Master's Thesis

'MADE IN GERMANY' – DIESELGATE'S REPUTATION IMPACT ON GERMAN AND EUROPEAN CONSUMER BEHAVIOUR

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Abstract: This paper aims to provide evidence that there was a negative reputation spillover in Germany after the Dieselgate scandal on VWs German competitors - Mercedes, BMW, Opel and Smart -, while VW's own subsidiaries -Seat and Skoda- who manipulated themselves could even benefit from the scandal by hiding in the shadows of German nation branding. The VW scandal "Dieselgate" is used in this paper as a natural experiment. By following a differences-in-differences estimation approach, the post-scandal impact on sales and market shares on the mentioned manufactures in Germany and the EFTA area can be found. A demand model, following a similar US study, allows me to estimate German consumers utility variation after the scandal in detail and compare it to previous literature. There is evidence that a strong reputation spillover on the VW competition took place on the German market and VW subsidiaries could even benefit from the scandal.

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Table of content

1 Introduction

Can a company's scandal and its resulting deteriorating reputation spill over to other companies from the same industry and nationality? Can a manipulating firm's foreign subsidiaries hide behind the different nationality of their parent firm and benefit from public misinformation? Are consumers more loyal to their national companies and therefore is their demand less elastic and impacted by a major scandal happens? Answers to those questions can be found, by using the concept of a reputation spillover effect, meaning that bad reputation of one country after a major scandal, can hurt sales of another company in the same country and/or industry. Previous literature on reputation spillovers is relatively scarce but exists and similar spillovers are a known and measured phenomenon and will be discussed in section 2. A good example is the working paper by Bai et al. (2019), which analyses the reputation spillover effect of Chinese dairy firms after a scandal on uninvolved but related companies. The authors determine that while the contaminated firms export revenue dropped by 84%, relative to the national industrial trend, the spillover effect on firms not involved in the scandal was 64% of the direct effect.

This paper uses the VW scandal, appearing in the international media on September 18, 2015, also known as 'Dieselgate' as a natural experiment, to measure if and to what extend firms share their reputation. Furthermore, the economic shock on homogenous companies with the same nationality, as the company directly involved in the scandal is calculated. On this date, the US federal Environmental Protection Agency, EPA publicly declared that VW has manipulated at least half a million Diesel engines, in their vehicles produced between 2009 and 2015, in order to meet strict emission regulations. VW developed a software that could sense when the car was being tested for emissions and subsequently activated equipment that reduced emissions artificially. During normal use the software was turned off, resulting in the emission of toxins above the legal quantities for nitrogen oxide, which can cause several respiratory diseases. (NYT, 2017) The scandal quickly spread internationally and not only had economic repercussions on VW, but also potentially damaged the reputation of Germany, which is usually known for high-quality products under the slogan 'German engineering' or the seal of quality 'Made in Germany'. This paper tries to find out if a reputation spillover existed not only in the EFTA area, but also in Germany, where the manipulated software was developed. This approach allows a comparison between post-scandal behaviour of German consumers and the rest of Europe towards German vehicles. In addition to analysing the spillover effect on VWs German competitors, this paper also tries to determine whether its non-German subsidiaries

Skoda and Seat were negatively affected by the decisions made by their mother firm, again in both Germany and the EFTA area.

On one hand, literature about consumers' behaviour towards a company after a scandal exists. On the other hand, specific literature about reputation spillovers and collective reputation is novel, and it seems to be a phenomenon that more recently started to get the attention of economists. This paper therefore is not only expanding the findings of Bachmann et al. (2019) but also expanding the research on consumers' after scandal utility, as well as reputation spillover effects in general. The results contribute to the literature about country reputation and spillover effects after the detection of a corporate fraud. These findings can help the stakeholder to understand the potential dangers of collective branding. Most importantly government agencies, shareholders and firms with homogenous competitors can use the results to assess the potential risks of a company scandal and assess their related economic and political decisions. After a risk assessment, precautionary measures can be taken. Furthermore, the results of a paper like this could give an incentive to companies to respect regulations if the cost benefit analysis shows huge losses for the whole industry in the first place. In the VW context, three days after EPAs announcement in September 2015, the German government raises a red flag and proclaimed that the scandal could jeopardise the reputation of the entire German car industry after the massive VW AG stock market crash. The German minister of economy likewise tells the company to clear up the scandal because it affects the whole industry, on which hundreds of thousands of employees rely. (Guardian, 2015)

This paper is inspired by the unpublished working paper by Bachmann et al. (2019), which is trying to analyse the reputation spillover effect of VW on their German competitors Mercedes, BMW and Smart in the US market, for the 12 months after it started to appear in the media in September 2015. The differences-in-differences estimations used in this paper are following the author's approach for both the reputation spillover calculations and the demand model created in section 6. Bachmann et al. (2019)'s paper allows me to compare my results of both the German and EFTA market with the US market and draw conclusions on possible similarities and differences. The paper about the US market is differentiating between three main forces that were driving the future US car sales after the scandal. The first 'force' they mention, is the substitution away from VW, the second 'force' the substitution away from Diesel vehicles and the last 'force' is the reputation spillover and reputation loss of German vehicles and decreasing sales due to the scandal. They found out that the reputation spillover

did happen on the US market, by using the 2015 scandal as a natural experiment and their demand model following Berry (1994) managed to quantify those 3 forces.

In this paper the following hypothesises are constructed: **(1)** The main hypothesis, that there is a negative reputation spillover effect in Germany on German non-VW vehicle manufacturers, matching the findings of Bachmann et al. (2019), who found out that 12 months after the scandal, US sales for all German manufacturers decrease, due to a spillovers, "collective reputation" and "group identity". **(2)** The second hypothesis is, that consumers tend to prefer national products, and therefore are more likely to look the other way, when a national company scandal happens. In this context, this paper wants to find evidence that non-VW sale losses, if they took place, were lower in their home market Germany than in the whole European Market (EFTA area), due to national preferences. **(3)** The last hypothesis is that a company that is to a certain degree involved in manipulations, but is not identified as the main culprit, can get away with it when it has the opportunity. It can hide behind another culprit. This means that this paper wants to present evidence, that this group identity only takes place on a national level, and that VW's subsidiaries were saved from losses due to the nation branding or misinformed consumers, even though they were also involved in software manipulations and are part of the VW Group.

This paper consists of two different types of regression models. The first model being the diff-in-diff estimation, trying to answer to the main research questions on the presence of reputation spillovers on VWs German competition in Germany. The second regression model is a demand model following Berry (1994) and Bachmann et al (2019), analysing German sales per model and year from 2010 to 2019. This nested-Logit model decomposes the scandal's impact on VW and competing German firms in detail, permitting me to draw conclusions on what the main reasons for increasing or decreasing sales are. The above mentioned three forces from the US VW-scandal paper can also be found in my adaptation of the regression model for the German market. Two of the research questions can be answered clearly by those two models. Per model data for the EFTA area is not available, so calculating the reputation spillover effect for this area is not possible. Therefore, in the EFTA area, only the total effect can be estimated and compared to the total effect in Germany. One can't apply the three forces from Bachmann et al. (2019).

The differences-in-differences estimation model estimates the total effect of the scandal in Germany and the EFTA area, 12 months after Dieselgate, on German Non-VW makes and

VW subsidiaries. Evidence is found, that in terms of sales, in Germany only VW-subsidiaries lost while in the EFTA area there is no significant decrease of sales. Smart has even sold more cars than before. In terms of total market share, in Germany subsidiaries gain while in the EFTA area their shares dropped. Smart benefited in both markets, while the other non-VW German manufacturers lost more in relative market share in Germany than in the EFTA area, where only Opel is negatively impacted. The differences-in-differences estimation alone is not a valid method to quantify the reputation spillovers, being only one of the three forces accompanied by the scandal.

To overcome this barrier, the Demand model, looking at per make and model sales, allows me to conclude that VW subsidiaries are profiteers of the scandal in Germany. There is evidence that the consumer was not informed about Seat's and Skoda's own involvement in the scandal or did not even know that both were VW subsidiaries, after Dieselgate. All the other non-VW manufacturers had to face a lower consumer utility. All the estimations are significant, expect for the make Smart. In addition to that, the regression table shows that the diesel engine's credibility hasn't decreased yet in 2016. Only including data from 2017 in the model makes the diesel coefficient significant, which can be derived from the appearance of the EU diesel bans in cities and not from the scandal.

A major obstacle is that one of the research questions, whether consumers tend to have a preference for national products and are willing to look the other way, cannot be answered with precision, as EU/EFTA data per model is not available, hence establishing a logit Demand Model is hence not possible. I could only compare the total impact, as merely a more sophisticated model would allow to differentiate between the 3 forces and make a credible analysis possible.

2 Theoretical background

Before establishing a regression model, previous literature about similar natural experiments must be analysed. In section 4, I prove that September 18 is the most important date of the scandal, because precisely at this day, the scandal got an international audience for the first time after the EPA issued a notice of violation of the Clean Air Act. Subsequently, I provide evidence that the negative effects of the scandal were not limited to VW, before computing the actual negative impact on them.

2.1 Literature on reputation loss and ‘Dieselgate’

The consequences of damaged reputation on an individual firm due to corporate misconduct has been invested in previous literature. Alexander (1999) shows that scandals are often surrounded by the termination of customer relationships. According to his research, these terminations are more common, when consumers are directly affected by cooperate fraud. One of the most prominent examples are environmental crimes committed by firms. He also finds proof that the stock market of the concerned company declines significantly as soon as the news of a scandal are released. Johnson et al. (2013), who examine the consequences of a firm scandal, after a fraud was detected in a product, find evidence that customers impose significant sanctions on fraudulent firms. They also draw the conclusion, that reputational losses estimated through an event study approach, approximately reflects the actual decrease in revenue of the firm who committed fraud. Event studies are therefore commonly used to estimate reputation spillover effects. Other papers on the corporate impact of fraud detection are: Karpoff & Lott (1993), Jiandong & Xiao (2016), Gatzert (2015), Li (2010) and Price, Nelson, & Rountree (200), with the two latter papers analysing the Enron audit scandal of 2001 in Texas, US.

Literature about reputation spillovers and country (group) specific spillovers after a scandal also exists: Ingenhoff, Buhmann, White, Zhang, & Kiousis (2018), Castriota & Delmastro (2014), Norheim-Hansen & Meschi (2020) and as mentioned before the working papers Bachmann et al. (2019) and Bai, Gazze, & Wang (2019).

There is also literature on the relatively recent ‘Dieselgate’, like Nunes & Park (2016), who investigate the US stock market response to the VW scandal and Strittmatter & Lechner (2017), who focus their research on the impact on used car sales, also following a differences-in-differences method and (Aurand et al., 2018), whose paper is proving that VW was using advanced greenwashing tactics, to mislead consumers and institutions and attempt to position themselves as one of the most environmentally friendly vehicle manufacturers. Mačaitytė & Virbašiūtė (2018) use the VW scandal as an experiment, to show that unethical behaviour of an international company causes negative effects on their stock price, financial performance and overall reputation. Multiple papers about the health impacts of the manipulation also exist, such as: Oldenkamp, van Zelm, & Juijbregts (2016) and Barrett, et al. (2015).

To prove that a reputation spillover is possible, we need to confirm that companies share some form of group identity, for which previous literature exists. Bachmann et al. (2019) provide evidence that in the US, ‘German engineering’ and ‘made in Germany’ are well-known

marketing terms, defining German products and unifying the German makes under a certain group identity. These companies are advertising with their origin and related notions of quality, making the US consumer see Germany cars as a unified brand. The authors use the Newsbank news aggregator and find out that 'German Engineering' was six times more likely to appear in a newspaper, journal or magazine, during the first weeks and months after EPAs announcement. Unfortunately, their methodology cannot be used, because of the analysis of the EFTA area and Germany. Both locations either include or are the country of origin of 'German engineering'. This inevitably renders the argument of German group identity less credible as well as biased, following an analysis of German marketing, as they are local products and brands and consumers are more informed about those companies.

Because of that limitation, I use another approach to prove that there is also a German Group identity for consumers, even in Germany. Thus, I use the stock market and Google news trends of the competitors in section 3, as proof that the public was also sceptical towards VWs German competitors after the scandal.

2.2 Differences-in-Differences and the natural experiment

In my estimations, I used a differences-in-differences approach, including various fixed effects, to account for unobservable factors as presented by Angrist (1999). Multiple papers use a corporate scandal as a natural experiment for a differences-in-differences estimation. Besides Bachmann et al. (2019), there are other papers using a scandal as a differences-in-differences model, to estimate post-shock or scandal variations. Che et al. (2019) for example, use as differences-in-differences model and discover that final bid prices of VW vehicles decreased by 14% for diesel and 9% for gasoline cars after the scandal, which they explain with a decreasing willingness to pay for VW products, due to a decreased reputation. In their regression model, Che et al. (2019) use an interaction term $(Scandal_t \times VW_i)$, which are dummy variables 1, if the scandal happened and if it is a VW model, and 0 otherwise. I am using similar interaction terms, in the EFTA, German and demand model regressions. Both papers provide evidence, that the scandal is an outstanding form of natural experiment, making a differences-in-differences estimation possible.

3 Hypothesis

Firstly, this paper hypothesises, why there is a potential reputation spillover effect by fragmenting the German market and their media coverage. This is because the analysis is mostly covering German sales and Germany is the biggest market in the EFTA dataset. The scandal is looking at the group identity of German companies, making this the most specific and probably most interesting country for further analysis. Secondly, I look at the Dieselgate events through a timetable to support the time period I use in my estimations. And finally, I summarise the socio-economic and health repercussions the scandal provoked and explain its severity. These pillars allow me to construct my regression model, which answers the following research questions. (1) The main hypothesis being the existence of a reputation spillover on non-VW firms in Germany. (2) The second hypothesis being that there was smaller reputation spillover in Germany than in the whole European Union (EFTA area) due to a preference for national products. (3) The third hypothesis, that VW non-German subsidiaries managed to hide in the shadows and were not hit because consumers saw the Dieselgate scandal as a national scandal, rather than a company scandal.

