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THE IMPACT OF DIESELGATE ON THE REQUIRED RATE OF RETURN ON EQUITY OF VW, BMW AND DAIMLER

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Abstract

Our paper studies the impacts of the Dieselgate scandal on the required rate of return on equity investments into VW, Daimler, and BMW. The object of investigation is the beta coefficient that determines the risk premium in the Capital Asset Pricing Model (CAPM). Our research takes a deep dive into the developments from the turning point of the scandal (the EPA NOTICE 2015) on September 18, 2015 – when a Notice of Violation of the Clean Air Act was issued to Volkswagen by the EPA – to the end of February 2016. This period also covers FORMAL COMMENCEMENT 2016, when the U.S. Department of Justice first sued Volkswagen on behalf of the EPA. The spillover (contagion) effect of fraudulent practices of VW impacted BMW, Daimler and other companies in the industry that share a similar business model and market segment. Our research of historical market betas has not confirmed the expectation that in the context of the Dieselgate scandal the return required on equity investments into VW, Daimler, and BMW would soar. The Dieselgate scandal proves that the reliability of beta estimates is an inverse function of market volatility. Historical market beta is, therefore, not a good estimate of the required rate of return for the companies in question.

JEL classification: D24, G32, O12
Keywords: historical market beta, CAPM model, signaling theory, contagion effect, Dieselgate

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Introduction

The German automotive industry has a well-documented history and has long held the dominant position in the vertical global production network. Through ownership control in the integrated peripheries (such as Slovakia, Czech Republic, and Hungary), it promotes and controls the focus on high value-added production (Čižinská & Neset, 2020, Gereffi et al. 2005, Pavlínek & Ženka, 2016). Germany's dominant position through ownership control in the vertical global production network affects the economic performance of many CEE countries. The automotive industry plays a significant role in economic growth of the EU-27 countries – the share of revenues (turnover) generated by automotive companies to GDP of the EU-27 is around 8 – 9% (see Čižinská & Neset, 2020). The revenues generated by the German automotive industry are the largest in the EU-27 region. The success of the German automotive industry is therefore of strategic importance for the European economy; however, the industry faces unparalleled environmental pressures towards sustainability.

Environmental regulation in connection with the automotive industry has a long tradition. The first automobile emissions standards to control pollution from cars were enacted in 1963 in the United States, soon followed by Japan, Canada, Australia, and several European countries. Over time, the regulations have been tightened and have reached a significant degree of *convergence* between countries. Currently, companies in the automotive industry face unprecedentedly strict regulation that forces them to undergo a painful and expensive transition towards low or even zero emission mobility.

The biggest German automotive companies are Volkswagen Group (further referred as "VW"), Daimler AG (further referred as "Daimler") and Bayerische Motoren Werke AG (further referred to as "BMW"), and it was cars produced by VW that launched the intensive crusade against the engine of our prosperity and that significantly increased public awareness of environmental challenges in the automotive sector.

On September 18, 2015, the US *Environmental Protection Agency (EPA) issued* a Notice of Violation of the Clean Air Act to Volkswagen AG, Audi AG, and Volkswagen Group of America, Inc. (collectively "Volkswagen") – further referred to as "EPA NOTICE 2015". According to EPA allegations, Volkswagen sold around a half million diesel motor vehicles (model year 2009 to 2016) equipped with "defeat devices" in the form of computer software designed to cheat on federal emissions tests. Diesel engines in these cars could detect when they were being tested and change the performance accordingly to improve the results. The major excess pollutants at issue were nitrogen oxides (NO_x), which pose a serious health concern (United States Environmental Protection Agency, 2020). This resulted in a gigantic industrial scandal called Dieselgate (or Emissiongate).

