Normal Returns

First, a simple linear regression is run to examine how the stock price return of interest follows the returns of an industry benchmark. The estimation looks as follows:

$$ER_{i,t} = \alpha_i + \beta_i * R_{m,t} + \varepsilon_{i,t}$$

This formula predicts the expected daily return of a specific stock ($ER_{i,t}$), given the return of an industry benchmark for that day ($R_{m,t}$). In this context, α denotes how consequently the stock return deviates from the industry return. In equilibrium, α is zero as no firm should be able to outperform the market over a longer period of time, according to economic theory (Fama, 1970). The second term captures movements in stock return that are subject to broader market movements. Here, β captures how closely the stock returns follow the industry benchmark. A β bigger than 1 for example entails that the returns of a given stock react more extreme to changes than the benchmark returns. If β is 1.5 this means that an increase in benchmark stock returns by 1 unit leads to the stock return increasing by 1.5 units on average. The same counts for negative returns, which is why β is also often used as a measure of volatility (Sharpe, 1964).

Estimation window length

This linear regression formula is firm-specific and will be calculated using a one-year estimation window that ends 30 days before the announcement to ensure that the event itself is not interfering with the estimators. Setting the right estimation window is crucial to ensure reliability of the results produced. A too short estimation window significantly renders the power of the analysis, while a too long estimation window can introduce unwanted noise to the model (Brown & Warner, 1985). Picking an estimation window of exactly a year ensures that all seasonal fluctuation that might exist find their way into the model (MacKinlay, 1997). The next step is to calculate the returns of the auto manufacturer’s stocks as predicted by the estimators that were just calculated. These can be obtained by plugging the actual daily benchmark returns in the OLS-formula. These newly obtained values depict how the stock returns should be if they just followed the market. They are basically the "Normal Returns" that were expected based on historical data.

(Cumulative) Abnormal Returns

Subtracting these predicted returns from the actual returns leaves us with a residual, the so called "Abnormal Return". These are returns that cannot be explained by regular market movements:

$$AR_{it} = R_{it} - ER_{it}$$

The last step to arrive at the final metric of Cumulative Abnormal Returns (CAR) is to sum up all abnormal returns of the event window in the following way:

$$CAR_i(-t, t) = \sum_{-t}^{t} AR_{it}$$

Average Abnormal Returns

Additionally to Cumulative Abnormal Returns, another measure can be calculated to allow for better comparability of the results. The Average Abnormal Return (AAR) captures the average daily return that is realized over the market benchmark:

$$AAR_i(-t, t) = \frac{AR_{it}}{2t + 1}$$

This metric has the advantage of being comparable across differently sized event windows, which will prove helpful in assessing the consistency of the results.

Event window length

Setting the size of the event window is a central question in this methodology, as it can have a big impact on the results obtained. While economic theory suggests that new information gets incorporated in stock prices immediately (Fama, 1970), realistically this is not the case in real life scenarios, and it can be expected that an event window of a single day will not capture the effect of the announcement to the full extent. Another factor to be considered is that there might be leakage of information and anticipation of the announcement. It therefore also makes sense to include trading days before the announcement day itself to fully capture the effects of the event. The trade-off now lays between picking a potentially too small event window leading to not capturing the full effects of the event and picking an event window that is too large, which might lead to other events being included that affect stock returns as well. To balance this tradeoff, this research will employ two different time event windows in the context of the CAR analysis, a 7-day window (-3,3), as well as a 21-day window (-10,10). This approach is following the research by Brown and Warner (1985), who suggest shorter event windows, to capture the immediate effects of the announcement while keeping noise from other events to a minimum. This analysis will then also make use of a larger event window of 21-days, which is in line with research of MacKinlay (1997) who suggests the usage of bigger event windows, if the effect is expected to be lasting multiple days.

The CAR is therefore capturing all the individual- and time-specific abnormal returns (AR_{it}), that are summed up to get a metric that depicts the full event window. As abnormal returns can take on both positive and negative values, the cumulated abnormal returns will do so as well. A positive CAR means that, during the event window, investors adjusted their expectations in a way which led them to increased demand for this particular stock. It can therefore be regarded as a positive sign, reflecting an optimistic view of investors on future returns of the underlying asset, while a negative CAR depicts the opposite.

4.2 Regression Analysis

The second part of the data analysis in this paper builds upon the first part and tries to find explanations for the results found in the previously conducted data analysis. In particular, this part will illustrate how different CAR values correspond with other observable firm characteristics and positionings. This, again, ultimately relates back to investors' expectations, so this second analysis essentially tries to find connections between shareholder optimism and other variables that could affect the car manufacturers' future business.

Estimation

Analyses on the interconnectedness of these variables with the CAR-measure will be first examined by studying the pair-wise correlations of these variables. After, a simple Ordinary Least Squares (OLS) regression will be run as well to drill a bit deeper into the examined relationships. This methodology cannot provide any causality of differences in CAR values, but merely establish an association between the two measures. This is not a problem for this research however, as the ambition is not to explain the cause of different CAR score. This second analysis should simply act as framework for possible origins of these differences.

4.3 Aggregation

The power of an Event study analysis can be significantly rendered, if exogenous events affect the CAR values. For that reason, it is common to use some form of aggregation in a CAR analysis, which hopefully cancels out these outside effects. A popular approach is to consider a bigger set of similar events or analyze the effects on a bigger set of entities (here: car manufacturers). In the case of this paper, however, these 2 options are not available, due to the high market concentration in the automobile industry and the lack of further comparable events that could be exploited for such an analysis. Instead, this paper uses 5 different event window lengths in the hope of mitigating the effect of unwanted events in that way. This results in 5 CAR values for every car manufacturer and event. Later, in the regression analysis part of this paper, these results will be aggregated to test the robustness of the findings. The levels of aggregation look the following: (A more detailed explanation of the datasets that were used can be found in the table notes of the regression results)

Level 1: Analysis by Event and Event window

The first step will analyze how firm-specifics affect the CAR value of a specific event and event window length (For example, how the Timing of Entry into the EV market affects the 7-day CAR in relation to the first event). Each regression coefficient will be specific to the event and event window that was used. Using all 5 CARs from different event window lengths would yield 10 regression results per firm-specific variable (5 event windows for 2 events). To keep this number down, only a 7-day and 21-day event window will be considered in this first step of the regression analysis.