3.1 Theory of the reputation spillover effects

For a reputation spillover to be existing, German manufacturers must share some form of group identity. Looking at EFTA and German vehicle sales and saying that the companies share a group identity because they are ‘made in Germany’ isn’t enough. This, as EU and especially German consumers are more biased and potentially more informed about all the concerned manufacturers, than US consumers. Consumers from Germany (and the EU) potentially have a more direct connection to the companies, as nearly a million people are directly employed by the car industry and fiercer competition between the manufactures negates the argument of German engineering as a brand. Furthermore, sales are much higher in both markets that I am analysing in this paper, as compared to the US, with a share of almost 50 percent German cars sold in the EFTA area in 2015. To prove that there is still some clear form of group identity, I compare the worldwide Google news trends, with the German Google news trends.

Figure 1a - Worldwide Google News Trends

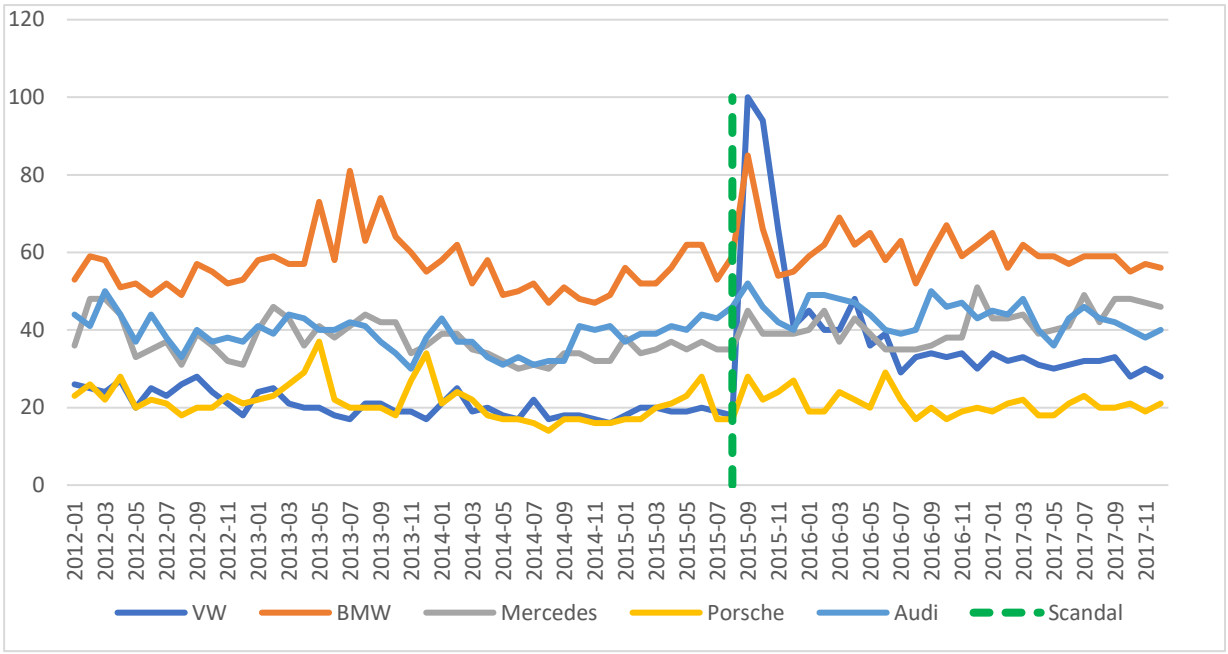
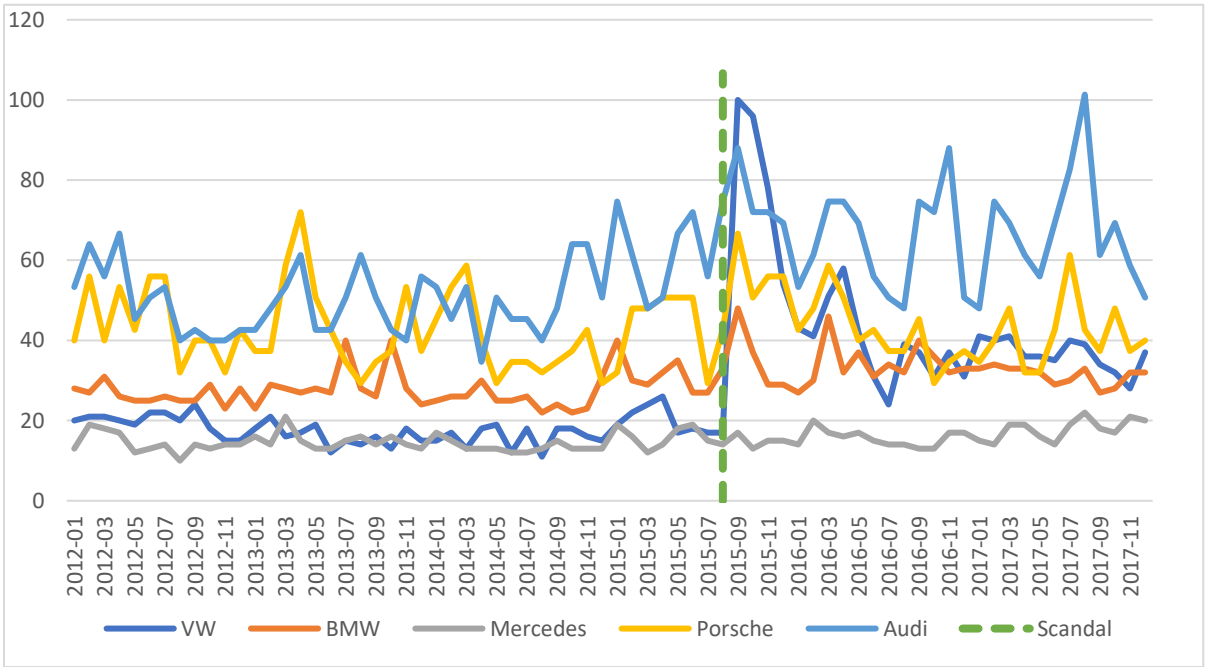


Figure 1b - Germany Google News Trends



Both showed similar patterns for the German and international media pre- and post-scandal. I specifically used Google 'news' trends, instead of regular Google trends, to avoid that the number is higher because consumers are looking for a German substitute vehicle, which would be positive in the case of VW's competition. In the company's country of origin, Google

News trends also significantly increased for VWs competitor BMW (Figure 1b), suggesting that newspapers also started to question the trustworthiness of the other German manufacturers or mentioning them next to negative articles about VW. Interestingly, an increase of Mercedes cannot be found through a purely graphical analysis In September 2015, the German magazine 'der Spiegel', one of the largest publishers in Europe with weekly sales of 1.1 million units, published the article 'Deutsche Manipulationskunst', 'Germanys art of manipulation', indirectly accusing the nation's automotive industry.

Not only is there a potential reputation spillover to another company, but there could also be a reputation loss of a technology, like the Diesel engine. Bachmann et al. (2019) for example found a substitution away from the Diesel car in the US market after the scandal. In Europe historically, the diesel car sales have always been very strong. However, after the scandal the product was discredited. The BBC called the scandal "a blow for the diesel market" (BBC, Volkswagen: The scandal explained, 2015) and the German Spiegel published an article with the title "Mit Abgas in den Abgrund", "With exhaust fumes into the abyss" (Spiegel, 2017), referring to the distrust of consumers in the product. In addition to the mistrust, several EU cities announced Diesel-bans, increasing this uncertainty about the sustainability and longevity of the diesel engine. The Atlantic posting the following headline "Is Diesel doomed after the Volkswagen Scandal?" (Atlantic, 2017)

We can therefore say that Bachmann et al. (2019)'s 'three forces', -the substitution away from VW, the substitution away from German cars and the substitution away from the Diesel engine- can play a role in consumer's choice in Germany, which I am estimating in the demand model of section 6. This Demand model looks at every model separately for both Diesel and other trims, while controlling for vehicle characteristics. Estimating the real reputation spillover is only possible through the demand model of section 6, which differentiates between the three forces.

Legend 1: Concerned manufactures

The Volkswagen group		Other German competitors
VW	Lamborghini	BMW
Audi	Bugatti	Mercedes
Porsche	Bentley	Opel
Seat	MAN	Smart
Skoda	Scania	
Ducati		

3.2 Timetable of the scandal

For the estimations to be as precise and non-biased as possible, the optimal time period has to be defined. This means that the correct scandal day or month has to be used for the differences-in-differences estimation, while years that falsify the estimations have to be excluded from the estimation. After-scandal variations (in sales or market share) do not necessarily meet the ceteris paribus condition, making a non-contaminated time period necessary.

VW announced in 2008 the release of their new clean diesel cars, which were already manipulated with the software (Reuters, 2015). VW got several environmental awards and tax breaks, while they were already selling their manipulated vehicles with 11mio affected cars globally (New York Times, 2015). In 2014 the International Council on Clean Transportation asked the West Virginia Center for Alternative Fuels, Engines and Emissions to investigate car emissions under various test conditions. For the VW Jetta, emissions were up to 35 times higher than allowed. Testing emissions on the road allowed the team to get the real emission results, as the cheat software was only designed to manipulate lab test results. This study was the first step in uncovering the global manipulations on VW cars (Citylab, 2015). After those results, EPA repeated the tests and informed VW about their findings. VW voluntarily decided to recall some of the Diesel vehicles in December 2014. On September 3rd, 2015, VW admits for the first time that they used a defeat device to achieve improved emission tests, of which the public was only informed about two weeks later in September 18, 2015. On that date, which is the most important day of the scandal, the EPA issued a public notice of violation of the Clean Air Act, accusing the company of having sold manipulated VW and Audi Diesel models from 2009 to 2015 (Reuters, 2017). On September 20, 2015, VW admits guilt and September 23, Winterkorn resigns to allow the company a “fresh start”. On September 29, 2015 the company announces to modify the 11 million manipulated vehicles with a software update. It became clear that not only VW cars were modified with manipulated software, but also Audi, Porsche, Seat and Skoda sold models equipped with the cheat engines, partly because they used the same engines as VW cars. April 21, 2016 VW agreed to fix or rebuy half a million rigged vehicles in the US. In January 2017, VW pleads guilty to the scandal and agrees to pay $4.3 billion. 6 VW executives also plead guilty (NYT, 2016). In Germany, VW’s direct subsidiary Audi agrees to a fine of 800 million Euros in June 2018 and Audi CEO Rupert Stadler is arrested (BBC, 2018). In October of the same year, Audi agrees to pay a fine of 800 million euros in Germany, to

resolve all the civil claims (NYT, 2017). In May 2019 also Porsche was fined 535 million dollars by German prosecutors for their own manipulations. (Telegraph, 2019) Seat and Skoda both also later admitted that they have manipulated their engines or used engines from their parent firm VW. (BBC, 2019)

Other German manufacturers were also committing fraud. Daimler (Mercedes) for example was already accused in February 2018 of possible manipulations by the German newspaper 'Bild'. Those allegations turned out to be true in June 2019, when the company recalled 60,000 vehicles, and in September the same year, Daimler was fined 870 million Euros for breaking diesel emission regulations. (Automotive News Europe, 2019), (Reuters, 2019). Similar to Daimler, also BMW was accused of manipulations. Their headquarters in Munich and a factory in Austria was raided by authorities in March 2018. About 100 investigators were working on finding proof for a manipulation of their vehicles. Before that raid, the Bavarian company was relatively unaffected by the German scandal (NYT, 2019)

This timetable shows that in the dataset, for a non-biased estimation, all of VW's German subsidiaries must be dropped, because Audi and Porsche also actively manipulated their vehicles. Both are German companies, so they can neither be part of the control nor treatment group. Nonetheless, the paper wants to find out if Skoda and Seat, the non-German VW subsidiaries still managed to hide their scandal from the public and didn't have negative repercussions, because they don't share the nationality with their parent firm. The fact that Mercedes and BMW started to get the attention of international prosecutors because of potential manipulation made me limit my dataset to the time before 2018. Including 2018 or more recent data, causes a measurement error of the reputation spillover estimation on German car manufacturers and making an unbiased estimation impossible.

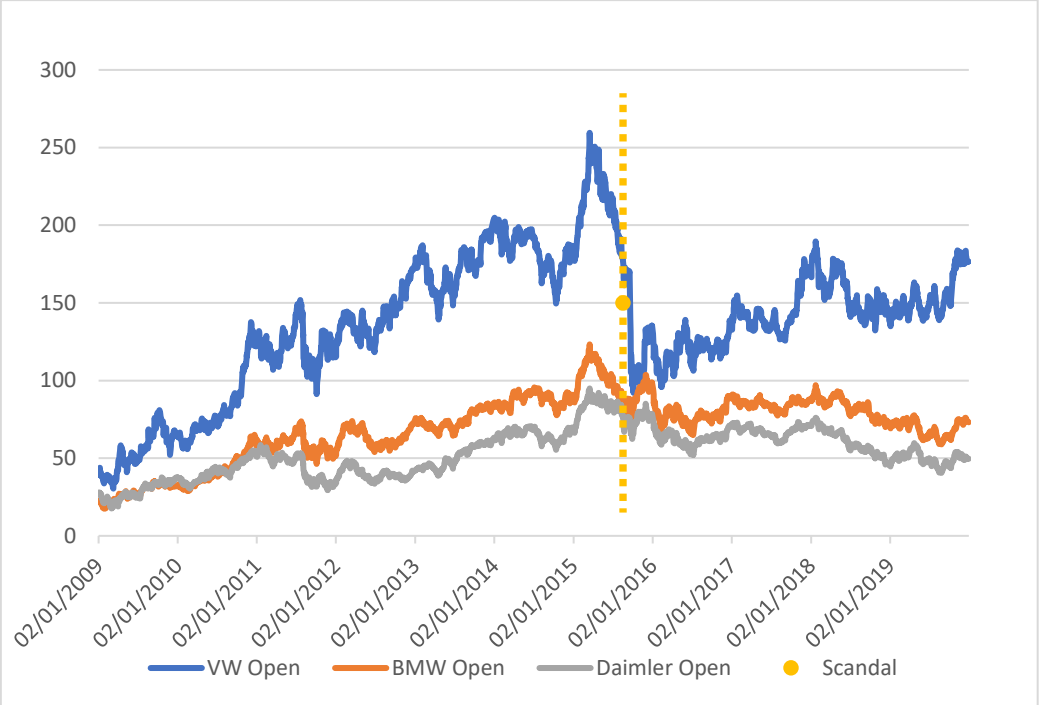
3.3 Economic and social impact

After the manipulation reports of the EPA, on September 26, not only VWs stocks lost in value but also the competitors experienced major devaluations on the stock market. The most important stock market losses were for VW -28.64%, Toyota -3.24%, BMW -3.55% and Mercedes -6.51% and Ford -12.42%. Meaning that there was a general mistrust and uncertainty in the industries' investments (Bruegel, 2015). This can already be a consequence of the reputation loss of the diesel engine and the resulting distrust in its longevity. The demand model

further analyses the post-scandal demand for Diesel engines to find out if the technology was discredited and consumers were scared of environmental regulations.