The formal commencement of the issue occurred on January 4, 2016, when the U.S. Department of Justice first sued Volkswagen on behalf of the EPA (further referred to as "FORMAL COMMENCEMENT 2016"). On June 28, 2016, VW agreed to spend up to $10.033 billion on buybacks and owner compensation and $4.7 billion on programs to offset excess emissions and boost clean-vehicle projects (Shepardson, 2016). On January 11, 2017, VW agreed to plead guilty to three criminal charges in the United States courts and pay a $2.8 billion criminal penalty. In separate civil resolutions of environmental, customs, and financial claims, VW agreed to pay $1.5 billion. Six VW executives and managers were also charged over their role in the emissions cheating (United States Department of Justice, 2017). On June 13, 2018 VW agreed to pay a one-billion-euro fine in Germany, admitting its responsibility for the diesel crisis (Agence France-Presse, 2019). In March of 2020, VW said its diesel cheating scandal had cost it 31.3 billion euros ($34.69 bln) in fines and settlements. The total cost of Dieselgate continues to soar, however, and VW expects the cash outflows to last until 2021 (Reuters Staff, 2020).

Dieselgate was primarily VW's problem, exclusively affecting this company at the outset. However, it has since morphed into a global issue and may have harmed the German (which means European) automotive industry in general as well as the label "Made in Germany" which had always been viewed as a positive expression, the sign of quality and trust (Aichner et al., 2020; Reuters, 2015). VW rivals Daimler and BMW were quick to say that the accusations against VW did not apply to them (Reuters, 2015). However, Daimler and BMW were later accused of similar manipulation issues. In 2019, for example, Daimler recalled hundreds of thousands of Mercedes-Benz diesel vehicles over diesel emission issues. Subsequently, Daimler was fined 870 million euros by German authorities for breaking diesel emissions regulations (Reuters Staff, 2019). In February 2019, it was announced that BMW would be fined 8.5 million euros for administrative lapses after the German luxury carmaker installed the wrong engine management software in 7,965 vehicles, leading to higher emissions (Reuters, 2019).

In April2019, the European Union Commission accused BMW, Daimler, and Volkswagen Group of colluding to restrict competition on emission-reducing technology in the period from 2006 to 2014.

The Dieselgate scandal has started a worldwide crusade against diesel cars. In December 2016, the mayors of Paris, Madrid, Athens, and Mexico City announced plans to ban diesel cars and vans from their roads by 2025. In May 2018, Hamburg banned diesel vehicles on two busy streets, the first city in Germany to place any kind of ban on diesel vehicles. In total, more than two dozen cities in Europe have announced plans to ban diesel vehicles over the next decade (E360 DIGEST, 2019).

In 2017, for the first time in recent history, more petrol than diesel passenger cars were sold in Europe, a trend which continued in the subsequent years. In 2019, only 30,5 % of all new cars registered in the European Union ran on diesel, compared to 52 % in 2015 and 49,2 % in 2016 (European Automobile Manufacturers Association ACEA, 2020). The problem with CO_2 emissions relates to a loss of interest in diesel cars. Petrol cars have higher consumption resulting in higher CO_2 emissions, creating a paradox in which the fight against emissions actually causes an increase in emissions. EU regulation 2019/631 (European Commission, 2019) sets an EU fleet-wide target of 95 g CO_2/km for the average emissions of new passenger cars. An excess emissions premium is to be imposed on any manufacturer whose average specific emissions of CO_2 exceed the target. The premium accounts to €95 for eachCO_2g/km of excess per vehicle registered (whether for new passenger cars or for new light commercial vehicles).