Level 2: Analysis by event

Next, the CAR values can be consolidated by event. Now, there will be 2 regression results (for 2 events) per firm-specific variable. The dependent variable are now CAR values of 5 different event window lengths

Level 3: Overall Analysis

Lastly, all the CAR values (of both events and all event window lengths) can be aggregated and considered as one dependent variable. This leads to a single regression result per firm-specific variable.

Aggregating the results is a trade-off in the context of this data analysis. On one hand, it mitigates the effect of including exogenous factors by considering different event window lengths within one analysis. On the other hand, it does not allow for interpretations of the speed of changes in expectation of investors, as no distinction between 5-day and 21-day CAR is possible in Level 2 and Level 3 of the aggregation.

5 Data & Transformations

5.1 Events

To set a timeframe for the analysis of this paper, two striking events for the event study were identified. First, on the 14th of July 2021, the European Commission announced their "Fit for 55" initiative. The goal of this program is to cut net emissions by 55% compared to 1990 before the year 2050 and to make Europe be the first climate neutral continent by 2050 (Eur-Lex, 2021). The Fit for 55 proposal lays upon the legal obligation towards lower emissions that was anchored in the European Climate Law in June 2021 (Eur-Lex, 2021.1). In section 2.2.2 the Fit for 55 proposal highlights the importance of a shift towards cleaner mobility and the use of alternate fuels, as transport accounts for roughly a quarter of the EUs total emissions and a significant share of air pollution in cities. The commission also highlights its long-term goal of zero-emission mobility, which entails the shift away from conventional internal combustion engines and towards new and more sustainable power sources like hydrogen or electricity. While the Fit for 55 proposal did not specifically state an ultimatum for the production of the internal combustion engine, it still provided a strong signaling effect, which can be expected to have an effect on the automotive industry and its manufacturers. The final ultimatum for

the internal combustion engine was set a year later on the 27th of October 2022. This date will act as the second event for this analysis.
End of October 2022 the European legislators announced their first deal in the context of the Fit for 55 initiative. Compared to 2021, new cars should emit 55% less CO2 by 2030 and 100% less CO2 by 2035. This effectively means a prohibition of internal combustion engines after 2035, as they will never produce zero CO2 emissions (Euronews, 2022). These 2 events are expected to significantly shape the car industry and therefore it is expected that investors will adjust their expectations accordingly.

5.2 Stock Return Data

All the following data was hence collected to be applicable for an analysis in this timeframe. The first dataset on daily stock closing prices of the 10 biggest car manufacturers (measured by number of registrations between 2013 and 2023 in Germany) as well as an industry benchmark were collected using Eikon Datastream. This includes Data on BMW, Mercedes, Volkswagen, Stellantis (formerly PSA & Chrysler), Kia, Nissan, Hyundai, Renault, Ford and Toyota. An ETF covering the European automotive industry including manufacturers and suppliers, the “Euro STOXX Automobiles & Parts ETF” was included as well to act as a benchmark for normal market returns. From the daily closing prices, daily stock returns were calculated. After gathering this data, the event study can be conducted.

5.3 Firm-specific Data

Next, to find possible explanations for differences in CAR scores, more firm-specific variables are needed that quantify the quality and competitiveness of a car manufacturer’s electric cars.

Timing of Entry

A metric that might be interesting to look at is the year in which a car manufacturer launched their first EV. There are numerous economic theories explaining the merits of market entries, that include early mover advantages and the protection of property rights. So, the timing of market entry could also act as an interesting variable in trying to explain different CAR scores. The data on that was obtained manually by reading through the applicable press releases. This variable is defined as a relative measure of time. Out of the manufacturers of this dataset, Stellantis released the first EV in the Year 2010, so their “Entry” variable will take on the value

1. Car manufacturers that released their first EV in the following year, will have an "Entry" variable equal to 2. If they released their first EV in 2014 it will be 5 etc. The range of this variable is surprisingly big with Toyota releasing their first EV in 2021, 11 years after Stellantis (see Table X). Note, that the EV releases captured in this variable only account for latest generation EVs, launched after 2010. Any older projects or concept cars are irrelevant in this context.

Technological Advancement

In 2024, there are still vast technological differences between EVs. Product attributes that affect the user experience the most are the range that can be driven on a single charge and the fast-charging capabilities of the model. Considered good EVs are models that have a high range and that charge back up quickly. It therefore also makes sense to include these metrics in the analysis as a proxy for the technological advancement of a manufacturer's electric cars. Ev-database.org provides helpful information to quantify this variable. For each manufacturer, the model with thew highest range, sold in 2023, was identified and the range specification in kilometers was extracted. To measure fast-charging capabilities, the website also provides a metric called "Fast-charging" which is measured in km/h and indicates how many kilometers can be travelled, if the car was charged in fast charge mode for an hour. Note that this is just a standardized value, as some cars might provide a fast charge in only 30 mins. In that specific case, the range gained in that time is doubled to get to a number that depicts range gained in an hour of fast charging. These values were then extracted for the highest scoring model of every manufacturer. Finally, next to using these numbers as they have been extracted, they were also transformed to more easily reflect how bad or well a model does compared to its competitors. This relative measure was calculated in the following way:

$$Relative\ Positioning = \frac{X_i - X_{min}}{X_{max} - X_{min}}$$

In this case X_i will be the company specific top range or top fast-charging metric. This newly created indicator takes on values between 0 and 1 with 0 being the worst performing and 1 being the best. A model that has a range that is exactly in between the worst and the best will score a 0.5 on that scale. This variable is perfectly colinear to the normal "Range" or "Fast-charging" variable. It is, however, easier to interpret the regression coefficient of these new variables.

Success of Current EVs

To get a measure for how successful current EV models are, annual data on new registrations in Germany will be used. This dataset, provided annually, by the KBA ("Kraftfahrt-Bundesamt") lists the number of newly registered vehicles of the past year, split by drive chain. To get an overview of how successful a manufacturer's EVs are in Europe, the share of newly registered EVs out of any newly registered car is extracted per manufacturer. To ensure that this number is not as subject to fluctuations caused by new EV releases or similar, an average over the three years between 2021 and 2023 will be used.