The VOW3, Volkswagen AG preference share dropped from 240 in early 2015 to 114 Euros per share after the scandal at the end of 2015, since investors feared a possible decrease in car sales and exports and they estimated massive fines, which VW is very likely to face in the upcoming years. The car industry being Germany's biggest exporter, 800.000 jobs were potentially at risk, which could have caused devastating consequences for the country's economy.

Figure 2 - Stock Market Price Evolution



Note: data for the opening stock prices comes from finance.yahoo.com

The scandal had economic impacts on VW and its subsidiaries as they did not only have to modify or recall 11 million vehicles worldwide and were likely to sell fewer cars due to mistrust, but they also had to pay billions in fines over the last couple of years. The most significant criminal fine came from a US court, which made the company pay 2.8 billion dollars in 2017 (WSJ, 2017). In the same year, VW had to pay 1.5 billion dollars in civil penalties to US consumers impacted by the manipulations (NYT, 2017). Also, in their home country, VW wasn't saved from legal consequences, Audi agreed to recompense 800 million Euros in civil claims in 2018 to German consumers. According to the company in March 2020, the whole scandal has cost them 31.3 billion euros. (REUTERS, 2020)

Researchers estimate that in 2013, 10,000 premature deaths were caused by NOx emissions in the EU28, which came from diesel cars and light commercial vehicles. 80% of these deaths in 2013 could have been prevented if those cars emitted as much as regular petrol cars (Jonson, et al., 2017) In total 526 kilotons of nitrogen oxides more than the legal limits allowed were emitted by VW cars, which accounts for 45 thousand disability-adjusted life years, which can be compared to 39 billion US dollars of damage to society. (Oldenkamp, van Zelm, & Huijbregts, 2016)

4 Research design

To estimate the Diesel scandal's impact on German makes and VW subsidiaries in Europe and Germany, I use a standard differences-in-differences regression model with a sample period from January 2010 to August 2016 for sales variation (1) and make market share (2). Both models are representing different outcomes. While using sales growth allows me to find out if the sales are deviating from the common trend for German makes after the scandal, whereas using market shares directly computes the relative impact on a manufacturer. The latter approach can be more interesting, as sales for a German make can decrease with respect to the pre-scandal period, but simultaneously relative market share increases, as other German manufacturers are even suffering more severely from lower sales. Both approaches can be used to draw conclusions about the scandal's absolute impact.

In the appendix, I also estimate the market share regression with an expanded time period to December 2017, just before BMW and Mercedes had their own emission scandal. This allows me to check for consistency in my analysis. To answer my research question, the estimation results are separated into 4 different tables. For the German and European markets, in each case one using per make and month sales growth as the dependent variable, another in each case using market shares per make and month. This methodology does not allow to draw conclusions about reputation spillovers, it only estimates the overall shift from and to other makes. To find Bachmann et al. (2019)'s 3 forces, including the reputation spillovers, the Demand model is applied later.

4.1 Estimation of the reputation Spillover in the EFTA and Germany

In the estimations, the dependant variable is always in a logarithmic form. A normal logarithmic transformation is not possible if the data x is 0 or negative, which is why a log-modulus transformation equation for the growth rate is used, which can be both negative and 0:

$$L(x) = \text{sign}(x) * \log(|x| + 1)$$

where L(x) is either the dependent variable C_{it}, the log growth rate of sales or S_{it}, the log market share and x the raw non-log data from the dataset.

The regression models are the following, for both markets:

(1) $C_{it} = a_t + b_i + \beta D_{it} + \varepsilon_{it}$ and (2) $S_{it} = a_t + b_i + \beta D_{it} + \varepsilon_{it}$

Where:
S_{it} is the log market share of sales of company i in month t,
C_{it} is the log sales growth rate of sales of company i in month t with respect to the same month the year before t-12,
a_t is a monthly time fixed effect,
b_i is a company specific fixed effect,
D_{it} is a 'Dieselgate' treatment indicator, that is 1 if the manufacturer is German or VW subsidiary and has been affected by the scandal and 0 if otherwise,
ε_{it} is the error term,
β, the coefficient of interest, estimates the impact of the scandal on German (1) sales and (2) market share.

The regression model (1) is using percentage sales variation with respect to 12 months ago as the dependent variable, it can be called sales growth rate. The dataset includes monthly data from January 2010 to August 2016, because of an easier comparison to the previous literature and a simpler analysis. Using the 12 scandal following months therefore allows the most accurate results.

The regression model for shares (2) also uses the time period January 2010 to August 2016 in the estimation, again under log form for normalisation. In the appendix (table 6 and 7), as a robustness check I use January 2010 to December 2017 as a timeline in my estimations, as shares are not relative to last year and the full dataset can in theory be used. In this specific case, every month starting from January 2018 has to be dropped from the dataset, because BMW's and Mercedes' own scandal started to appear in the media. Otherwise an estimation of

the 3 forces was contaminated. Seat and Skoda, VWs subsidiaries are always dropped from the dataset, apart from rows (7) which estimates the absolute impact on both makes, this is to avoid contamination of the control group, as Seat and Skoda are directly linked to VW and used their manipulated engines.

The whole estimations consist of 42 regressions, including 14 using the expanded time-period from the appendix in table 6 and 7. The model includes time fixed effects, to account for seasonal changes and changes in oil price. Make specific fixed effects are included in every single regression to capture heterogeneity. Control variables are not necessary in the estimations, as the model include those fixed effects. Every regression in every row excludes the German makes, which is not specifically mentioned above. (E.g. If the regression tries to find the scandal's impact of the scandal on BMWs sales, all the other German makes not mentioned on top of the column are dropped. If the regression model wants to compute scandal's impact on VW subsidiaries market share, all German are dropped from the dataset.) This allows me to estimate the reputation spillover more accurately, as there is a clear treatment and control group with no contamination.

The key assumption in the differences-in-differences identification is that without treatment, all makes follow the same time trend and have the same mean outcome. If not, parallel trends are not the case, making an estimation biased, and a post-scandal estimation on some makes not accurate. Throughout the tables, the regressions and tables, the coefficient of interest β captures Dieselgate's impact on German non-VW manufactures respectively on VW subsidiaries Skoda and Seat.

4.2 Data and Sample

The dataset only includes car manufacturers, for which data is consistently available for Germany and EFTA, or for which sales are significant enough, to be seen as competitors to German makes. Tesla, Chrysler, Chevrolet Saab, Subaru and Tesla are not in the dataset, because they do not fulfil these criteria.

Legend 2: Makes used in the regression model

Control Group		Treatment groups
Alfa Romeo	Mazda	(1) VW
Citroen	Mitsubishi	
Dacia	Nissan	(2) ALL German (non-VW
DS	Peugeot	
Fiat	Renault	(3) BMW
Ford	Suzuki	
Honda	Toyota	(4) Opel
Hyundai	Volvo	
Jaguar		(5) Mercedes
Kia		
Lancia		(6) Smart
Land Rover		
Lexus		(7) Subsidiaries - Skoda, Seat

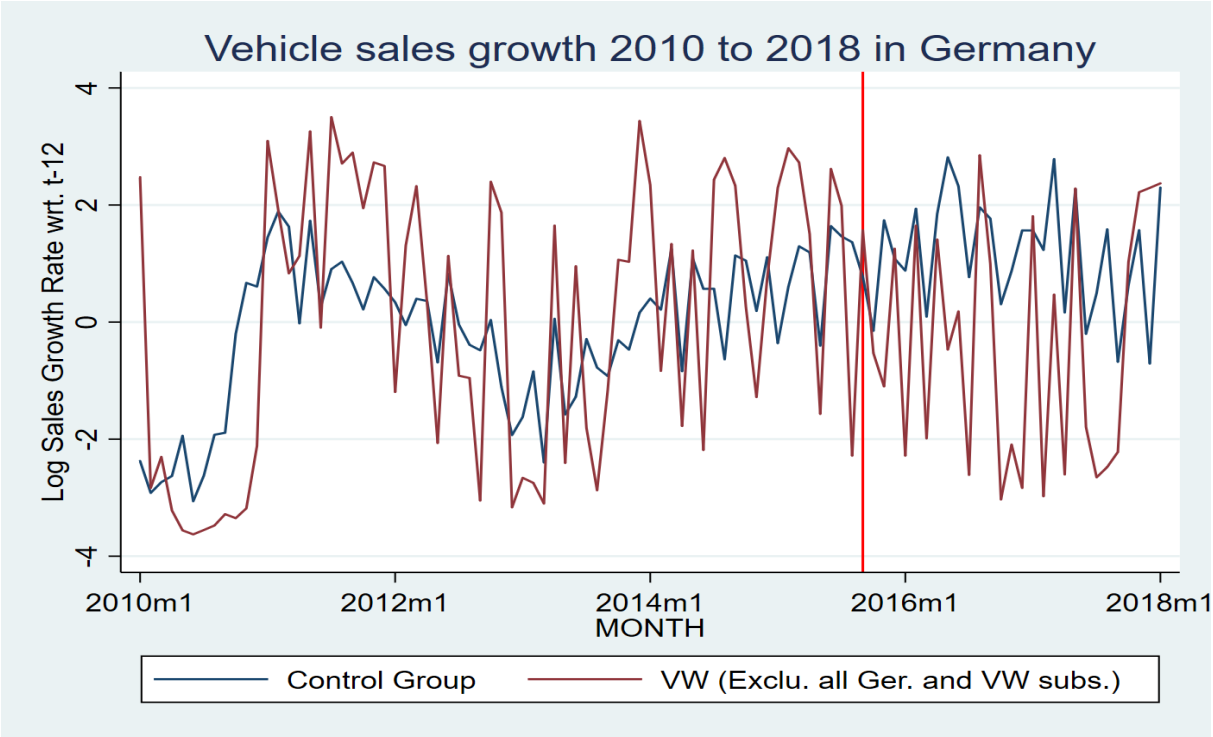
Data for the market registrations is very accurate and publicly available by the Kraftfahrt-Bundesamt, a government agency, which publishes all the new registrations per make on a monthly and yearly basis. European data is published on a monthly basis for all the European registrations of new cars, by the European Automobile Manufacturers' Association located in Brussels, ACEA (French abbreviation). Vehicles are not only Germanys main export (source), but also represented 55.8% of new car registrations in Germany in 2015 and 49.3% in the European & EFTA market. Which can be seen in the KBA and ACEA datasets respectively. This means they have by far the biggest market size relative to all the other manufacturing countries.

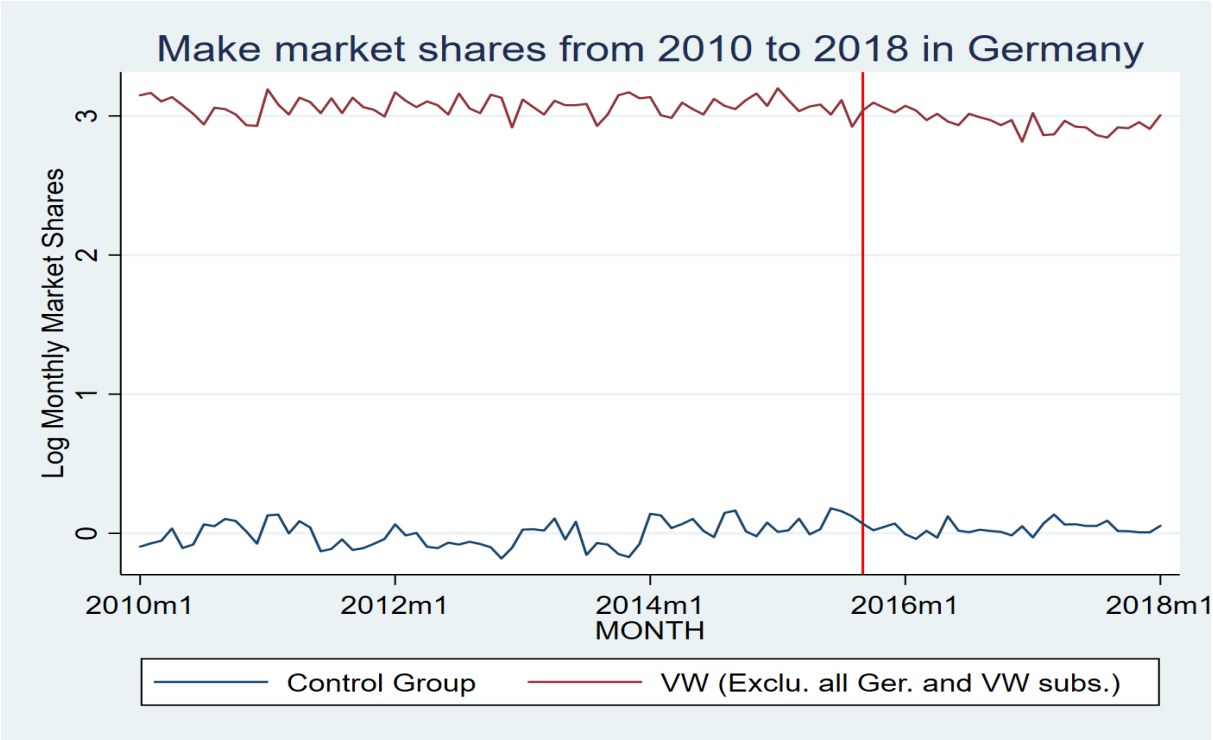
EFTA data includes German sales, as it is the biggest buyer, with the biggest population on the market and because the data is not available without German consumers. Nonetheless, EFTA sales growths excluding Germany are computed, by simply subtracting German sales from EFTA sales. With that data table 3 can be estimated again excluding Germany, as a robustness check, in table 9 (appendix) and to find out if Germany is the engine of European demand.