In the following pages, we study the spillover (contagion) effect of the Dieselgate scandal and its impact on the required rate of return on equity investments into VW, Daimler, and BMW. Our research takes a deep dive into the developments from the turning point of the scandal (called EPA NOTICE 2015) on September 18, 2015—when a Notice of Violation of the Clean Air Act was issued to Volkswagen by EPA – to the end of February 2016. This period also covers FORMAL COMMENCEMENT 2016, when the U.S. Department of Justice first sued Volkswagen on behalf of the EPA. Bouzzine and Lueg (2020), who conducted the study of how the Dieselgate scandal affected the stock returns of VW and its industry peers, developed a framework that combines two related theories from the school of information economics: agency theory and signaling theory. They assume these two perspectives as necessary to grasp the financial impact of the scandal itself (agency theory) and of its contagion effect (signaling theory). Agency theory discusses the issues in the relationships between principals (owners) and agents (managers) in business organizations. Since the principal is unable to fully control the actions of the agent, moral hazard arises (see Ross, 1973; Mitnick, 1975). Signaling theory is useful to describe behavior when two parties (agents and principals) hold different information bases. One party, the signaler, must choose whether and how to signal (communicate) the information to the other party (receiver), who must choose how to interpret the signal and how to react to it (see Spence, 1973).

The object of investigation in our paper is the beta coefficient that determines the risk premium in the Capital Asset Pricing Model (CAPM). According to this model, the rate of return that shareholders require for investing in a business (i.e. the cost of equity) equals the sum of the risk-free rate and the premium expected for risk. Risk premium is a product of beta and the current risk premium for an equity market, i.e.:

$$r_E = r_f + \beta . ERP + OP$$

Where:

r_E - is the required rate of return on equity

r_f - is the risk-free rate

β - beta of an asset (equity investment)

ERP - equity risk premium, risk premium for average-risk asset

OP - are other premiums (e.g. country risk premium and/or liquidity premium)

Average-risk asset is a market portfolio, which (at least in theory) should include all traded assets in the marketplace held in proportion to their market value (Damodaran, 2006, p. 32). The risk-free rate is the rate of riskless assets which have a certain, definite future return. A proxy for risk-free assets are treasury bills or government bonds issued by a country with a high credit rating. Beta is a measure of an asset's (equity investment) volatility compared to the systematic, non-diversifiable risk of the average-risk asset. It is a degree of change in the asset (equity) return for every 1-unit of *change* in the market return. The beta of the market portfolio is 1, the riskless asset will have a beta of 0. Common approaches to measure beta include its estimation from company fundamentals (i.e. fundamental beta) or its estimation from company accounting data (i.e. accounting beta). However, the most commonly used technique, which we have applied in our paper, is based on the utilization of a sample of historic time series data from the market (i.e. historical market beta). Here we assume that there will be little to no variation between historic time series returns and returns in the future and that historical data can be used effectively to create a realistic assessment based on an extrapolation of betas (Pratt & Grabowski, 2014).

In beta of the asset (equity investment), all the market risk is captured since it is measured relative to market portfolio. If we assume that all approaches to beta quantification would lead to the same results, then historical market beta would contain all fundamental factors of a given equity investment. Several theoretical papers and empirical studies address different fundamental factors of the company or its environment that have shown a relationship with beta of the asset (see Schlegel, 2015). The major determinants of fundamental betas according to Kumar (2015) include company size, the degree of operating leverage and the firm's financial leverage. The generally recognized method for the quantification of the impact of financial leverage on beta is based on the work of Hamada (1972) who shows a linear relationship between leverage (debt-to-equity ratio) and beta of the levered stock according to the following formula:

$$\beta_L = \beta_U \,.\, (1 + (1 - t) \,.\, D/E)$$

Where:

β_L - is levered or equity beta

β_U - is unlevered or asset beta

t - is marginal tax rate

D - is market value of company's debt

E - is market value of company's equity

Higher leverage (higher relative amount of debt) increases the variance in earnings per share and makes equity investment in the firm riskier. Hamada's formula is most commonly cited for levering and un levering estimates. Since we work with market data of individual companies in question, our historical market beta quantification produces beta levered (β_L).