Additionally, the quality of their EVs can be conceptualized by comparing third party rating scores. The third party picked in this paper is the ADAC, which is a German automotive club, being the largest in Europe with around 21 million members. Next to roadside assistance they release a scoreboard of car models that have been tested by ADAC that year. This scoreboard is released annually. The rating covers different aspects but does not take price into account (ADAC, 2023). For this analysis, the ratings of cars in the timeframe between 2020 and 2023 is considered, which amounts to nearly 400 cars, 98 of which are EVs. The 10 biggest car manufacturers used in this paper launched 74 of the 98 tested EVs. Out of these latest generation EVs, an average test score is calculated for every car manufacturer. The rating can theoretically take on values between 1 and 6 with 1 being the best, which is a common scale in Germany, also found in school grading systems. In the data, however, the rating ranges only from 1.82 to 3.33 (see Table 5).

Policy Exposure

Lastly, another variable should be included that does not describe the nature of the product but rather how reliant the manufacturer is on the EU market. This is for two reasons. First, a EU industry benchmark is used, so it makes sense that it is harder for European companies to gain abnormal returns than it is for American or Asian manufacturers. Second, the two events were announced by the European Commission and do only directly affect car sales within the European Union. Therefore, an additional variable is created. For every manufacturer, a variable will be added that denotes the shares of total sales that EU countries generate for this company. The higher the number, the more affected will the manufacturer be by the two events in question. This variable is especially interesting, as it can act as a control variable in the regression analysis to get a better and more fair estimation of the connectedness to the firm-specific factors.

6 Results and Robustness Checks

6.1 Cumulative Abnormal Returns

Table 1 provides an overview of the different CAR and AAR results, related to the first event, the announcement of the Fit for 55 initiative. The 7-day and 21-day event window CARs mostly indicate the same relationship, meaning they have the same sign. The magnitude differs, which was to be expected, as the event window for CAR(-10,10) is larger and therefore allows for the accumulation of higher returns. BMW, Hyundai, Kia, Renault and Stellantis exhibited negative abnormal returns in at least one of the CARs estimated. In the specific case of BMW for example, the 7-day CAR is almost equal to zero, so no abnormal effect can be observed. Looking at the CAR of the 21-day event window however, negative abnormal returns can be found. This could be explained by the fact that a 7-day event window probably failed to capture the full effects of the announcement. Renault exhibits the exact opposite case. Here, an immediate negative CAR can be observed over the 7-day event window, which is later countered by more positive abnormal returns, making the 21-day CAR positive. A reason for this inconsistency could be the fact that the 21-day window captures additional events that improved investors' optimism about Renault's future business performance. Mercedes seems to be mostly unaffected by this announcement, using both the 7-day and 21-day event window. Ford initially exhibited a CAR of almost -10%, but when considering a larger event window, their CAR becomes strongly positive with about +16%. Toyota and Volkswagen are the only manufacturers that exhibited positive CARs over both event windows, with about 2.75% and 4.4% respectively, being constant over both event windows.

The AAR is often roughly consistent for both event windows. Different magnitudes of AAR can be explained by different even windows capturing more (less) of the effect. If the CAR is equal for both the 7-day and 21-day event window, the AAR will be larger for the 7-day window as can be observed in the case of Volkswagen. The additional 14 abnormal returns roughly cancel themselves out when accumulated, resulting in the same CAR for both periods. When the 7-day AAR is stronger of magnitude than the 21-day AAR, this means that the announcement probably had the biggest impact close around the event. Including more days mitigated the average daily effect.

Table 1. Cumulative Abnormal Returns (CAR) and Average Abnormal Returns (AAR) for a 7-day and 21-day event window in %. Fit for 55 Announcement.

	CAR(-3,3)	CAR(-10,10)	AAR(-3,3)	AAR(-10,10)
BMW	0.37	-6.57	0.05	-0.31
FORD	-9.84	16.23	-1.41	-0.77
HYUNDAI	-5.35	-25.22	-0.76	-1.20
KIA	-6.27	-20.27	-0.89	-0.97
MERCEDES	-0.19	0.66	-0.03	0.03
NISSAN	-0.45	19.06	-0.06	0.91
RENAULT	-9.54	3.42	-1.36	0.16
STELLANTIS	-10.86	-12.50	-1.55	-0.59
TOYOTA	2.74	2.71	0.39	0.13
VOLKSWAGEN	4.36	4.44	0.62	0.21

Note. AAR is the average abnormal return per day. This can be calculated by dividing the CAR by its respective event-window length.

The estimated CARs of the second event, the ultimate decision to ban internal combustion engines by 2035 are presented in Table 2. An outstanding finding of this second analysis is the strongly positive effect that this announcement had on abnormal stock returns of Ford. A possible explanation could be that the benchmark is only capturing the European automobile market, while Ford is US-American car manufacturer. So, even if Ford is not realizing significant positive returns, their CAR will be positive when the benchmark realizes significant negative returns. This relationship will be further investigated in the second part of the data analysis. Another remarkable result is found in the CARs of Renault. They exhibit cumulative abnormal returns of about -17% and -36% for the 7-day and 21-day event window respectively. This indicates strong investor pessimism about Renault's future performance in the EV market. The results of the second announcement are largely in line with those of the Fit for 55 announcement.

Table 2. Cumulative Abnormal Returns (CAR) selected event windows (7- and 21-days) for the ICE ban by 2035 Announcement

	CAR(-3,3)	CAR(-10,10)	AAR(-3,3)	AAR(-10,10)
BMW	-0.18	0.09	-0.03	0.01
FORD	16.73	13.95	2.39	0.67
HYUNDAI	-5.16	-3.23	-0.73	-0.15
KIA	-7.46	-9.79	-1.07	-0.47
MERCEDES	-1.07	3.46	-0.15	0.16
NISSAN	3.19	1.65	0.46	0.08
RENAULT	-17.15	-36.46	-2.45	-1.74
STELLANTIS	1.30	-2.63	0.19	-0.13
TOYOTA	1.23	-11.70	0.18	-0.56
VOLKSWAGEN	-1.08	0.58	-0.15	0.03

Note. AAR is the average abnormal return per day. This can be calculated by dividing the CAR by its respective event-window length. Returns are denoted in %.