4.3 Parallel trends

A differences-in-differences estimation requires parallel trends before the scandal happened, so in this paper, parallel trends in sales must be checked for. The control group in each of the following figures represents the makes in the left column of Legend 2, non-German and Non-VW subsidiary manufacturers. Figures 4 a and b graphically show VW's decrease in both market share and vehicle sales after the scandal, represented by the vertical line, relative to non-German and non-VW AG makes. Graphically, there is already evidence, that the main culprit, the VW group has outstandingly lost in market share, due to the scandal. Figure 4a and b also show that there is a common trend between VW and non-VW group makes, before the scandal in September 2015, as both control and treatment group seem to follow a similar graphical pattern before September 2015.

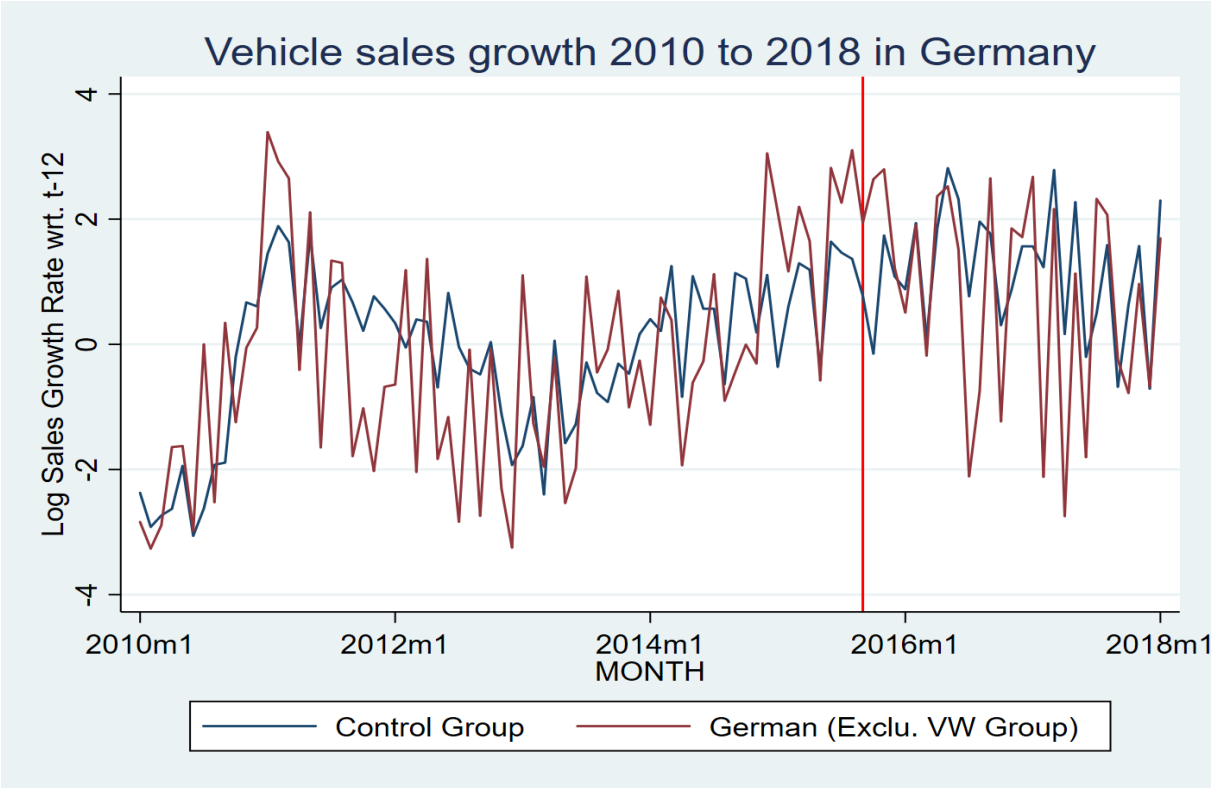
Figure 4a and 4b:

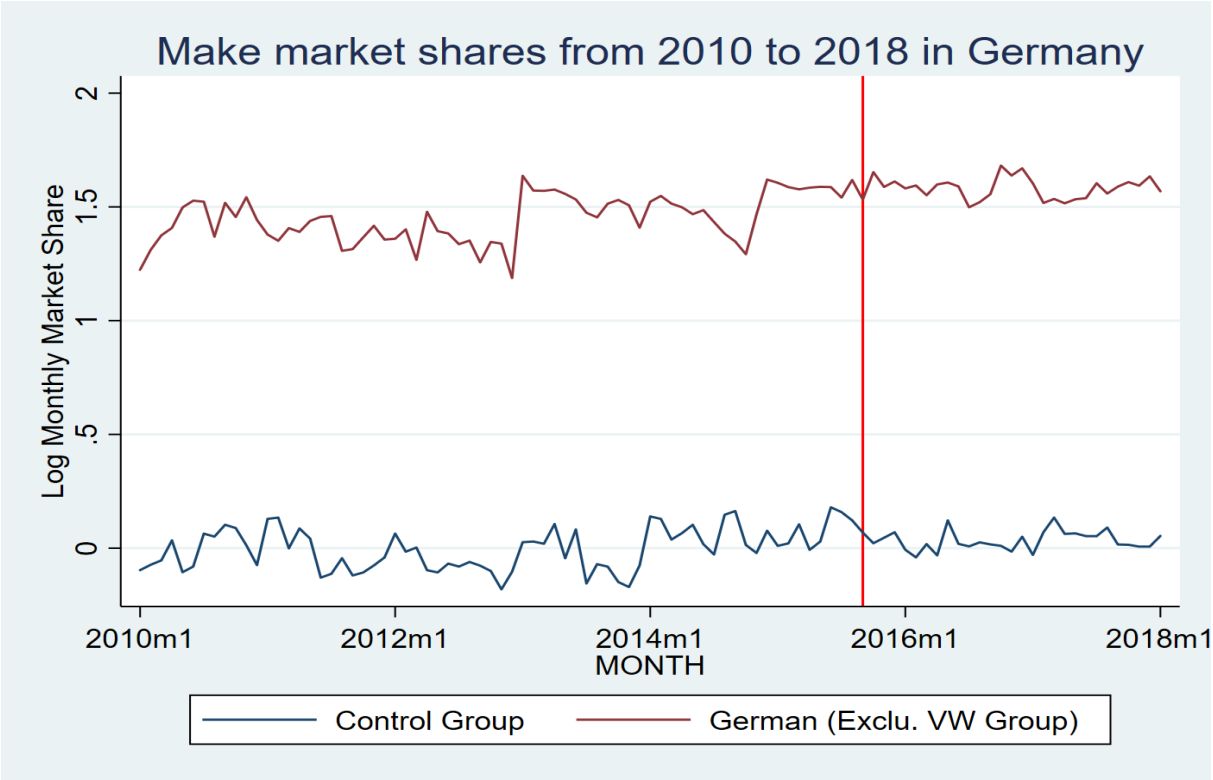




Note: Data comes from Kraftfahrt Bundesamt, and the red vertical line represents the scandal.

Figure 5a and 5b:





Note: Data comes from Kraftfahrt Bundesamt, and the red vertical line represents the scandal.

Figure 5 a and b represent the sum of VW's German competitors' sales and market share's before and after the scandal, which is represented by the vertical line. VW and its subsidiaries are therefore all dropped from the dataset for the representation of this model, as they falsify the causal effect of the scandal. Pre scandal trends seem to be very similar for both the control and treatment group as they both follow a similar graphical pattern. The parallel trends assumption seems to hold, and the natural experiment, Dieselgate, works great in estimating the effect of a reputation spillover. Non-German manufactures are a good control group for an estimation of the scandal's impact on the industry, as without the scandal treatment, both groups follow a similar sales and market share evolution.

Figure 5a suggests that German manufacturers (excluding the VW group) slightly increase their vehicle sales immediately after the scandal, but after a couple of months, sales seem to have decreased. The red treatment group sales growth curve surpasses the blue control group sales growth curve for a couple of months immediately after the scandal. For the market shares, it seems like German makes had lost in market power after the scandal, with a recovery at the beginning of 2017. Graphically, in contrast to figures 4a and b, which show much clearer that VW had a worse post-scandal economic outcome, figures 5a and b do not provide crystal clear, visible evidence of decreasing sales and market share.

In the appendix, figures 6-10 represent the parallel trends of the vehicle sales growth for every non-VW German make separately. BMW's parallel trends are incomplete between 2010 and 2013, due to the unstandardized dataset, which combined BMW and Mini's sales in that period. Due to a lot of volatility in sales growth, analysing the trends graphically is very challenging. Especially Smart and Opel are very volatile, with a lot of graphical variances in figures 7 and 9. Overall, they seem to follow a similar pattern, with increasing sales growth in 2011 and 2014 until mid-2015.

5. Empirical results and analysis

5.1 German results

Table 1: Diff-in-Diff estimation, Vehicle Manufacturers sales growth rate in Germany, excluding all German makes and VW subsidiaries not mentioned from column (1) to (7), January 2010 -August 2016

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	VW	ALL	BMW	OPEL	MERCEDES	SMART	SUBS
Scandal * German	-1.557***	-0.128	-0.0706	0.470	-0.280	-0.639	
	(0.305)	(0.363)	(0.292)	(0.304)	(0.305)	(0.305)	
Scandal * Subsidiaries							-2.585***
							(0.760)
Observations	1,584	1,788	1,548	1,584	1,584	1,584	1,664
R-squared	0.322	0.315	0.319	0.326	0.317	0.311	0.322
Manufacturer FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Data is on a monthly basis and comes from Kraftfahrt-Bundesamt. The time-period covered is January 2010 to August 2016. The dependant variable is in a log format. "All" represents non-VW German makes, without including VW subsidiaries. "SUBS" represents all non-German VW subsidiaries, excluding every single German manufacturer.

Table 1 is representing the German market sales growth with respect to the same month last year and its post-scandal changes on car makes using data from the Kraftfahrt-Bundesamt. The interaction term *'Scandal * German'* respectively *'Scandal * Subsidiaries'* is 1 if the observation in the panel was taken from a German company/VW subsidiary after August 2015, and 0 otherwise. Standard errors are clustered at the make ID level in the parentheses and every row is only including the data of German makes or VW subsidiaries if specifically mentioned

above. This means that all the other German makes are dropped in the regression model, to avoid a contamination of the treatment groups. (E.g. Estimating the scandal's impact on BMW, column (3), VW, all of their German and non-German subsidiaries, Opel, Mercedes and Smart have to be dropped before regressing) The table contains both manufacturer and time fixed effects, for the reasons stated in 4.1. Column (1) is looking at VW only, dropping all the other German manufacturers and its subsidiaries. The statistically significant coefficient -1.557 for VW shows that VW sales during the first 12 months after the scandal decreased by 155 percentage points, which is a massive drop in sales. Meaning that if they had increasing sales of 5% per year on average, they now have a negative growth of over 2.5%. Column (1) just is a control, to check for any inconsistencies, as it is expected that VW is certainly suffering from decreasing sales due to their scandal. Column (1) representing the direct impact on VW should be significantly negative for all the following estimations, if not a reputation spillover cannot happen at all, or there are measurement issues with the data.

"ALL" in column (2) is simply looking at all the non-VW German makes combined. Columns (2) to (6) don't contain any significant coefficients, as the p-value is below 0.05, suggesting that in Germany, consumers were not buying significantly fewer German cars (sales growth), relative to the control group. This result could also be explained with the combination of Bachman et al. (2019)'s 3 forces. The substitution away from VW, the reputation spillover and the substitution away from the Diesel technology. The massive decrease in VW sales growth could be first evidence that part of the negative spillover was compensated with the substitution away from VW, as historically Germans tend to buy local vehicles. BMW, Mercedes, Opel and Smart are direct substitutes, and the closest to their own technology. If 60% of German consumers buy German cars, it seems very likely that they decide to acquire a German car again in the future making them perfect homogenous products. To check for consistency with the sales growth rate, market shares are used in table 2. Column (7) is suggesting that VW's subsidiaries suffered from the scandal in relative terms, with a significant loss of sales by 258 percentage points with respect to t-12. VW subsidiaries -Skoda and Seat- also manipulated the emission tests in their cars, partly by using the same engines as VW cars used. Therefore, regression (7) is not analysing a reputation spillover but trying to find out if subsidiaries could hide behind their parent company and the vehicle manufacturing nation Germany.

Using growth rates might help to capture seasonality and make-specific trends, but cause other problems, if the country's consumers have a preference for their local products.

Even though my estimations seem to be accurate, as VW and its subsidiaries show negative impact in terms of growth rate, further analyses must be done. In a first stage those results are compared to the market share changes after the scandal.

Table 2: Diff-in-Diff estimation, Vehicle Manufacturers market shares in Germany, excluding all German makes and VW subsidiaries not mentioned from column (1) to (7), January 2010 – August 2016

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	VW	ALL	BMW	OPEL	MERCEDES	SMART	SUBS
Scandal * German	-0.0990***	-0.0102	-0.0721**	-0.0571**	-0.0549*	0.134**	
	(0.0317)	(0.0288)	(0.0312)	(0.0290)	(0.0309)	(0.0613)	
Scandal * Subsidiaries							0.0769**
							(0.0337)
Observations	1,538	1,742	1,502	1,538	1,538	1,538	1,618
R-squared	0.964	0.962	0.954	0.957	0.958	0.948	0.953
Manufacturer FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Data is on a monthly basis and comes from Kraftfahrt-Bundesamt. The time-period covered is January 2010 to August 2016. The dependant variable is in a log format. "All" represents non-VW German makes, without including VW subsidiaries. "SUBS" represents all non-German VW subsidiaries, excluding every single German manufacturer.