Data and Methodology

We used daily adjusted closing prices of BMW, Daimler, and VW from the period 2010 - 2019 to calculate the return of the shares in question published by http://finance.yahoo.com. Adjusted close (adjusted closing price) is the closing price of the shares adjusted for applicable splits, new stock offerings, and dividend distributions. We calculated the daily returns according to the following formula:

$$\text{Stock return at the day t} = \frac{adjusted\ price_t}{adjusted\ price_{t-1}} - 1$$

The selected benchmark portfolio of investments into the shares of Daimler, VW, and BMW is Dax Index (GDAXI), the blue-chip stock market index consisting of the 30 major German companies (including VW, Daimler, and BMW). GDAXI is the performance index which measures total return, taking into account not only the capital gains but also the dividends and distributions realized over a period on the portfolio. The data for the period 2010 - 2019 was obtained from http://finance.yahoo.com.

The formula for the calculation of beta is the covariance of the stock's (Daimler, VW, BMW) returns and the market's (GDAXI) returns by the variance of the market's return over a specified period.

$$\beta_L = \frac{Cov(r_i, r_M)}{var(r_M)}$$

Where:

$Cov(r_i, r_M)$ - is the covariance between the returns of asset *i* (r_i – i.e. either Daimler or VW or BMW shares' returns) and the return of the market (r_M – i.e. GDAXI's returns)

$var(r_M)$ - is the variance of the market return (GDAXI)

Since we come out from the market data of individual companies (VW, BMW, Daimler), the results of the quantification using adjusted prices is beta reflecting a given proportion of debt in the capital structure – in other words, our calculations produce levered betas of investments into equity of the companies in question.

The variance is defined as the average of the squared differences from the mean (average value of the variable). The formula for the population covariance is as follows:

$$Cov(r_x,r_y) = \frac{\sum_{i=1}^{n}(r_{x,i}-\overline{r_x})(r_{y,i}-\overline{r_y})}{n}$$

Where:

$r_{x,I}$ - are the values of the variable x (for example stock returns of VW shares)

$\overline{r_x}$ - is the mean (average) of the variable x

$r_{y,I}$ - are the values of the variable y (for example returns of GDAXI)

$\overline{r_y}$ - is the mean (average) of the variable y

n - is the total number of data points (total number of trading days in question)

To uncover and intelligibly describe the relationship between the return of individual assets (Daimler, VW, BMW shares) and the market (GDAXI) in different periods of time, we used the Pearson correlation coefficient calculated according to the following formula:

$$\rho_{x,y} = \frac{Cov(x,y)}{\sigma_x \sigma_y}$$

Where:

X - is the variable x

Y - is the variable y

Cov(x,y) - is the covariance between the variables x and y

Σx - is the standard deviation of the x-variable

Σy - is the standard deviation of the y-variable

Standard deviation measures the dispersion of a dataset relative to its mean. It is the square root of variation.

Correlation coefficient is similar to covariance. Both characteristics measure the linear relationships between variables. However, correlation coefficient measures not only the direction but also the strength of the linear relationship using the range from -1 (strong negative relationship) to +1 (strong positive relationship). Values at or close to zero imply weak or no linear relationship.

To analyze the volatility of shares we use Bollinger Bands, a type of statistical chart consisting of K times and N-period standard deviation level above and below a simple N-period moving average of the adjusted price (Bollinger, 2001). The bands (level above and below simple N-period moving average) widen when volatility increases and vice versa. For N we used the value 20 and for K we used the value 2 (referred to as typical by most of the literature). A 20-day simple moving average of adjusted prices of the share is calculated according to the following formula:

$$SMA(20\ days) = \frac{\sum_{t=1}^{20} adjusted\ price_t}{20}$$

Where:

t - is trading day

Upper Bollinger Band (UBB) is calculated as follows:

UBB = SMA(20 days) – 2 * σ_x

Where:

σ_x - is the standard deviation of the adjusted prices of the share

Lower Bollinger Band (LBB) is calculated according to the following formula:

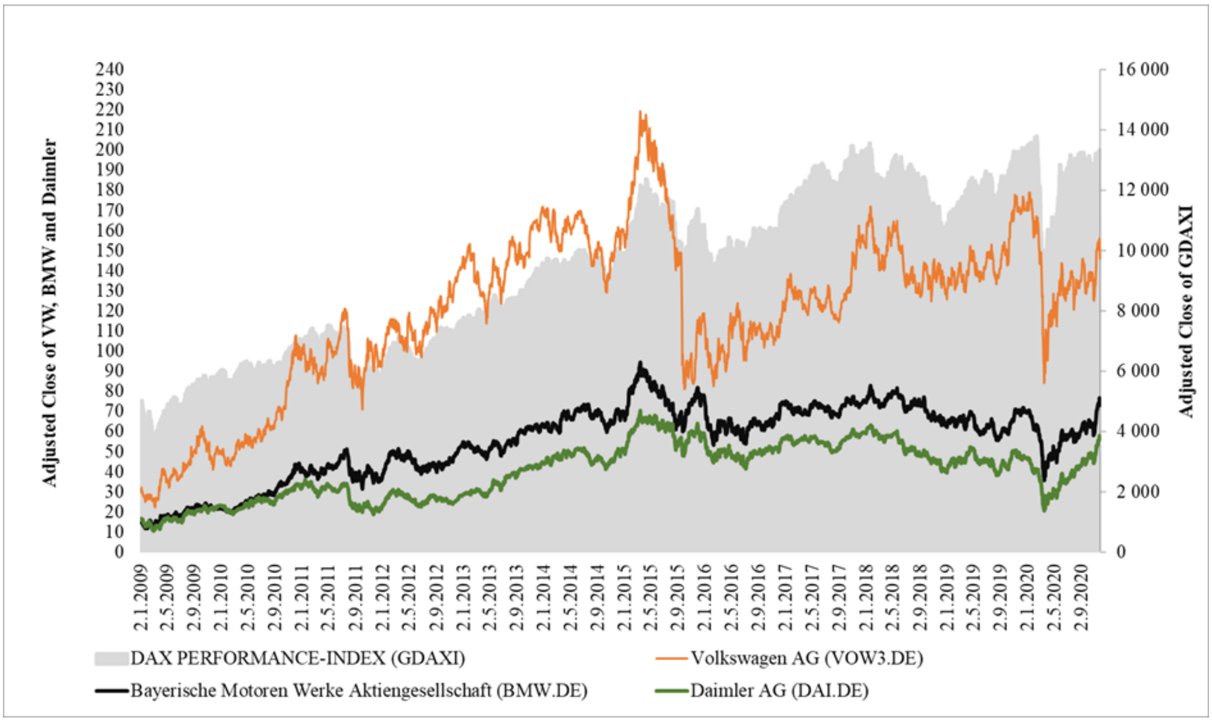
LBB = SMA(20 days) – 2 * σ_x

Results and Discussion

Figure 1 depicts the development of adjusted close prices of the assets in question in the period from January 2009 to November 2020. Adjusted close prices of BMW, Daimler, and VW are projected on the left vertical axis. Adjusted prices of GDAXI index are projected on the right vertical axis. GDAXI index is represented by grey area. From Figure 1, it is apparent that EPA NOTICE 2015 had a radically negative impact on the adjusted price of VW. The second biggest slump in the observed time area happened in March 2020 in connection with the COVID-19 pandemic, and it relates to all assets in question – BMW, Daimler, VW and even the GDAXI index. This period, however, is anomalous to our research in this paper. The development in January 2016 does stand out and appears to be fully correlated with the market (GDAXI index).