It is important to note, that these findings are based on single events and could very well be influenced by outside factors, like other events. Imagine for example, if Ford announced their quarterly results on the same day as the announcement of the internal combustion engine ban of by 2035. In that case, it is impossible to distinguish between abnormal returns that arose due to the announcement of the quarterly results and the ones that are due to the ban of the internal combustion engine.

6.2 Correlation Analysis

The correlation Matrix in Table 6 (see Appendix) shows that some of the firm-specific variables correlate with each other. The timing of entry, for example, seems to be related to some other qualities of the produced EV. A car manufacturer that started building EVs earlier, on average has higher top range, better ADAC ratings and sells more EVs (as share of total sales).

Correlations between firm-specifics and CAR values are ambiguous. The only consistent result over all 4 observed CARs can be found for EV Share of Sales. These correlations are always negative, implying that a car manufacturer who already sells a lot of EVs (as share of their total sales) will on average exhibit a more negative CAR than a manufacturer that sells less EVs. One shortcoming of a conventional correlation analysis is, that it does not provide any significance levels and does not allow for the inclusion of control variables. Nevertheless, it is a powerful tool, showcasing that there are some interesting relationships to be explored in further analyses.

6.3 Regression Analysis

As explained in the methodology section of this paper, the regression analysis was conducted for three levels of aggregation. In this section, the results will be presented by firm-specific variable, covering all 3 levels simultaneously. The application of different degrees of aggregation will also act as a form of a Robustness Check in the context of this analysis.

Policy Exposure

EU Sales (Share) will be applied as a control variable for later models, which is why the regressions of policy exposure on Cumulative Abnormal returns were run first. The first level of aggregation did not yield any significant results (Table 7). The coefficient of the level 2 regression for the Fit for 55 event also was not significant, but the coefficient for the internal combustion ban announcement was calculated to be -23.045 at a 1% significance level (Table 13). The level 3 regression yielded a coefficient of -11.414 at 5% significance (Table 19).
This implies that if manufacturer exhibits an increase in share of EU sales of 10% (say from 20% to 30%), their CARs are lower by 2.3% (1.1%) on average for the level 2 (level 3) aggregation. Manufacturers with higher exposure to EU policies therefore exhibit lower CARs, on average. This result is robust to different models.

Timing of Entry

The level 1 regression did not return any significant results, as well as the base model of level 2 (Table 8, 14). After adding Policy Exposure as a control variable however, the coefficient related to the internal combustion ban announcement is found to be -1.227 at 1% significance (Table 14). The level 3 regression did not return significant results (Table 19)
If a car manufacturer started selling EVs only one year later than a competitor, it will have a CAR that is -1.2% lower, on average. For a manufacturer that started 10 years later, CARSs will be lower by 12%, on average.

Technological Advancement

This characteristic was proxied by 2 variables “Range” and “Fast-charging”. While “Fast-charging” did not return significant results for any of the three aggregation levels, Range

seemed to have a relation to CARs (Table 10, 16, 19). In the level 2 regression, when controlling for policy exposure, the coefficient is 16.353 at a 5% significance level for the internal combustion ban event (Table 15). In case of the level 3 regression, the coefficient was calculated to be 7.205 at 10% significance, when controlling for policy exposure (Table 19).
This evidence shows a positive relationship between the Range of car models and their manufacturers abnormal returns. Improving the competitiveness in terms of range for a car model by 10 percentiles (say from the 50^{th} to the 60^{th} percentile rank) will, on average, yield CARs that are higher by 1.6% following the level 2 results and 0.7% following the level 3 results. This relationship is robust in models on different aggregation levels.

Success of Current EVs

The success of current EVs was quantified into 2 measures – the ADAC rating and new EV registrations as share of total registrations.

The ADAC rating returned significant coefficients for all 3 levels of aggregation. On the first level, for a 21-day event window of the internal combustion engine ban, the coefficient was calculated to be -21.970 at 5% significance and even -25.557 at 5%, when controlling for policy exposure (Table 11). The second level regression yielded similar results with a coefficient of -13.267 and of -12.772 when controlling for policy exposure, both at 1% significance for the internal combustion engine ban event (Table 17). The third level of aggregation has a coefficient of -7.494 and, controlling for policy exposure, of -8.068 both at 5% significance (Table 19). All the results found were robust to policy exposure as a control variable and in line for different degrees of aggregation. While the magnitude shifted between aggregation levels, the sign remained constant and negative.
This means that if a car manufacturer scores better in ADAC ratings (ADAC rating is lower), it will have a higher (more positive) CAR. For an improvement of a whole grade, this effect on CARs ranges from 7.5% to 25.6% depending on the model, which is quite substantial.

For the EV Registrations (Share of total registrations), the analyses on all 3 aggregation levels returned significant coefficients. First, the baseline model returned a coefficient of -75.044 for the 7-day event-window CAR of the internal combustion engine ban. Adding policy exposure as a control renders the effect to -69.202.Both results are statistically relevant at 5%. (Table

12). The second degree of aggregation yielded significant regression results for the internal combustion engine ban. The coefficients without and with policy exposure control variable are -62.384 and -50.664, respectively, both at 1% significance. The fit for 55 announcement only returned a 1% significant coefficient of -32.548, when controlling for policy exposure (Table 18). In the fully aggregated regression, the coefficients were calculated to be -44.980 without control and -41.106, controlling for policy exposure, both significant at 1%. All the results found were robust to policy exposure as a control variable and in line for different degrees of aggregation. While the magnitude shifted between aggregation levels, the sign remained constant and negative.

These results are counterintuitive, as they imply, that a car manufacturer that already shifted their business more towards electromobility will have more negative CAR values, following the EU announcements than competitors that still have to shift. Depending on the model, this negative effect ranges from a 3.3% to 7.5% decrease in CAR, after an increase in Share of EV Sales by 10% (e.g. from 20% to 30%).