Table 2 is representing the German market shares and its post-scandal change. The interaction term *'Scandal * German'* respectively *'Scandal * Subsidiaries'* is 1 if the observation in the panel was taken from a German company/ VW subsidiary after August 2015, and 0 otherwise. Standard errors are clustered at the make ID level in the parentheses and every row is only including the German make or VW subsidiary if specifically mentioned above. The table contains both Manufacturer and time fixed effects, for the reasons stated in 4.1. The R-squared value is surprisingly high and consistent between 0.959 and 0.977.

Column (1) again shows a negative impact on VW's, this time on their market share after the scandal. They lost 9.9 percentage points of their market share, with respect to their non-German competitors, which is again not very surprising as VW is the main culprit of the scandal. Evidence for an overall negative impact on their German counterparts can also be found with BMW losing 7.2 percentage points, Opel losing 5.7 percentage points and finally

Mercedes loosing 5.5 slightly less significant percentage points. Looking at table 6 in the appendix, which is using the same regression, with a longer time period (December 2017) included, there is even higher and more significant evidence for a negative reputation spillover to BMW, Mercedes and Opel in terms of market share.

In column (6), Smart seems to have increased its total market share, relative to the control group, which is consistent with column (6) of table 6, with an increased timeline. This implies that the company even benefitted from the scandal and increased their relative market share, even though their relative sales haven't increased significantly. The size of their cars, the fact that they almost exclusively use gasoline engines and the low fuel usage are all potentially attracting consumers towards buying their vehicles. The sum of market shares of VW's German competitors in column (2) implies that due to the increasing market share of Smart, an estimation of the reputation spillover is not that straight forward. Finally, in both, table 2 and 6, row (7) suggests that VWs subsidiaries did benefit from the scandal, increasing their market share relative to the control group, even though their sales growth rate was negative in table 1. This means that parts of the German consumers could have substituted to VWs subsidiaries, while other substitutes away from them. A possible explanation for the positive results for market share and negative results for sales growth can be that because a lot of consumers stopped buying German cars, which represent 60% of the market. German makes sold fewer cars and therefore the relative market share of subsidiaries increased. If German makes sell fewer, and a non-German make sells a constant or decreasing amount of cars, relative market share of subsidiaries could increase, depending on the weight. A conclusion for this phenomenon can only be drawn from the Demand model in section 6. Interpreting market share variation is very challenging, but interesting as it gives another perspective on the scandal's impact.

Table 1, 2 and 6 implies that German consumers might have been punishing the other German makes for VWs manipulations, but it is unclear if they sold less because of the bad reputation of the diesel engine. Their subsidiaries and Smart on the other hand seem to even have benefited from the scandal and managed to increase their market power. For all the others makes, there is already a lead, that they have been hurt by collective reputation. Furthermore, as the appendix table shows, increasing the timetable doesn't have a significant impact on the results, promising robustness and an overall trend. If you don't include 2018 or a more recent year, where BMW and Mercedes had their own scandals.

It is a major difference whether one uses sales growth rates (table 1) or market shares (table 2 and 6) as the dependent variable, because they represent different results and scenarios. Interpreting both is very different, and a real conclusion can only be drawn from the demand model. Before coming to the demand model, which is analysing the German market in Detail, through the three forces, the following tables 3, 4 and 7 make the same analysis for the EU/EFTA market, allowing to check for consistency throughout the continent.

5.2 EFTA results

Table 3: Diff-in-Diff estimation, Vehicle Manufacturers sales growth rate in the EFTA area, excluding all German makes and VW subsidiaries not mentioned from column (1) to (7), Jan. 2010 – Aug. 2016 (Including Germany)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	VW	ALL	BMW	OPEL	MERCEDES	SMART	SUBS
Scandal * German	-1.591***	0.369	-0.268	0.171	0.0365	1.539***	
	(0.319)	(0.479)	(0.319)	(0.319)	(0.319)	(0.320)	
Scandal * Subsidiaries							-1.880**
							(0.702)
Observations	1,774	2,005	1,774	1,774	1,774	1,774	1,851
R-squared	0.380	0.374	0.373	0.381	0.374	0.376	0.377
Manufacturer FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Data is on a monthly basis and comes from Kraftfahrt-Bundesamt. The time period covered is January 2010 to August 2016. The dependant variable is in a log format. Data for EFTA is not available in August 2010 and 2011 the panel is unbalanced since most models are not available throughout the entire time period. "All" represents non-VW German makes, without including VW subsidiaries. "SUBS" represents all non-German VW subsidiaries, excluding every single German manufacturer.

Table 3, identically to table 1, represents growth in sales with respect to the same month last year, but for the EFTA area. This data comes from the ACEA, a whole different source than German data, but still similarities between table 1 and 3 can be seen. The interaction term *'Scandal * German'* respectively *'Scandal * Subsidiaries'* is 1 if the observation in the panel was taken from a German company/ VW subsidiary after August 2015, and 0 otherwise. Standard errors are clustered at the make ID level in the parentheses and every row is only including the German make or VW subsidiary if specifically mentioned above. The table

contains both manufacturer and time fixed effects, for the reasons stated in 4.1. Column (1) again shows a relative decrease of sales, due to the scandal. The 159 percentage points decrease in sales for VW relative to the control group, 12 months after the scandal is unsurprisingly significant. Column (2)-(5) analysing German-non-VW makes sales growth, are like in the German market analysis not significant. This means that the scandal was not significantly impacting sales growth of BMW, Opel and Mercedes. Only Smart, in column (6) seems to have benefited from the scandal, with a 153 percentage points significant increase in sales, which is potentially the case because of their car dimensions and environmentally outstanding products. In Germany this wasn't the case, as the coefficient was negative but insignificant. A massive reputation spillover in terms of sales growth rates cannot be found in the EFTA area. In table 4 where market shares are used again in the estimation, different results can be observed. Subsidiaries have lost 188 percentage points in sales. (column 7). The results from table 3 are very close to their German competitors in table 1. The consistency of both markets, using completely different datasets, while achieving very similar results makes the results even more trustworthy, especially because of the consistency of column (1).

In table 9 (appendix), Germany is excluded in the estimation of sales growth. This gives very interesting results, as all non-VW AG German makes combined "ALL" now significantly increase their sales by 79.2 percentage points. BMW increases sales growth with respect to the control group by 70.6 percentage points and Smart sales increase even stronger than before. The negative sales growth on non-German VW subsidiaries is now only -128.7 instead of -188 percentage points. Those results are consistent with the results from table 1, as there, subsidiaries sold 258.5 significant percentage points less cars, a much bigger impact than on the EFTA sales. Furthermore, German consumers seem to have substituted away from VW stronger than the average European consumer. The EU consumer on average substituted towards alternative German makes stronger, most significantly towards BMW, which is now significant and positive with 70.6 percentage points.

Table 4: Diff-in-Diff estimation, Vehicle Manufacturers market shares in the EFTA area, excluding all German makes and VW subsidiaries not mentioned from column (1) to (7), Jan. 2010 – Aug. 2016 (Including Germany)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	VW	ALL	BMW	OPEL	MERCEDES	SMART	SUBS
Scandal * German	-0.169***	0.00490	-0.00937	-0.134***	0.0459	0.117**	
	(0.0343)	(0.0260)	(0.0274)	(0.0249)	(0.0328)	(0.0461)	
Scandal * Subsidiaries							-0.0534*
							(0.0294)
Observations	1,774	2,005	1,774	1,774	1,774	1,774	1,851
R-squared	0.961	0.961	0.957	0.958	0.957	0.955	0.956
Manufacturer FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: Data is on a monthly basis and comes from Kraftfahrt-Bundesamt. The time-period covered is January 2010 to August 2016. The dependant variable is in a log format. "All" represents non-VW German makes, without including VW subsidiaries. "SUBS" represents all non-German VW subsidiaries, excluding every single German manufacturer.

Table 4 is representing the German market shares and its post-scandal change. The interaction term *'Scandal * German'* respectively *'Scandal * Subsidiaries'* is 1 if the observation in the panel was taken from a German company/ VW subsidiary after August 2015, and 0 otherwise. Standard errors are clustered at the make ID level in the parentheses and every row is only including the German make or VW subsidiary if specifically mentioned above. The table contains both Manufacturer and time fixed effects, for the reasons stated in 4.1. The R-squared value is consistent between 0.968 and 0.974.

Column (1) again shows a decrease for VW in market shares in Europe, with a -16.9 percentage points decrease in table 4 and -20 percentage points in table 7, using a longer time period December 2017 included. This table now shows significant differences in market share due to the scandal, more accurately the repercussions of the three forces combined. Opel loses 13.4 percentage points in EU market share and Smart sees a significant increase in market power by 11.7 percentage points in 2016 (column 6), both estimations being relative to the non-German control group. All the other makes did not see any significant changes, which can again be explained by a substitution away from VW and a negative reputation spillover. Finally, the

biggest difference between Europe's and Germany's Differences-in-Differences analysis is that VWs subsidiaries seem to have gained in market share in Germany and lost in the whole EFTA area. This could be explained by higher substitution away from VW to another European company that is totally independent.

Interestingly, both economic areas are almost identical, when I use sales growth as the dependent variable. Using market shares implies that German consumers in general reacted more strongly to the scandal, as BMW, Opel and Mercedes lost in market share, while in Europe, only Opel was affected. Smart is a winner in both markets, increasing their market share significantly. Subsidiaries only benefited from the crisis in Germany.

The research questions are therefore not that straight forward to answer to and need to be further analysed with the demand model. But it can be said that there are positive and negative repercussions, which can be measured on multiple manufacturers due to the scandal in Europe and Germany. The scandal seems to not have affected every make equally, as some of them could have benefited from consumers substituting away from the VW group, which we are going to analyse in the demand model with Bachmann et al. (2019)'s 3 forces. Both, Europe and Germany showed almost identical sales growth results, but their market share results were very different. To analyse the scandals' impact even further, and draw conclusions, comparing them to matching research papers and use a consumer demand model is necessary. The demand model uses per model sales data and differentiates between the three forces, the US-paper discovered. To summarise, I can say that there is evidence for a reputation spillover to VWs subsidiaries. Worth mentioning is that Smart is an outlier for almost every single model, which could be explained with their very low total sales and market total market share under 1%, making it very volatile in a less than 10 years' time period and their very special product characteristics. These regressions are way too broad to draw conclusions and reply with certainty to my research questions, therefore I am going to create the utility model in section 6.

5.3 Comparison to the literature

The paper of Bachman et al. (2019) finds very significant evidence, that every single German manufacturer have been negatively affected by reputation spillover in the US, the scandal following 12 months. The authors follow the same differences-in-differences estimation model, as this paper. For all the non-German makes, they find on average 9.2 percentage points less sales growth, relative to their non-German competitors. In detail they find that BMW's sales growth decreased by 13.1 percentage points, Mercedes-Benz sales

growth by 5.5 percentage points and Smart's by 30.3 percentage points, because of the Dieselgate in September 2015. The researchers did not use market share data in their estimations, so a comparison of tables 2, 4, 6 and 7 to their findings is not possible. Using table 1 and 3 makes a direct comparison of the German market and the European (EFTAA) area possible.

Interestingly, by using the same Vehicle Sales growth variable as the dependent variable approach, no significant negative impact on German makes neither in Germany, nor Europe can be found. The only exception is Smart in the EFTA area, which is positive and significant. The VW group has significant losses in table 1 and 3. Using market shares as the dependant variable, evidence that BMW, Mercedes and Opel lost around 6 percentage points in market share relative to the control group one year after the scandal in Germany can be found. In Germany only Opel lost around 13% in relative European market power. On the US market Smart was the biggest loser in terms of sales, whereby in Germany, Smart is the only company that has even gained in market power. Unfortunately, the paper Bachmann et al. (2019) does not use market shares, making a direct comparison impossible.

Germans consumers, like their US counterparts prefer consuming cars from their own country, with almost 60% of newly registered cars in Germany being German in the dataset. Analysing the sales growth of German makes in Germany in that case is therefore questionable, as there seems to be a clear preference for their own national products, meaning that a substitution away from German cars becomes less likely.

Another promising partial explanation is that Europeans have more diesel cars than gasoline cars, implying that in the US, consumers lost trust in the diesel engine technology in general. The diesel engine has been historically more common in Europe (with 51.5% in 2015) than in the US (around 22% in 2015). Because of that US consumers may have tried to avoid buying German cars, which are almost exclusively diesel vehicles, 12 consecutive months after the scandal. Other manufacturers sold almost exclusively gasoline cars on the US market. This substitution is also confirmed by Bachman et al. (2019), meaning that people stopped believing in the sustainability of diesel cars after the appearance of the scandal in the news. In Europe, most manufacturers sell diesel cars anyways, making a substitution and a direct decrease in sales with respect to last year less likely.

6. The demand model and consumer's utility

After finding out that overall there was no clear reputation spillover on German manufactures and probably also no collective punishment of German or VW group subsidiaries, after the scandal, the following section wants to analyse, what happened in Germany after the scandal in detail. The only thing that is very clear, is that VW and its German makes did make significant losses in sales and lost in reputation also in Europe and Germany. But to find out which of Bachman et al. (2019)'s three forces were the strongest, a vehicle demand model is established, following previous research in the automobile industry, for the German market only, as per model data for EFTA is not available. Following Berry (1994) for the Demand model and the theory of Bachman et al. (2019) for the underlying theory of the three forces of substituting away from VW, substituting away from diesel and the reputational spillover effect, I construct the following regression model:

$$(3)\ \ln s_{it} - \ln s_{0t} = \alpha\, p_{jt} + x_{ji}\,\beta + \sigma \ln s_{j|gt} + \theta\, V_{jt} + \varepsilon_{it}$$

Where:

Sit is the market share of sales of vehicle i in year t,

Vjt is a vector of key observed characteristics of the vehicle,

pjt is the price of vehicle i in year t,

xji contains the interaction terms of interest like *company x scandal* or *Diesel x scandal*,

ln s j | gt is the market share of vehicle j in country g, also called nesting parameter.