Below, Table 1 displays the beta coefficient values of the analyzed companies in the years preceding and following the beginning of Dieselgate (EPA NOTICE 2015). According to CAPM, the higher the beta coefficient (ceteris paribus), the higher is the rate of return that shareholders require for investing in a business. Throughout the entire period, it is Daimler that has the highest beta coefficient and therefore also the highest

Figure 1: Adjusted Close of BMW, Daimler, and VW from January 2009 to November 2020



Source: https://finance.yahoo.com/

rate of return required on equity investments. The beta coefficient of BMW is higher than the beta coefficient of VW – the exception being the year 2011 and the period EPA NOTICE 2015 (September 18, 2015 to December 31, 2015). From Table 1, it is evident that immediately after the turning point (EPA NOTICE 2015) the beta coefficient of VW increased by approximately 18% compared to its value in the period January 2, 2015 to September 17, 2015. A mild increase also happened in the case of Daimler and BMW shares. However, a fundamental change in beta coefficient happened in 2016 in the case of all three companies in question –

Table 1: Beta coefficient of BMW, Daimler and VW from January 2009 to November 2020

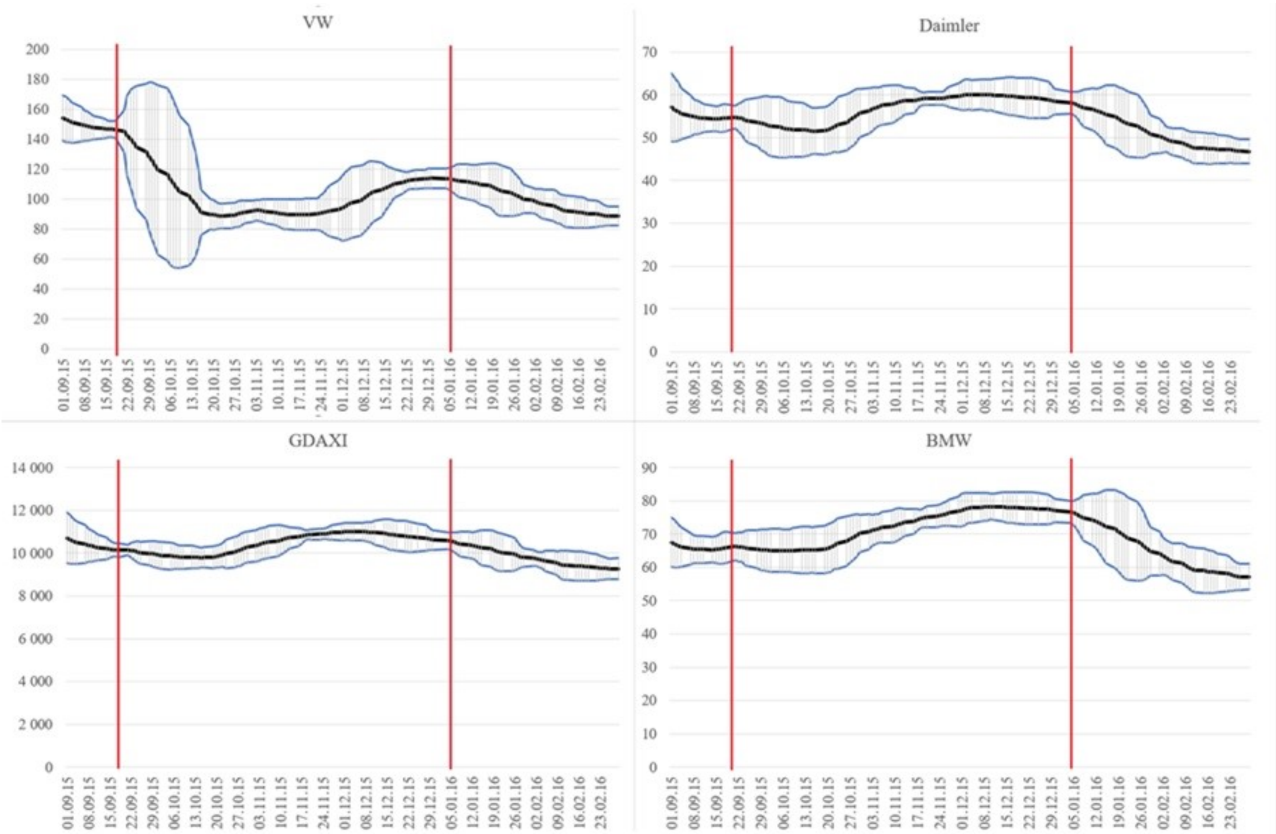
Year	VW	Daimler	BMW
Year 2009	0.862	1.521	1.185
Year 2010	1.080	1.373	1.237
Year 2011	1.265	1.197	1.147
Year 2012	1.168	1.315	1.260
Year 2013	1.125	1.282	1.134
Year 2014	0.958	1.171	1.056
2.1.2015 - 17.9.2015	1.044	1.168	1.128
18.9.2015 - 31.12.2015	1.235	1.266	1.197
Year 2016	0.027	0.147	0.124
Year 2017	-0.059	0.010	0.080
Year 2018	-0.114	-0.148	-0.111
Year 2019	-0.208	-0.062	-0.094
2.1.2020 - 27.11.2020	0.039	0.244	0.079