Comparison of Events

Next to comparing firm-specific coefficients, differences between the 2 events can be investigated and interpreted as well. Aggregation levels 1 and 2 distinguish between the announcement of the Fit for 55 initiative and the internal combustion engine ban. Level 3 does not and is therefore not relevant for this section. First, it is notable that the ICE ban event produced 10 significant regression results, while the Fit for 55 event only yielded 1. Second, when comparing the Fit for 55 coefficient to its ICE ban equivalent, the magnitude is far bigger for the internal combustion engine ban announcement. Intuitively, this makes sense, as the Fit for 55 initiative was only a guiding policy for future reference, while the 2nd event set a final deadline for incumbent car manufacturer to stop the production of internal combustion engines. It therefore could be expected that the second event will force a more definite and extreme reaction of the investors.

7 Discussion

This section will discuss the results and evaluate their power by examining potential limitations of the research. Another goal of this part is to explain the results, using the economic theories, introduced to motivate the hypotheses in the Literature Review part of this paper.

7.1 Hypotheses and Economic Theories

The first crucial step is to evaluate the hypotheses formed previously, which will be done in this section, split by topic.

CAR Values

I. The EU's recent zero-emission mobility policies affect investor expectations, leading to measurable changes in the stock returns of major automobile manufacturers.

The first hypotheses is supported by the results of the first part of the data analysis in this paper. A shortcoming, however, is that the Event-Study conducted did not include p-values to control for statistical significance. Therefore, the hypothesis cannot be rejected, but the evidence in favor of the hypothesis is limited as well. Additionally, the result could be influenced by exogenous factors, which will be addressed in the Limitations section.
However, the mere existence of abnormal returns support theories of Fama (1970) or Grossman & Stiglitz (1980), who argue that information will always be incorporated into stock prices, the timing however can be delayed.

Timing of Entry

II.I The timing of entry of automobile manufacturers into the EV market relates to investors' expectations about that firm's future performance.

The hypothesis cannot be rejected. The regression results suggest a negative relationship between market entry and CARs – the earlier a firm entered the EV market, the less pessimistic are investors about that firms' future performance, when faced with an event like the EU policies exploited in this paper. These findings are in line with theories that claim the existence of first-mover advantages like Lieberman & Montgomery (1988). Evidence for "liability of knowledge", as found by Christensen et al. (1998) cannot be derived from the results of this paper.

Technological Advancement

II.II The degree of technological advancement of a car manufacturer's EVs relates to investors' expectations about that firm's future performance.

This hypothesis cannot be rejected. While the "Fast-charging" variable failed to produce significant results, the results indicate that "Range" of a car model is positively related to investor expectations about that manufacturer's future performance. This is supported by the principles of Rational Choice Theory (Adam Smith, 1776).

Success of Current EVs

II.III The consumer's perception of a car manufacturer's current EVs relates to investors' expectations about that firm's future performance.

This hypothesis cannot be rejected. The results however were ambiguous. First, the results indicate that positive consumer perceptions, proxied by third party ratings relate positively to investor's expectations about that firm's future performance. A better rating was found in combination with less negative CARs. Second, the results also indicate, that investors are more pessimistic about the future of firms that already sell a lot of EVs. Both results, however, imply that brand equity does not really affect investor's expectations. This contradicts the theories of Aaker (1991). The fact that consumers are biased by branding does not seem to affect investment choices of investors in the automobile market.

Policy Exposure

II.IV The car manufacturer's exposure to the EU green mobility policies relates to investors' expectations about that firm's future performance

This hypothesis cannot be rejected. The results show that incumbents that are more exposed to EU policies have lower CARs.

7.2 Limitations and Future Research

The methodologies, used in this paper produced multiple significant results. However, there are still some weak points of this paper and lots of opportunities for future research, which shall be discussed in this subsection.

Significance of CAR values

First, one shortcoming of this paper is, that the calculated CAR values could not be tested for statistical significance. While there are methods available to do so, this would have exceeded the scope of this research. Applying novel and more extensive statistical methods to the CAR calculations is a possibility for future research.

Lack of Data

The biggest limitation however is the lack of data on 2 levels - on firm-level and on event-level. Expanding the dataset to more than 10 firms would help significantly to cancel out unwanted noise that arises on firm-level. If there is, for example, a release of any firm-specific news in proximity of the event, the CAR values will most likely be affected by it. Adding more firms will make sure that these news nullify by the law of large numbers and the CAR without the events of the event study will move closer to the statistical mean, which is probably around zero.

Second, next to firm-specific news, also other exogenous news can render the power of an event study. While the use of an industry benchmark mitigates these exogenous shocks, it would still be more optimal to exploit a larger set of events to ensure that the CARs calculated are not biased.

Unfortunately, however, both data is hard or even impossible to find. The high market concentration of the automobile industry only leads to a handful of companies that are applicable for the analysis. Finding more green mobility policies will also be challenging. Even within this study, the Fit for 55 Initiative announcement hardly produced any significant results. Finding another event of the same magnitude as the announcement of the internal combustion engine by 2035 is not possible.

Causality

Lastly, a disadvantage of the methodologies used is, that it does not allow for causal interpretations. Far more advanced techniques need to be applied to make sure to rule out any unwanted effects to the calculated estimates. This was not the scope of this research. However, examining the relationships of this paper in a causal way, could provide immense value to both car manufacturers and policy makers. A possible way to do this is to use far more events in an event study setting or to find more applicable firms in order to construct a synthetic control group for a difference-in-difference analysis.

8 Conclusion

This study used Cumulative Abnormal Returns to find the impact of green mobility policy announcements on investor sentiment about big car manufacturers. A second analysis examined how these findings correlate to firm-specific variables. Results about the investor sentiment were multidirectional, some had positive results, some were negative. Part of this effect was explained by the second analysis that showed that exposure to EU policies, timing of entry into the EV market, technological advancement of the product and success of current EVs have significant correlations with the investors' perception of a car manufacturer's future. Specifically, lower exposure to EU policies, higher technological advancement, earlier entry into the EV-market and better EV ratings seemed to relate to positive investor sentiment about the respective firm. This paper also uncovered a paradox, finding that the current EV-Sale numbers relate negatively to investor sentiment.