εit is the error term.

The key observed vehicles characteristics Vjt contain information like performance in HP, length and width of the car and a dummy if the model also exists as an electric car. These characteristics are used to avoid an omitted variable bias and to create heterogeneity under all the products on the market. The nesting parameter σ should lie between 0 and 1, with a larger value meaning that there is a larger substitution within a country. The smaller this coefficient, the closer the model is to a standard logit function. Therefore, this nest is created to group every country from the same nest. In this model Swedish and UK sales are nested under *EU*, as they only represent a comparatively small share of sales. The variable *ln(sjt)* represents the market share of vehicle j in year t, while ln(*s0t)* represents the share of the consumers outside option, when they do not buy a car. A study trying to find county level reputation spillovers, according to the paper of the national bureau of economic research should use a nested-logit model with

country-level nests to "allow vehicles with the same country of origin and those with different country origins to have different degrees of substitutability".

The regression follows the Stata approach of (Hao, 2018), also about the car industry, under which the nested country share and the market share are calculated manually. Implementing the nest parameters in the model transforms the regression from a standard logit model into a nested logit model.

Legend 3: Nested country Shares

Country Group Code	Nested Countries
CZ	Czech Republic
EU	UK, Sweden
FR	France
GER	Germany
IT	Italy
JP	Japan
RO	Romania
SK	South Korea
US	US
SP	Spain

Note: I bundled Swedish an UK cars under EU, as they only sell a minority of all the cars on the German market. All the under makes are nested under their real country of origin.

As mentioned before, the regression model includes control variables for vehicle characteristics, as they are not only determining how often they are sold, but also create a certain heterogeneity between the products. Similar as for characteristics, price is also an important control variable, as it is significant for consumer choice of whether to buy are vehicle or not. Increasing prices should in theory also decrease the utility in the demand estimation model and make the outside option of not buying or buying a different model appealing. The model includes manufacturer, year and power type fixed effects. The make FE captures heterogeneity in sales rates, the year FE captures seasons and oil price shocks which affect vehicle demand, and power type FE captures trends in technology used. To distinguish between the three forces, the model uses the variable *xji*, which contains all interaction terms. Those interaction term help finding the coefficient of interest β, which is critical to quantifying the three forces that are established in the previous literature about the US light vehicle sales.

There is potential correlation between market share of a vehicle, its price and the unobservable demand shock in a nested-logit demand model like the model following Berry 1994, which would if true cause selection bias, more specifically an omitted variable bias, and

could also lead to estimation issues. This problem of selection bias can be dealt with only a few instruments mentioned by Bajari (2007). The first instrument he mentions is constructing IVs based on the characteristics of competing products or vehicles in my model. The price and market share of the vehicle also depend on the characteristics of all the other vehicles, making it in theory a good instrument. This IV-approach is used by Berry et al. (1995) and Bachmann et al. (2019) and other papers. Nonetheless, this IV-approach can cause even more problems, as one must assume the makes chose the characteristics of their vehicles optimally, while the unobserved characteristics of a vehicle are independent of the observed ones in X. In addition to that price and demand must be strictly uncorrelated. This separation theorem is very likely to be violated in the author's and my Demand model if characteristics are used as an instrument.

Another potential instrument for price, is the average price of products in other markets (e.g. France or US), the "Hausman" instrument. This can be problematic as well if the instrument also picks up common demand shock, which makes foreign vehicle price a bad instrument and causes a bias in the measurement of the price correlation in the second stage (Bajari, 2007).

A third instrument could be a shifter, more specifically a supply shifter, which is simply using a specification that changes supply as an instrument. The most obvious example would be a change in production cost. The problem is that only a few changes exist, and they might be extremely weak causing incorrect standard errors and a large bias. Instrumenting for cost might cause more problems than it solves.

A final potential instrument, mentioned by Bajari (2007) is the measurement of isolation in product space, which has been established by Berry (1994). This approach uses the weight of how much product/vehicle j contributes to the average of all characteristics. This instrument tends to be highly correlated with price. The problem with the latter instrument is the lack of significant variation over time and the necessity of a strict separation between the omitted characteristics and the observed characteristics $cov(\xi jt, xjtk) = 0$. This assumption seems very unlikely because there is also a correlation within the observable characteristics. There is no ideal 2LS approach available in the literature, and therefore estimating the demand model using a regular fixed effect estimation seems the most promising approach. Using an instrument could potentially cause more problems than it solves, if any bias even exists in the first place. Using a strong fixed effect estimation seems to be the best alternative, including make, fuel and time fixed effects.

Vehicles in my dataset were partly sold in over 250 trims, only considering the Diesel or gasoline models in Germany separately. This makes me use minimum price and characteristics, maximum price and characteristics and the arithmetic mean of both *(x min + x max/2)*. The huge numbers of trims make it impossible to use any other approach. Furthermore, as I am going to explain in the data section, a dataset for characteristics and prices does not exist as it changes from model to model and year to year. Data points had to be collected separately from the ADAC to achieve the most accurate results. To guarantee robustness overall prices and characteristics min, max and arithmetic-mean characteristics and prices are included in 4 different regressions, with one of them bundling all non-VW group makes under "*German Non-VW*".

With the results of this paper, further analysis can be done to estimate how much market power and money every single make has lost due to the scandal. Using simulations, it is possible to estimate the expected sales without treatment and use the percentage point coefficients from the table to calculate the number of cars, sold less by German manufacturers, and finally estimate how much money they lost due to 'Dieselgate'. In addition to that, it is also possible to estimate the costs of the reputation spillover in Germany and to find out how many people substituted to homogenous German products, to a VW competitor. For future papers, the substitution to the emerging electro engine market can also be very interesting. During the scandal, its popularity was relatively low, but with better and more complete data, calculating the substitution to this relatively new technology, is also possible for the German and European market.

6.1 Data and Sample

I could only do a demand model for Germany, not for Europe/EFTA, because per model vehicle registrations are not available on a European level. The German data for the specifications and list prices is also publicly available on the website of the ADAC, the German automobile association, which had 22,1 million members in December 2019, which consists of over a quarter of the German population. Data for the per model sales again come from the Kraftfahrt-Bundesamt, which are monthly and yearly uploaded press releases about German vehicle registrations.

The dataset also separates diesel and all other alternative engines, which includes gasoline, into two groups. The analysis could only differentiate between diesel and all the other engine types combined, as the agency only started to document the alternatives like electro

engine sales after 2014. Meaning that in the dataset, there are two categories, so the models use either a diesel engine or any alternative (OTHER) with "D" standing for diesel and "O" standing for others in the dataset (E.g. D_Ford_Focus or O_Ford_Focus). Most of the vehicles used in the dataset appear as both diesel and Non-diesel cars in the dataset (E.g. Skoda Octavia with a diesel engine and Skoda Octavia with a non-diesel Engine). The non-diesel engine vehicles include all the other alternative automobile engines using cars potentially sold on the German market (including electric, H2O and natural gas engines). The manipulation software installed to meet environmental standards was only installed in diesel vehicles. Because of the lack of data for electric cars, which are starting to become more popular in recent years, I included a dummy variable 1 if the model in the panel data was part of the OTHER group and was available for sale in Germany with an electric engine and 0 otherwise.

Using all the non-diesel vehicles in the dataset, not only gasoline, makes controlling for '*weight'* and '*miles per gallon'* impossible, as electric cars and natural gas cars are not comparable in their characteristics. They tend to be much heavier. Controlling for miles per gallon is therefore also not possible, as the electric or gas vehicles do not have a comparable fuel usage. Nonetheless, excluding alternative fuel engines, in an economy with an emerging trend for those products, causes measurement issues in the estimation of consumer utilities. Therefore, fewer characteristics (control variables) are used but more data points, by not only looking at diesel and gasoline engines, in the estimation.

Some models exist in over 150 trims for gasoline only, which is why the arrhythmic means of both price and performance (HP) are used in columns (2) and (3) instead of the middle trim like the previous literature. Bachmann et al. (2019) use the characteristics of the trim's middle as the mean. (e.g. characteristics of car 10 out of 20). If a consumer preferred to buy electric cars, the average weight of the model sold is much higher. Also because of the low electric car sales before 2016, the dataset did not differentiate between those sales and doesn't include the number of cars that were only produced in an electric version, nor the number of electric trims.

Previous literature used make specific time trends in their regression model, which cannot be used because of the '*make*scandal'* interaction terms. Including *Year*make specific time trends* causes multicollinearity issues, and makes an estimation of the coefficients of interest, the interaction terms not possible. Including diesel and super e10 prices in the model is not necessary and causes multicollinearity issues. The model already contains FE estimations,

which capture seasonality and petrol price changes and it's resulting vehicle demand volatility throughout all the years in the dataset. For the country shares, I regrouped British and Swedish Sales under European SALES (EU), because their sales in Germany were individually much lower than the shares of all the other countries. In this Group, there is only the Swedish make Volvo, and the British makes Jaguar and Land Rover, which are comparatively not very successful in Germany. Using the same methodology, with data from the whole EFTA area was not possible, because there is simply no dataset available, presenting new registrations per model and trim. Therefore, a direct comparison of the 3 forces, within Europe and Germany is not possible. One can just draw conclusions of the overall effect in Europe by using tables 3 and 4, but not about the details of substituting away from VW, reputation spillovers and substitution away from the diesel engine on an EU wide level.

6.2 Empirical results

Table 5: Diff-in-Diff estimation, Demand model with a nested logit estimation, 2010 – 2017

VARIABLES	(1) Min	(2) Arith-Mean	(3) Arith-Mean	(4) Max
Price/1000 in EURO	-0.106	-0.333***	-0.333***	-0.313***
	(0.0787)	(0.0975)	(0.0975)	(0.0892)
Performance in HP	-0.0238	0.0813***	0.0812***	0.0808***
	(0.0324)	(0.0312)	(0.0312)	(0.0256)
LENGH	-0.00294	0.0259	0.0262	0.0168
	(0.0413)	(0.0439)	(0.0439)	(0.0449)
WIDE	0.331***	0.212*	0.212*	0.175
	(0.127)	(0.113)	(0.112)	(0.113)
Electric	-0.00680	0.0249	0.0249	0.0306
	(0.0239)	(0.0245)	(0.0239)	(0.0241)
Scandal * BMW	-0.0822***	-0.0824***		-0.0835***
	(0.0261)	(0.0261)		(0.0263)
Scandal * Opel	-0.0845***	-0.0847***		-0.0850***
	(0.0275)	(0.0275)		(0.0275)
Scandal * Mercedes	-0.0725***	-0.0726***		-0.0716***
	(0.0236)	(0.0234)		(0.0233)
Scandal * Smart	-0.0555	-0.0819*		-0.0891*
	(0.0478)	(0.0478)		(0.0480)
Scandal * Audi	-0.0793***	-0.0830***	-0.0830***	-0.0839***
	(0.0264)	(0.0269)	(0.0268)	(0.0270)
Scandal * Porsche	-0.0719**	-0.0793***	-0.0793***	-0.0786***
	(0.0286)	(0.0296)	(0.0296)	(0.0295)
Scandal * VW	-0.0981***	-0.102***	-0.102***	-0.105***
	(0.0313)	(0.0318)	(0.0318)	(0.0322)
Scandal * Diesel	0.0203	0.0216	0.0216	0.0216
	(0.0297)	(0.0298)	(0.0297)	(0.0298)
Scandal * VW Subsidiaries	0.186***	0.184***	0.184***	0.185***
	(0.0419)	(0.0420)	(0.0420)	(0.0419)
Country-Share, Nest Parameter	0.981***	0.979***	0.979***	0.977***
	(0.00817)	(0.00866)	(0.00865)	(0.00909)
Scandal * German Non-VW			-0.0789***	
			(0.0229)	
Observations	2,768	2,768	2,768	2,768
R-squared	0.982	0.982	0.982	0.982
Manufacturer FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Power-Type FE	YES	YES	YES	YES

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

Note: In the dataset, 2015 had to be dropped, as my data is on a yearly basis and the scandal took place in September 2015 and the data is on an annual level.

The table consists of 4 columns, with the (1) column, using the minimum available characteristic and price per model and per construction year, on the German market and answering the research questions with the *scandal * company* interaction terms for every single German make and VW subsidiary. In addition to that, the model also tries to capture potential demand shocks towards the diesel engine. Column (2) is using the arithmetic-mean of price and characteristics, with again every single German make and VW subsidiary having their own interaction term. Column (3) is also using the arithmetic-mean of prices and characteristics, but groups all non-VW German makes into one interaction term, being one if the observation, the model i is from Mercedes, Smart, BMW or Opel and the scandal already happened, and 0 otherwise. Finally, column (4) is using the maximum available trim price and characteristics per model and construction year.

The nested parameter is between 0.977 and 0.981 percentage points and statistically always very significant, which means that there is a huge substitution of products within the same countries. The higher σ, the more consumers tend to buy from the same country. σ must be between 0 and 1 and if it is 0, the model becomes a standard logit model, with the nests disappearing. The model includes Manufacture fixed effects, Year fixed effects and Power-Type fixed effect, to account for every possible invariant factor. R-squared is very high throughout the model, with 0.982.

The findings in the demand model are more accurate than the ones in section 5.1., because they don't only look at the sum of the three forces. Both models are using different datasets, and table 2 is only looking at the total impact of the scandal, but there is a similar pattern between market shares and demand model, with German makes (except Smart) loosing and VW subsidiaries gaining from the scandal with respect to the control group. This seems to be a very promising sign, as two approaches show the same results for the German market, but we have to look at the three forces in detail to find out how consumers actually reacted to the scandal. Direct similarities in results are possible, as the substitution away from diesel seems to be insignificant, but the Demand model only also captures the substitution away from VW force. The results from this demand model are far more representative than those from the previous section, as they don't only look at relative sales changes or make market shares, but at the share of market power on the product level. The dataset analyses every single car model, for each make, which produces a significant enough quantity to be significant. The results are consistent over column (1) to (4), where different control variable are used to control for heterogeneity.