Source: Own calculations based on https://finance.yahoo.com/

the values of beta coefficient are unprecedentedly low till the end of the investigated time period.

To measure volatility, we used Bollinger bands. In Figure 2 it is possible to compare the volatility of shares in question and the market (GDAXI index) in the period from September 1, 2015 to February 29, 2016. It is clear that the highest volatility from any asset in question was produced by VW in relation to EPA NOTICE 2015. On the other hand, FORMAL COMMENCEMENT 2016 seemed to have a bigger impact on Daimler and BMW. Also, the study of Bouzzine and Lueg (2020) shows that VW suffered its biggest loss of market share values soon after EPA NOTICE 2015. It seems that the events which followed (VW's fine in the USA, investigation in Germany and the EU connected with fines and the subsequent crusade against diesels) did not have such a significant impact on the VW shares' value as in the early stage of the Dieselgate scandal. The cited study works with the hypothesis that markets also assessed the aforementioned negative future aspects and included them in the VW share price at the beginning, i.e. immediately after EPA NOTICE 2015. However, subsequent events had a contagion effect on the supply chain in the automotive industry and on the overall automotive group in Germany (VW, Daimler, BMW).

Figure 2: Bollinger bands of BMW, Daimler, VW and GDAXI since 01.09.2015 to 29.02.2016



Legend: EPA NOTICE 2015 (September 18, 2015) and FORMAL COMMENCEMENT 2016 (January 4, 2016) are market with vertical red line. 20 days moving average is the bold black line, upper and lower Bollinger bands

Source: Own calculations based on https://finance.yahoo.com/

Table 2 displays the correlation coefficients in the years preceding and following the beginning of Dieselgate (EPA NOTICE 2015). It is apparent that the correlation of VW share returns with the market return (return on GDAXI index) decreased significantly after EPA NOTICE2015. The returns on Daimler and BMW shares were still strongly correlated with the market. The situation did not change until 2017. From 2017 till the end of the investigated timeframe, the correlation coefficients of the return on VW, BMW, and Daimler shares with the market return (return on GDAXI index) indicate nearly linear independence.

Table 2: Correlation coefficient of the BMW, Daimler, and VW share returns with GDAXI returns from January 2009 to November 2020

Period	VW – GDAXI	Daimler - GDAXI	BMW – GDAXI
2009	0.415	0.841	0.714
2010	0.560	0.784	0.725
2011	0.824	0.877	0.822
2012	0.725	0.831	0.807
2013	0.686	0.765	0.772
2014	0.763	0.881	0.794
2.1.2015 - 17.9.2015	0.813	0.927	0.865
18.9.2015 - 31.12.2015	0.441	0.919	0.906
2016	0.810	0.876	0.872
2017	0.314	0.543	0.524
2018	0.100	0.092	0.010
2019	-0.075	-0.020	-0.029
2.1.2020 - 27.11.2020	0.177	0.136	0.244