While the methodologies and data exploited in this paper can surely be optimized in further research, this paper still proves helpful to better understand the re-shuffling of market shares that is happening in one of the biggest global industries at the moment. This paper demonstrates that various factors influence the future of incumbent automobile manufacturers and provides valuable insights for car producers and policy makers to successfully navigate this shift in mobility.

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10 Appendix

10.1 Additional CAR Values

Table 3. All Cumulative Abnormal Returns of different event window lengths for the Fit for 55 Initiative announcement and the ICE ban by 2035 announcement

	Fit for 55 Initiative					***ICE ban by 2035***				
	CAR(-2,2)	CAR(-3,3)	CAR(-5,5)	CAR(-10,10)	CAR(-2,10)	CAR(-2,2)	CAR(-3,3)	CAR(-5,5)	CAR(-10,10)	CAR(-2,10)
BMW	1.234	0.367	-1.006	-6.574	-3.942	1.010	-0.176	-1.451	0.089	-1.033
FORD	-8.002	-9.844	-6.360	-16.232	-10.016	12.031	16.726	14.299	13.951	11.686
HYUNDAI	-0.342	-5.351	-12.507	-25.224	-11.217	-0.690	-5.162	-5.598	-3.233	4.177
KIA	-0.698	-6.271	-9.905	-20.271	-9.411	-2.207	-7.462	-11.774	-9.790	-2.197
MERCEDES	1.182	-0.189	-4.203	0.660	5.007	-2.100	-1.074	-3.344	3.458	-0.009
NISSAN	-1.057	-0.445	-4.022	19.062	4.629	2.464	3.187	5.194	1.649	7.804
RENAULT	-10.614	-9.539	-8.545	3.418	-1.153	-13.075	-17.149	-13.292	-36.458	-30.114
STELLANTIS	-6.675	-10.863	-13.951	-12.499	-10.098	0.557	1.299	4.265	-2.633	-3.606
TOYOTA	3.444	2.738	0.000	2.706	2.638	3.367	1.227	-0.785	-11.695	-7.311
VOLKSWAGEN	-0.255	4.365	10.245	4.437	-0.536	0.052	-1.082	-1.549	0.582	2.337

Note. Returns are denoted in %

10.2 Descriptive Statistics

Table 4. Descriptive Statistics of multiple CAR values

Variable	Min	Max	Mean	StD.
Fit for 55 (FF55)				
CAR(-2,2)	-10.614	3.444	-2.178	4.599
CAR(-3,3)	-10.863	4.365	-3.503	5.558
CAR(-5,5)	-13.951	10.245	-5.025	7.070
CAR(-10,10)	-25.224	19.062	-5.052	13.570
CAR(-2,10)	-11.217	5.007	-3.409	6.421
ICE ban by 2035 (ICE35)				
CAR(-2,2)	-13.075	12.031	0.141	6.182
CAR(-3,3)	-17.149	16.726	-0.967	8.580
CAR(-5,5)	-13.292	14.299	-1.403	8.116
CAR(-10,10)	-36.458	13.951	-4.408	13.311
CAR(-2,10)	-30.114	11.687	-1.827	11.383

Note. Every CAR value is computed individually for each car manufacturer which results in a dataset of n=10. CAR values are denoted in %.

Table 5. Descriptive Statistics of the Firm-specific variables

Variable	Min	Max	Mean	StD.
EU Sales (Share)	0.110	0.644	0.304	0.182
Year Dummy (1^{st} EV)	1	12	4.700	3.057
Range	0	1	0.642	0.277
Fast-Charging	0	1	0.384	0.386
ADAC-Rating	1.817	3.329	2.146	0.442
EV Registrations (Share)	0.019	0.278	0.152	0.082

Note. Firm-specifics are time-invariant and therefore only have one unique value for each car manufacturer. This results in a dataset of n=10 for all these variables. Variables with the addition “(Share)” are denoted as decimals, not percentages.

10.3 Pairwise Correlation

Table 6. Pairwise Correlation of Firm-specifics and selected CAR values

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1)	CAR(-3,3), FF55	1									
(2)	CAR(-10,10), FF55	0.54	1								
(3)	CAR(-3,3), ICE35	0.05	-0.05	1							
(4)	CAR(-10,10), ICE35	0.20	-0.16	0.86	1						
(5)	First EV Year	0.41	-0.10	-0.07	-0.22	1					
(6)	Top Range	-0.02	-0.08	-0.09	0.24	-0.64	1				
(7)	Top Fast Charge	0.33	-0.37	-0.32	0.11	0.15	0.46	1			
(8)	ADAC Rating	-0.50	0.29	-0.51	-0.73	-0.29	0.07	-0.43	1		
(9)	EV Registrations (Share)	-0.36	-0.21	-0.71	-0.44	-0.37	0.43	0.40	0.41	1	
(10)	EU Sales (Share)	-0.22	0.20	-0.39	-0.41	-0.44	0.60	-0.13	0.69	0.35	1

Note. Correlation of selected CAR values (7-day and 21-day) event windows for 2 events: Fit for 55 Initiative (FF55) and the ban of the internal combustion engine by 2035 (ICE35).

10.4 Regression Results

Level 1: Analysis by Event and Event window

These are the regression results of the first level of aggregation that was done. These results are based on a dataset with n=10 (10 unique car manufacturers). For every row, firm-specifics (time independent, only current [2023] values) and 4 different CAR values (2 event windows for 2 events) are given.