Table 5 shows that consumers' utility decreases with the price of the vehicle. Price is nonetheless only significant, if we use the arithmetic mean (column 2 and 3) or maximum value (column 4). Using the *minimum price* is statistically insignificant, with the coefficient -0.106 instead of around -0.33. Therefore, the car price in Germany doesn't seem to affect the utility significantly, if the *minimum price* is used. The situation for the control variable *performance* looks identical, with coefficients of -0.0238 instead of around -0.081. Moreover, there definitely is a correlation between price and performance, which means that estimating the coefficients is biased no matter if we use minimum or maximum trims, this correlation could be stronger at the lowest trim. To avoid any estimation problems, I only analyse results from column (2) to (4), which seem to be consistent.

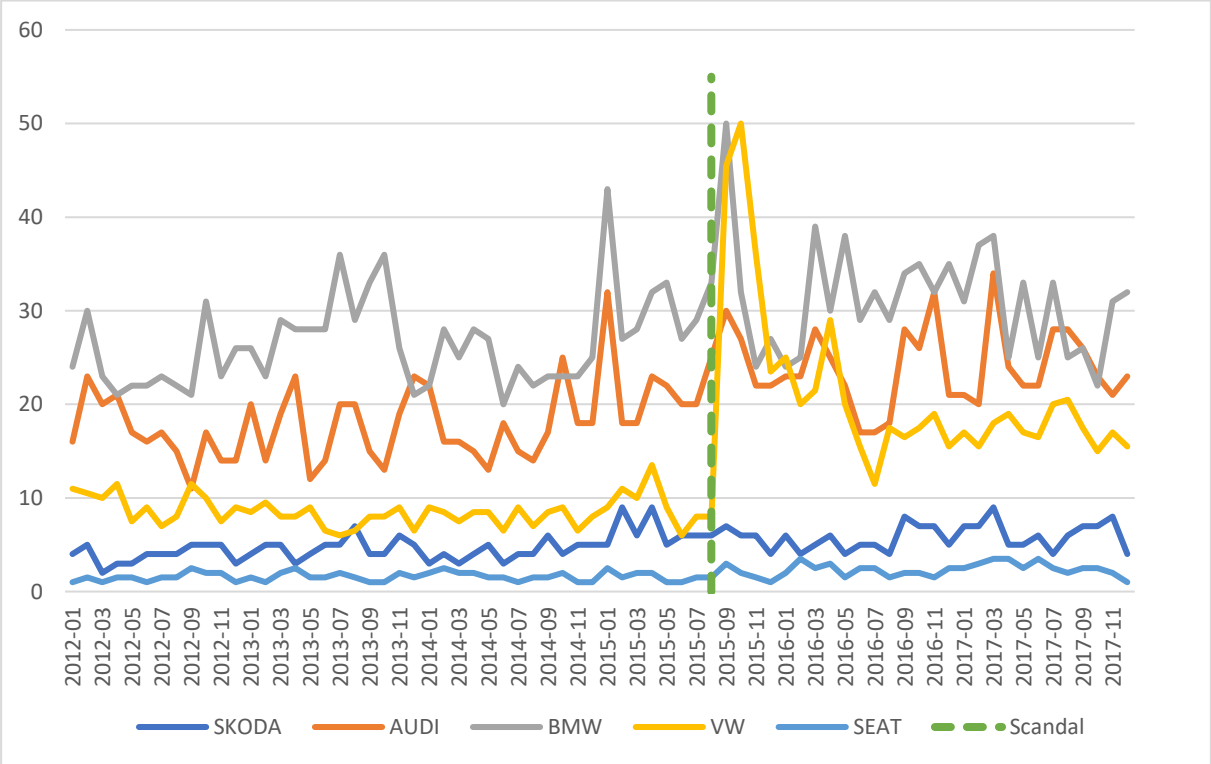
Most noticeably, the study doesn't find any evidence for a substitution away from diesel cars in 2016 and 2017. Germans seem to not have lost trust in the diesel engine so the following year after the scandal, and before the diesel ban debate started in 2018. As table 8 shows, that prolonging the dataset to 2019, makes the interaction term *Diesel * Scandal* very significant, suggesting that it took German consumers more than 2 years to get a lower valuation for diesel engines. As German consumers historically buy diesel cars, they may need more time and incentives to change their behaviour and substitute to a similar product.

Unsurprisingly, VWs negative coefficient is the highest of all of them meaning that their consumers were most affected by distrust and decreasing utility towards the manufacturer after the scandal. Their German subsidiaries, Audi and Porsche both also show significant losses in consumer utility up to almost -8.4 percentage points in 2016 and 2017. More interesting are the results for VWs German competition, where Mercedes has a negative coefficient of -7.2 and BMW around -8.2, meaning that both makes experienced decreasing consumer's utility. Unsurprising, as we can see with the extremely high nesting parameter, that consumers see models coming from the same country as very close substitutes.

While the results for Smart are negative, but not very significant, likely due to the relatively small market share or measurement errors in Germany registrations, the utility for VW subsidiary products increased a lot. This means that the hypothesis was true, after all and Skoda and Seat could hide behind Germany's image loss and could even boost their sales, because of German consumers substituting away from local vehicles. This increase of sales for the manipulating subsidiaries – Skoda and Seat – can be explained by my hypothesis, that they managed to hide behind the main culprits, VW and the German car industry. German

consumers were less informed about both company's manipulation, as they are no German-based companies and because of that mentioned less by the national media, which is illustrated in figure 8. All German Manufactures are mentioned significantly more frequently, during, and after the scandal in the media in Germany, while the trends for Skoda and Seat seem to have been constant, implying that people were less informed about their involvement in the manipulations. Due to a relatively lower reputation loss, both companies managed to increase their overall consumer utility and sales.

Figure 8 - Germany Google News Trends - Including Subsidiaries



Note: Data from these figures comes from trends.google.com and represents the news trends exclusively for Germany.

A possible critique on the differences-in-differences approach of section 5, is that in Germany, analysing such an effect with the approach of section 5 is very hard, as the whole market consists of around 60% local cars. The elimination of that 60% in the dataset for the per make estimations is done to avoid contamination and underestimation, as they vastly change the whole model. Using the Demand model specifically for Germany to find evidence for spillovers is way more accurate, as it not only analyses the after-scandal consequences on a model and trim level, but it also includes every single make in all of the 4 columns, increasing the number of per period observations significantly. The demand model also has the advantage,

that it can find out why sales increased or decreased, with the help of the 3 forces theorem developed by the US-paper.

With the results of section 6, one can clearly show that there is a reputation spillover on all German makes, with Smart being affected the least, considering statistical significance. VW is the one that suffered the most from a lower product utility after the scandal, but all their German competitors suffered from decreasing reputation as well.

Comparing the results to the finding of Bachmann et al. (2019), who created an almost identical demand Model for the US market, can lead to the conclusion that both demand models give very similar results. The US paper, like this paper finds evidence for a negative reputation spillover towards non-VW German manufactures. In their estimations, all the German makes lost in consumer utility. Smart is in table 5 an outlier, as it is again the only German make that does not significantly experience a decrease in their consumer's utility in Germany. This is the complete opposite of US results, where Smart's consumer utility is decreasing almost as much as VW's. The nest parameter is also stronger in the model with 0.982 compared to about 0.85 in the US, which might result from German preferences for their local cars, which they see as substitutes.

These results reinforce the evidence of the estimations in table 2 in the last section, arguing that a reputation spillover did happen in Germany. Interestingly, there is no proof for a substitution away from the diesel engine, which is very surprising if one compares it to the US results. A possible explanation is a European preference for the diesel engine, which has always been extremely high. More than half of all European cars have been diesel engines (and around 45% in Germany) in 2015. This only changed in early to mid-2017, when European countries and cities announced the diesel ban in certain areas, consumers finally lost their trust in it and uncertainty raised. The German newspaper WAZ published an article and a graphical representation in Summer 2018 about the ratio of diesel, gasoline and alternative fuel cars and their conclusions are matching with the results from the Demand model. Diesel sales plummeted significantly stronger due to diesel ban announcements, than due to the scandal in Germany (WAZ, 2018). In addition to that, prolonging the time-period of the estimation to December 2019, a significant utility decrease for the diesel engine can be found. Unfortunately, this causes the inclusion of a contaminated time period for estimating the spillover effect, due to BMW and Mercedes-Benz's own scandal which started to appear in the news early 2018.

Nevertheless, this is a relatively promising estimator of the substitution away from the diesel engine.

Therefore, one of Bachmann et al. (2019)'s three forces did not appear in Germany after the scandal. Only the diesel ban waves that hit European consumers, have caused a decreasing utility for the less clean technology. As mentioned before, table 5 which captures the events in detail does find negative utility impacts for all German cars, expect Smart. A negative reputation spillover took place in Germany, even though it might be less clear and strong than the one in the US. Consumer devaluation for their own national products in Germany did happen, and after Mercedes and BMW shocked consumers with their own scandal in 2018, this effect could even have deteriorated the consumer's trust in the industry.

7. Conclusions

This paper most importantly provides further proof for the existence of collective reputations for companies with the same nationality, like treated by previous literature. By using the VW group diesel scandal, often referred to as 'Dieselgate', as a natural experiment, this paper finds evidence, that the scandal did not only negatively affect the main culprit, VW and its German subsidiaries, but also Skoda, Seat, BMW, Audi and Opel. Reputation spillovers exist, and a companies' image can be damaged due to the discovery of their competitors' illegal activities, especially in times of internet and at the golden age of social media. The analysis therefore found evidence supporting the hypothesis, that a reputation spillover exists. Nonetheless, VW subsidiaries could partially hide from the scandal behind the image of German engineering, especially in Germany, where they even increased their market power and consumer utility. My third hypothesis, that German consumers might be less elastic to negative news cannot be proven clearly, because of the lack of EFTA per model data, which is required for a demand model. It nonetheless seems like German manufacturers were hit more significantly in Germany than in the EFTA area in absolute numbers. The reputation spillover on German makes after the scandal, seems to have been overall more devastating in the US than in Europe. This conclusion can be drawn by comparing the results of this paper and the US-paper. Further research, which analysed the financial loss of every manufacturers can be done, by estimating a mean trim price and multiplying it with the number of sales. The scandal's impact estimation approach in this paper can not only be used in the automobile industry. It can be applied in the estimation of every possible scandal in every possible industry.

8. Reference list

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9. Appendix

Table 6: Diff-in-Diff estimation, Vehicle Manufacturers market shares in Germany, excluding all German makes and VW subsidiaries not mentioned from column (1) to (7), January 2010 – December 2017

VARIABLES	(1) VW	(2) ALL	(3) BMW	(4) OPEL	(5) MERCEDES	(6) SMART	(7) SUBS
Scandal * German	-0.195***	-0.0417**	-0.112***	-0.109***	-0.0686***	0.106**	
	(0.0272)	(0.0210)	(0.0257)	(0.0227)	(0.0249)	(0.0482)	
Scandal * Subsidiaries							0.0810***
							(0.0275)
Observations	1,929	2,184	1,893	1,929	1,929	1,929	2,026
R-squared	0.963	0.962	0.954	0.956	0.957	0.948	0.953
Manufacturer FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 7: Diff-in-Diff estimation, Vehicle Manufacturers market shares in the EFTA area, excluding all German makes and VW subsidiaries not mentioned from column (1) to (7), January 2010 – December 2017

VARIABLES	(1) VW	(2) ALL	(3) BMW	(4) OPEL	(5) MERCEDES	(6) SMART	(7) SUBS
Scandal * German	-0.200***	-0.00890	-0.0141	-0.185***	0.0762***	0.0877**	
	(0.0261)	(0.0186)	(0.0219)	(0.0201)	(0.0246)	(0.0363)	
Scandal * Subsidiaries							-0.0132
							(0.0217)
Observations	2,180	2,462	2,180	2,180	2,180	2,180	2,274
R-squared	0.955	0.956	0.951	0.952	0.951	0.949	0.950
Manufacturer FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 8: Diff-in-Diff estimation, Demand model with a nested logit estimation, 2010 – 2019

VARIABLES	(1) Min	(2) Arith-Mean	(3) Arith-Mean	(4) Max
Minimum Price/1000 in EURO	-1.120***	-3.258***	-3.267***	-3.102***
	(0.341)	(0.478)	(0.477)	(0.441)
Minimum Performance in HP	-0.313***	0.651***	0.652***	0.665***
	(0.108)	(0.113)	(0.113)	(0.0972)
LENGH	-0.142	0.162	0.164	0.107
	(0.166)	(0.157)	(0.157)	(0.152)
WIDE	1.662**	0.709	0.724	0.339
	(0.779)	(0.756)	(0.753)	(0.738)
Electric	-0.299***	-0.0417	-0.0370	0.0106
	(0.0782)	(0.0663)	(0.0645)	(0.0659)
Scandal * BMW	-0.392***	-0.391***		-0.393***
	(0.0647)	(0.0654)		(0.0661)
Scandal * Opel	-0.350***	-0.347***		-0.347***
	(0.0886)	(0.0843)		(0.0824)
Scandal * Mercedes	-0.317***	-0.325***		-0.311***
	(0.0727)	(0.0721)		(0.0699)
Scandal * Smart	0.00781	-0.234		-0.299*
	(0.190)	(0.166)		(0.163)
Scandal * Audi	-0.393***	-0.435***	-0.434***	-0.439***
	(0.0685)	(0.0722)	(0.0722)	(0.0722)
Scandal * Porsche	-0.418***	-0.516***	-0.516***	-0.511***
	(0.103)	(0.111)	(0.111)	(0.110)
Scandal * VW	-0.475***	-0.506***	-0.507***	-0.515***
	(0.0883)	(0.0903)	(0.0902)	(0.0907)
Scandal * Diesel	-0.150**	-0.134**	-0.135**	-0.132**
	(0.0637)	(0.0626)	(0.0626)	(0.0620)
Scandal * SUBS	-0.211**	-0.228***	-0.228***	-0.206**
	(0.0856)	(0.0882)	(0.0882)	(0.0871)
Country-Share, Nest Parameter	0.734***	0.723***	0.724***	0.712***
	(0.0351)	(0.0357)	(0.0357)	(0.0365)
Scandal * German Non-VW			-0.348***	
			(0.0526)	
Observations	4,156	4,155	4,155	4,156
R-squared	0.819	0.821	0.821	0.824
Manufacturer FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Power-Type FE	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 9: Diff-in-Diff estimation, Vehicle Manufacturers sales growth rate in the EFTA area (EXCLUDING GERMANY), excluding all German makes not mentioned makes from column (1) to (7), Jan. 2010 – Aug. 2016