Source: Own calculations based on https://finance.yahoo.com/

The research of Fernandez and Bermejo (2009), Fernandez (2004) and Suh (2009) has shown that market volatility negatively affects the accuracy of beta estimates – when the market is highly volatile, beta estimates are less reliable – as well as the correlations of individual stock returns with returns on the market. Taking high volatility and low correlation with the market into consideration, it is not possible to take historical market beta of VW as a reliable parameter for the estimation of the required rate of return on equity after EPA NOTICE 2015. VW shares were more volatile than the market (GDAXI index) after EPA NOTICE 2015 and also (although slightly milder) after FORMAL COMMENCEMENT 2016. Since 2017, VW shares lost their correlation with the market (GDAXI index). In the case of BMW and Daimler, historical market beta lost its reliability after FORMAL COMMENCEMENT 2016 when their returns recorded a significant increase in volatility. The development of beta coefficients of VW, BMW, and Daimler in the early stage of the Dieselgate scandal (see Table 1) proves that the reliability of beta estimates is an inverse function of market volatility.

Immediately after FORMAL COMMENCEMENT 2016, the spillover (contagion) effect of Dieselgate impacted BMW and Daimler. Share market data indicates that markets reacted to the Dieselgate scandal with some time delay and absorbed subsequent events that this scandal produced in the USA and then in Europe as well. Similar to the study by Bouzzine and Lueg (2020), we can work with the agency theory (principal – agent theory) leading to moral hazard and subsequently to the fraudulent practices of VW. However, from the perspective of our study, the application of signaling theory is more relevant. It is a demonstration of signaling theory that the unlawful actions of a key player in the automotive industry has, with a certain time delay, some considerable effects on the financial indicators of other automotive companies. It appears that, in this respect, the financial market behaves efficiently (see efficient market hypothesis by Fama, 1970) and important negative news on one entity is evaluated in all relevant aspects of horizontal and vertical structure of the whole industry. The Dieselgate scandal is a classic example of contagion effect that is observable even in other industries (moral hazard and its subsequent impact on the world financial markets in the years 2007 to 2009 is another demonstrative example of how contagion effect and signaling behavior have strong impacts on the other companies in the industry including the entities that are acting ethically).

It is apparent that EPA NOTICE 2015 had a devastating effect on VW shares. As soon as the markets absorbed and processed the initial information of the Dieselgate scandal, they sent a signal (according to signaling theory) that the problems with diesel engines will not be an isolated issue but will constitute a much weightier problem, mainly in the context of other legislative arrangements regarding the environment that are gaining importance in the beginning of the 21st century. Surprisingly, it shows (Bouzzine & Lueg, 2020) that contagion effect has bigger impact on Daimler than on BMW. This is mainly because Daimler operates (similarly to VW) also in the segment of vans that, to a large extent, use diesel engines. Contagion effect has, therefore, a bigger impact on other companies in the industry that share a similar business model and market segment. Financial markets evaluate this situation rationally as a danger with subsequent impact into the financial indicators.

Conclusion

On September 18, 2015, EPA NOTICE 2015 significantly increased insecurity regarding the future development of the value creation of VW, Daimler, and BMW. The Dieselgate scandal had (or more precisely will have until at least 2021) a strongly negative impact on the free cash flow to equity investors of VW. Environmental issues also affected companies such as Daimler and BMW. Therefore, it makes economic sense to expect that in the context of this development the return required on equity investments would soar. However, our research of historical market betas has not confirmed this expectation. Beta coefficient that is a constituent of the required rate of return in the CAPM model had recorded only short term and moderate increases (from September 2015 to December 2015) in the case of all three companies. Afterwards, the beta coefficient recorded an unprecedented decrease almost to zero – i.e. almost on the level of a risk-free asset. We discovered that this finding connects to the increase of volatility and the decrease of correlation with the market (GDAXI index). The reliability of beta estimates based on historical data is an inverse function of market volatility. Historical market beta does not seem to be a good estimate of the required rate of return of VW, Daimler, and BMW. However, our research is still ongoing, and we received promising preliminary results from the adjustments and extension of the basic statistical model applied in this paper.

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