Policy Exposure

Table 7. Regression Results: EU-Sales as Share of Total Sales on different CAR values

	CAR(-3,3), FF55	CAR(-10,10), FF55	CAR(-3,3), ICE35	CAR(-10,10), ICE35
	(1)	(2)	(3)	(4)
EU Sales (Share)	-6.699	15.096	-18.336	-29.896
	[10.539]	[25.806]	[15.349]	[23.589]
Constant	-1.467	-9.639	4.605	4.677

Note. OLS regression of the significance of the EU market on different CAR values (7-day and 21-day event window, 2 events). EU Share of Sales denotes the proportion of total Sales that is generated in EU-markets. Events: “Fit for 55 initiative” (FF55) and “Ban of the internal combustion engine by 2035” (ICE35). Standard errors in [brackets]. *p < 0.1. **p < 0.05 ***p < 0.01

Timing of Entry

Table 8. Regression Results: First EV Year Dummy on different CAR values

	CAR(-3,3), FF55	CAR(-10,10), FF55	CAR(-3,3), ICE35	CAR(-10,10), ICE35
	(1)	(2)	(3)	(4)
Year Dummy (1st EV)	0.739	-0.426	-0.198	-0.956
	[0.587]	[1.562]	[0.989]	[1.502]
Constant	-6.975	-3.051	-0.036	0.089

Note. OLS regression of the timing of entry on different CAR values (7-day and 21-day event window, 2 events). Year dummy takes on the value of 1 for the first automotive manufacturer of the dataset that introduced an EV. A manufacturer that introduced an EV for the first time 5 years after that will have year dummy = 6 etc. Events: “Fit for 55 initiative” (FF55) and “Ban of the internal combustion engine by 2035” (ICE35). Standard errors in [brackets]. *p < 0.1. **p < 0.05 ***p < 0.01

Technological Advancement

Table 9. Regression Results: Relative Positioning Range on different CAR values

	CAR(-3,3), FF55	CAR(-10,10), FF55	CAR(-3,3), ICE35	CAR(-10,10), ICE35
	(1)	(2)	(3)	(4)
Range	-0.401	-3.980	-2.785	11.631
	[7.095]	[17.268]	[10.910]	[16.489]
Constant	-3.245	-2.491	0.825	-11.888

Note. OLS regression of the relative current positioning compared to competitors in Range technology on different CAR values (7-day and 21-day event window, 2 events). Range variable will be 1 for manufacturer with the highest range model and 0 for the manufacturer with the lowest range model in the current EV-lineup. Events: “Fit for 55 initiative” (FF55) and “Ban of the internal combustion engine by 2035” (ICE35). Standard errors in [brackets]. *p < 0.1. **p < 0.05 ***p < 0.01

Table 10. Regression Results: Relative Positioning Fast-Charging on different CAR values

	CAR(-3,3), FF55	CAR(-10,10), FF55	CAR(-3,3), ICE35	CAR(-10,10), ICE35
	(1)	(2)	(3)	(4)
Fast-Charging	4.676	-12.882	-7.105	3.744
	[4.817]	[11.569]	[7.449]	[12.124]
Constant	-5.300*	-0.101	1.764	-5.847

Note. OLS regression results of the relative current positioning compared to competitors in Fast-Charging technology on different CAR values (7-day and 21-day event window, 2 events). Fast-Charging variable will be 1 for manufacturer with the fastest charging model and 0 for the manufacturer with the slowest charging model in the current EV-lineup. Events: “Fit for 55 initiative” (FF55) and “Ban of the internal combustion engine by 2035” (ICE35). Standard errors in [brackets]. *p < 0.1. **p < 0.05 ***p < 0.01

Success of Current EVs

Table 11. Regression Results: ADAC Rating on different CAR values

	CAR(-3,3), FF55	CAR(-10,10), FF55	CAR(-3,3), ICE35	CAR(-10,10), ICE35	CAR(-10,10), ICE35
	(1)	(2)	(3)	(4)	(5)
ADAC Rating	-6.380	8.769	-9.948	-21.970**	-25.557**
	[3.826]	[10.392]	[5.886]	[7.268]	[10.494]
EU Sales (Share)					12.705
					[25.499]
Constant	10.191	-23.873	20.387	42.748**	46.586**

Note. OLS regression of the average ADAC Rating of current EVs on different CAR values (7-day and 21-day event window, 2 events). Controlling for EU Share of total Sales if results were significant. ADAC-Rating will take on values between 1 and 6 with 1 being the best and 6 the worst. Events: “Fit for 55 initiative” (FF55) and “Ban of the internal combustion engine by 2035” (ICE35). Standard errors in [brackets]. *p < 0.1. **p < 0.05 ***p < 0.01

Table 12. Regression Results: EV Share of Registrations on different CAR values

	CAR(-3,3), FF55	CAR(-10,10), FF55	CAR(-3,3), ICE35	CAR(-10,10), ICE35	CAR(-3,3), ICE35
	(1)	(2)	(3)	(4)	(5)
EV Registrations (Share)	-24.306	-35.355	-75.044**	-71.979	-69.202**
	[22.460]	[57.368]	[25.966]	[51.664]	[28.910]
EU Sales (Share)					-7.550
					[12.975]
Constant	0.196	0.329	10.456**	6.548	11.861

Note. OLS regression of newly registered EVs (as share of total newly registered vehicles, per manufacturer) on different CAR values (7-day and 21-day event window, 2 events). Controlling for EU Share of total Sales if results were significant. Events: “Fit for 55 initiative” (FF55) and “Ban of the internal combustion engine by 2035” (ICE35). Standard errors in [brackets]. *p < 0.1. **p < 0.05 ***p < 0.01

Level 2: Analysis by Event

Additionally, in another analysis, CAR values were aggregated by event. This yields a dataset of n=50 (10 unique manufacturers for 5 event-window lengths). In the 50 rows of this new dataset, every car manufacturer is listed 5 times, with a different CAR each time, due to different event-window lengths. Firm-specifics are time independent and therefore do not change.

Policy Exposure

Table 13. Regression Results: EU-Sales as Share of Total Sales on different CAR values

	FF55	ICE35
	(1)	(2)
EU Sales (Share)	0.216	-23.045***
	[6.479]	[7.171]
Constant	-3.899*	5.311**

Note. OLS regression of the significance of the EU market on different CAR values (2 events). EU Share of Sales denotes the proportion of total Sales that is generated in EU-markets. Events: "Fit for 55 initiative" (FF55) and "Ban of the internal combustion engine by 2035" (ICE35). Standard errors in [brackets]. *p < 0.1. **p < 0.05 ***p < 0.01

Timing of Entry

Table 14. Regression Results: First EV Year Dummy on different CAR values

	FF55	ICE35	FF55	ICE35
	(1)	(2)	(3)	(4)
Year Dummy (1st EV)	0.375	-0.390	0.471	-1.227***
	[0.382]	[0.467]	[0.428]	[0.446]
EU Sales (Share)			3.680	-32.070***
			[7.192]	[7.480]
Constant	-5.595**	0.142	-7.165*	13.821***

Note. OLS regression of the timing of entry on different CAR values (2 events). Controlling for EU Share of Total Sales. Year dummy takes on the value of 1 for the first automotive manufacturer of the dataset that introduced an EV. A manufacturer that introduced an EV for the first time 5 years after that will have year dummy = 6 etc. Events: "Fit for 55 initiative" (FF55) and "Ban of the internal combustion engine by 2035" (ICE35). Standard errors in [brackets]. *p < 0.1. **p < 0.05 ***p < 0.01.

Technological Advancement

Table 15. Regression Results: Relative Positioning Range on different CAR values

	FF55	ICE35	FF55	ICE35
	(1)	(2)	(3)	(4)
Range	-1.167	1.541	-1.943	16.353***
	[4.257]	[5.192]	[5.350]	[5.428]
EU Sales (Share)			1.975	-37.849***
			[8.137]	[8.256]
Constant	-3.081	-2.684	-3.184	-0.708

Note. OLS regression of the relative current positioning compared to competitors in Range technology on different CAR values (2 events). Controlling for EU Share of Total Sales. Range variable will be 1 for manufacturer with the highest range model and 0 for the manufacturer with the lowest range model in the current EV-lineup. Events: "Fit for 55 initiative" (FF55) and "Ban of the internal combustion engine by 2035" (ICE35). Standard errors in [brackets]. *p < 0.1. **p < 0.05 ***p < 0.01

Table 16. Regression Results: Relative Positioning Fast-Charging on different CAR values

	FF55	ICE35	FF55	ICE35
	(1)	(2)	(3)	(4)
Fast-Charging	-0.582	-1.880	-0.579	-3.384
	[3.056]	[3.720]	[3.116]	[3.414]
EU Sales (Share)			0.053	-23.997***
			[6.604]	[7.236]
Constant	-3.610	-0.970	-3.627	6.901**

Note. OLS regression results of the relative current positioning compared to competitors in Fast-Charging technology on different CAR values (2 events). Controlling for EU Share of Total Sales. Fast-Charging variable will be 1 for manufacturer with the fastest charging model and 0 for the manufacturer with the slowest charging model in the current EV-lineup. Events: "Fit for 55 initiative" (FF55) and "Ban of the internal combustion engine by 2035" (ICE35). Standard errors in [brackets]. *p < 0.1. **p < 0.05 ***p < 0.01

Success of Current EVs

Table 17. Regression Results: ADAC Rating on different CAR values

	FF55	ICE35	FF55	ICE35
	(1)	(2)	(3)	(4)
ADAC-Rating	-1.721	-13.267***	-3.365	-12.772***
	[2.655]	[2.630]	[3.671]	[3.651]
EU Sales (Share)			5.826	-1.756
			[8.920]	[8.872]
Constant	-0.141	26.784***	1.619	26.254***

Note. OLS regression of the average ADAC Rating of current EVs on different CAR values (2 events). Controlling for EU Share of total Sales. ADAC-Rating will take on values between 1 and 6 with 1 being the best and 6 the worst. Events: “Fit for 55 initiative” (FF55) and “Ban of the internal combustion engine by 2035” (ICE35). Standard errors in [brackets]. *p < 0.1. **p < 0.05 ***p < 0.01

Table 18. Regression Results: EV Share of Registrations on different CAR values

	FF55	ICE35	FF55	ICE35
	(1)	(2)	(3)	(4)
EV Registrations (Share)	-27.576	-62.384***	-31.548***	-50.664***
	[13.877]	[15.137]	[14.862]	[15.551]
EU Sales (Share)			5.133	-15.149**
			[6.670]	[6.980]
Constant	0.364	7.803***	-0.592	10.623***

Note. OLS regression of newly registered EVs (as share of total newly registered vehicles, per manufacturer) on different CAR values (2 events). Controlling for EU Share of total Sales. Events: “Fit for 55 initiative” (FF55) and “Ban of the internal combustion engine by 2035” (ICE35). Standard errors in [brackets]. *p < 0.1. **p < 0.05 ***p < 0.01

Level 3: Overall Analysis

Last, all CAR results for both events, all 5 event windows and 10 unique car manufacturers were consolidated into one dataset. This set has n=100 observations (2 events for 5 event windows for 10 manufacturers). In the 100 rows of this new dataset, every car manufacturer is listed 10 times, with a different CAR each time, due to different events and event-window lengths. Firm-specifics are time independent and therefore do not change.

Table 19. Regression Results: Firm-specifics on CAR values

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Timing of Entry											
Year Dummy (1st EV)		-0.008					-0.378				
		[0.304]					[0.328]				
Technological Advancement											
Range			0.186					7.205*			
			[3.351]					[4.017]			
Fast-Charging				-1.231					-1.981		
				[2.401]					[2.367]		
Success of Current EVs											
ADAC-Rating					-7.494***					-8.068***	
					[1.956]					[2.701]	
EV Registrations (Share)						-44.980***					-41.106***
						[10.407]					[11.097]
Policy Exposure											
EU Sales (Share)	-11.414**						-14.195**	-17.937***	-11.918**	2.035	-5.008
	[4.965]						[5.513]	[6.109]	[5.017]	[6.563]	[4.981]
Constant	0.706	-2.727	-2.883	-2.290*	13.321***	4.083**	3.328	-1.946	1.637	13.934***	5.015**

Note. OLS regression of 6 firm-specific (time-invariant) variables on aggregated (2 events, 5 event windows) CAR values. Controlling for EU Share of total Sales. Events: “Fit for 55 initiative” (FF55) and “Ban of the internal combustion engine by 2035” (ICE35). Standard errors in [brackets]. *p < 0.1. **p < 0.05 ***p < 0.01