VARIABLES	(1) VW	(2) ALL	(3) BMW	(4) OPEL	(5) MERCEDES	(6) SMART	(7) SUBS
Scandal * German	-1.241***	0.792**	0.706*	0.241	-0.373	2.569***	
	(0.451)	(0.343)	(0.416)	(0.466)	(0.654)	(0.660)	
Scandal * Subsidiaries							-1.287***
							(0.453)
Observations	1,256	1,418	1,223	1,256	1,256	1,256	1,321
R-squared	0.391	0.398	0.395	0.398	0.392	0.394	0.393
Manufacturer FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Figure 6:

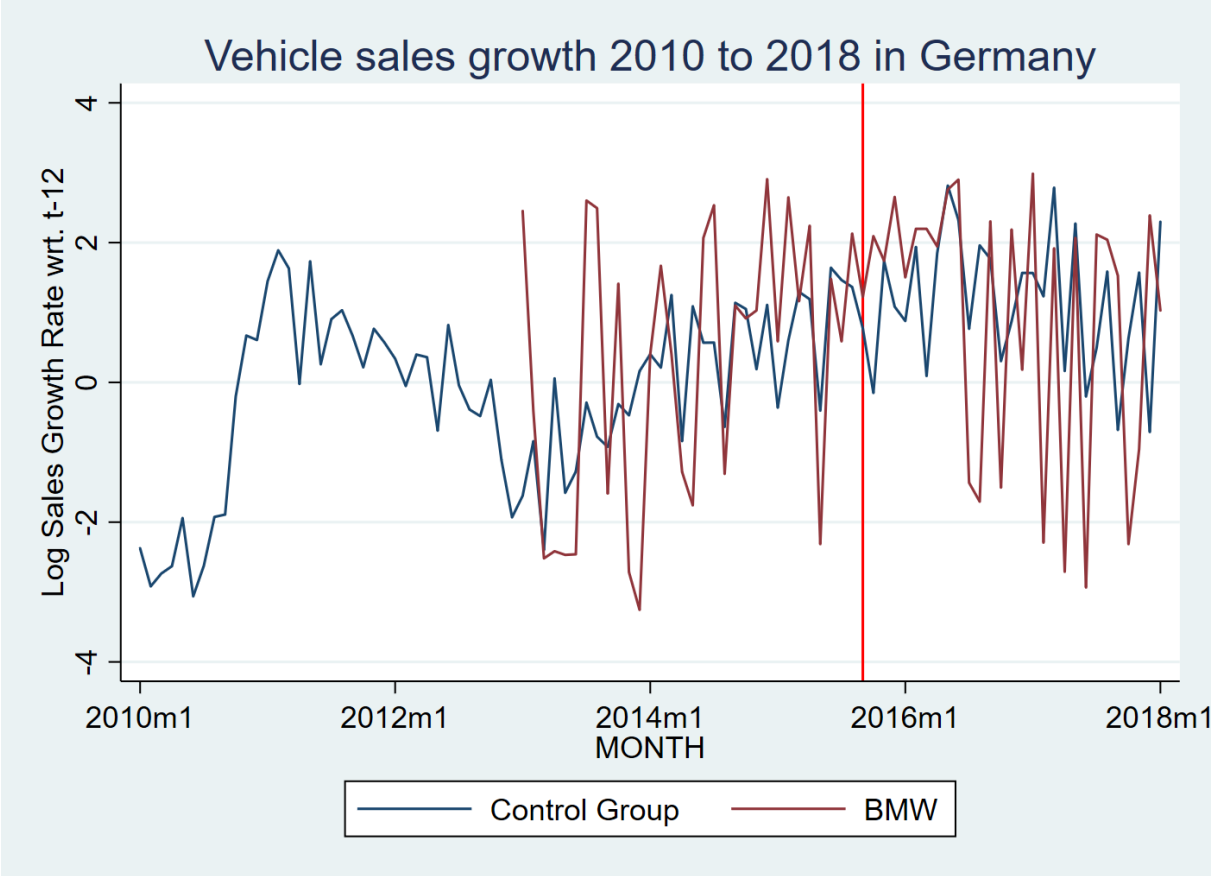

Figure 7:

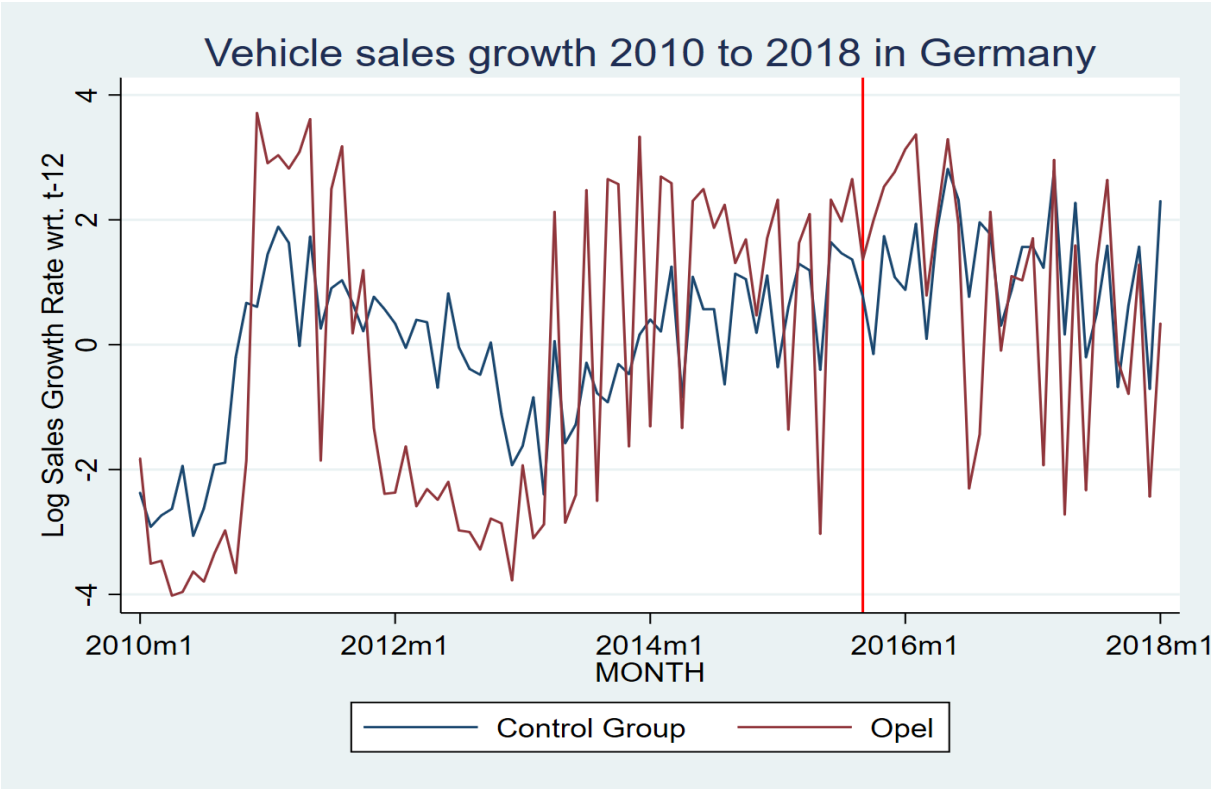

Figure 8:

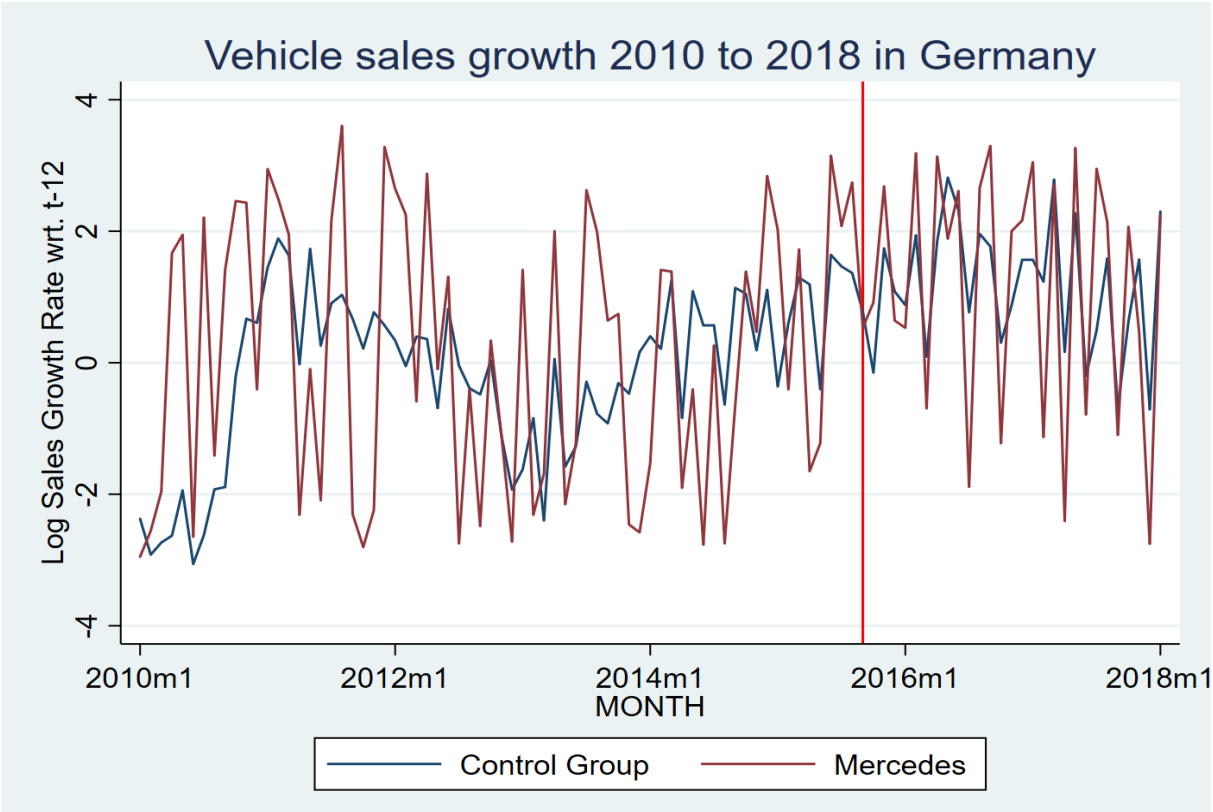

Figure 9:

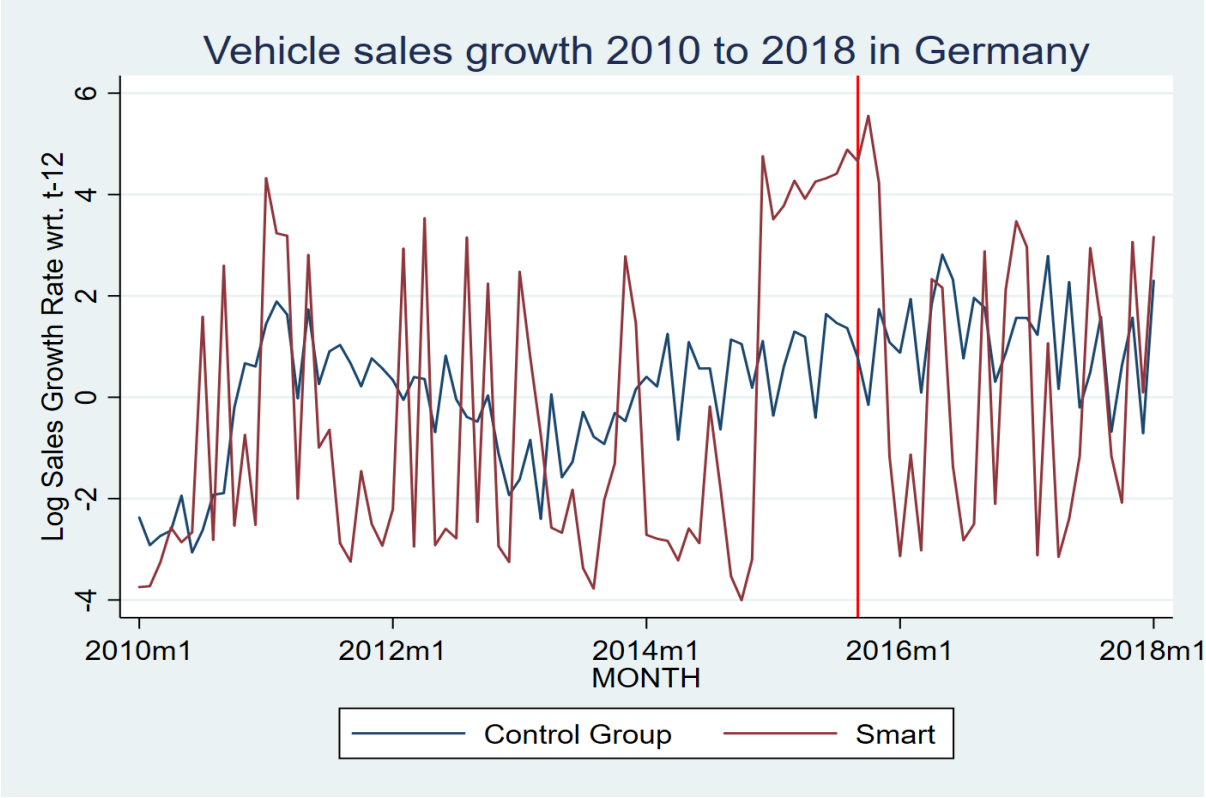

Figure 10: