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Published in:
Business Strategy and the Environment

DOI:
10.1002/bse.2566

Publication date:
2020

Document Version
Publisher's PDF, also known as Version of record

Received: 20 March 2020 | Revised: 24 May 2020 | Accepted: 14 June 2020

DOI: 10.1002/bse.2566

RESEARCH ARTICLE

Business Strategy and the Environment

WILEY

The contagion effect of environmental violations: The case of Dieselgate in Germany

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Abstract

We examine how environmental violations affect the stock returns of the violating firm and how these financial implications then spread to industry peers. Volkswagen's diesel emissions scandal (Dieselgate) and the German automotive industry serve as a seminal case for the examination. Research often limits examinations of corporate environmental scandals to the primary event announcement. Yet the Dieselgate scandal exhibits a processual character that requires the examination of multiple events over time. We identify 10 Dieselgate events and employ event study methodology to detect abnormal stock reactions. Based on agency and signaling theory, the results indicate that Dieselgate has harmed the stock returns of Volkswagen and its industry peers substantially. Surprisingly, Volkswagen suffered financial damage only upon the initial event of Dieselgate. Subsequent events had significant effects only on industry peers. These findings contribute comprehensively to the research of environmental misconduct and provide valuable implications for practitioners.

KEYWORDS

business model, contagion effect, Dieselgate, environmental violation, event study, German automotive industry

1 | INTRODUCTION

A growing body of academic literature deals with the question of how a firm's financial performance reflects environmental incidents. There is rich empirical evidence that the announcement of environmental regulation violations and poor environmental performance damages a firm's stock substantially (Dasgupta, Hong, Laplante, & Mamingi, 2006; Dasgupta, Laplante, & Mamingi, 2001; Gupta & Goldar, 2005; Lundgren & Olsson, 2010). We contribute to this stream of literature using the case of Dieselgate. Specifically, we address the contagion effect on industry peers that relate to new, pertinent events after the scandal's first revelation.

Volkswagen's (VW) Dieselgate is one of the biggest ongoing corporate environmental violation scandals globally. In 2014, a research team of the West Virginia University investigated the emissions of VW diesel vehicles following suspicions by other automotive firms. This investigation revealed that nitrogen oxides (NO_x) emissions for a running VW Jetta 2012 and a VW Passat 2013 are much higher than the declared test values, a finding that the US Environment Protection Agency (EPA) could confirm (Robertson, 2017). In direct response, VW recalled and "repaired" affected diesel vehicles; however, this did not mitigate the excessive emissions, which led to both the EPA and the California Air Resource Board withholding approval for the 2016 model year VW diesel vehicles. Eventually, VW had to admit that they had implemented a software-based defeat device in the 2009–2015 vehicle models with 2.0-L diesel engines, which recognized when a vehicle was undergoing emission testing and automatically adjusted emissions to legal threshold values. This led the EPA to issue a notice of violation accusing VW of contravening the US Clean Air Act (the EPA announcement on

September 18, 2015). The EPA stated that the NO_x emissions of these particular diesel vehicles were 10–40 times higher than allowed (Barrett et al., 2015). Although Dieselgate represents the latest automotive environmental violation scandal, using defeat devices for emission testing has a history. The EPA enforced penalties against other automotive firms (e.g., Honda and Ford) for emission manipulation in the past (Schaeffer, 1998), making the fallout of Dieselgate repetitive. To conclude, Dieselgate represents a corporate scandal combining dismal ecological performance with fraudulent characteristics, which provides broader insights into the theoretical understanding of corporate environmental violations. Although the emergence of management's unethical behavior exhibits links to agency problems, a firm's unethical behavior might signal common business practices of misconduct within the industry to the stakeholders. This is particularly so for interrelated and similar industries such as the German automotive industry. In these settings, the impact of major corporate scandals may not be limited to the guilty firm, and the risk of industry peer contagion increases (Laufer & Wang, 2018).

Existing studies explain very well the negative stock returns for VW, as well as a negative spillover (contagion) effect on industry peers and suppliers around the initial EPA announcement (Barth, Eckert, Gatzert, & Scholz, 2017; Fracarolli Nunes & Lee Park, 2016; Griffin & Lont, 2018; Wood, Wang, Duong, Reiners, & Smith, 2018). However, we know little about Dieselgate's financial effects on VW and its industry peers after new information became available. All prior event studies on Dieselgate limit their examination to the EPA announcement on September 18, 2015. Yet Dieselgate comprises several subsequent events; some of them are still ongoing (e.g., diesel vehicle bans in cities). Moreover, the German automotive industry provides a special setting for the analysis of Dieselgate. Germany's car manufacturing industry is closely linked, and stakeholders overlap heavily, making Dieselgate a German automotive rather than a purely VW problem. Then, it represents one of Germany's biggest economic sectors, employers, and institutions (The Economist, 2018). Additionally, Germany's automotive industry espouses strong interlocks among and across supply chains (Barthel et al., 2015). Nonetheless, current studies do not analyze Dieselgate's impact on stock returns in a manner that accounts for both further events and the contagion effect. Thus, we conjecture that the impact of environmental violations deserves special attention among German car manufacturers. This motivates us to pose the following research question:

RQ: How do Dieselgate announcements affect the stock returns of VW and its industry peers (contagion effect)?

Methodologically, we conduct an event study (Brown & Warner, 1985, 1980; MacKinlay, 1997). This methodology allows us to evaluate the impact on stock returns of Dieselgate events on both an individual and a group level. Thus, we extend the understanding of Dieselgate's financial impact in two ways: First, we use Dieselgate events in direct relation to VW (individual events) to measure the comprehensive reaction of VW's stock. Second, we use Dieselgate events affecting the overall automotive industry in Germany (group events) to determine the stock price reaction of industry peers individually and for a group. We select events based on how meaningful the media portrays them, as media has a strong impact on the public perception and the value relevance of a scandal (Carberry, Engelen, & van Essen, 2018; Clemente & Gabbioneta, 2017; Xu, Zeng, Zou, & Shi, 2016).

Our findings suggest large and highly significant, negative abnormal stock returns for VW on the initial EPA announcement event. Deviating from our prediction, the following events remain statistically insignificant for VW, indicating that the markets have anticipated and priced the full extent of VW's misconduct. However, the contagion effect analysis of Daimler, BMW, and the car manufacturing group as a whole (portfolio of VW, Daimler, and BMW) reveals major significant and negative abnormal stock returns for subsequent events.

Our study makes four substantial research contributions to the literature on the financial effects of corporate scandals: First, we provide evidence for a strong horizontal contagion effect at the same level of the supply chain. Second, our analyses demonstrate that the full extent of the contagion effect becomes more visible by considering subsequent events over a longer timeline. Third, we combine information economic theoretical frameworks, which help to better understand the stock market reaction to VW and the contagion effect. We conjecture that two related theoretical perspectives are necessary to grasp the financial impact of the corporate scandal itself (agency theory) and the financial contagion effect on industry peers (signaling theory). Fourth, we show that the "guilty by association" effect holds in the specific case of Dieselgate, where the heavy industry peer contagion effect (sum of stock losses for Daimler and BMW for the specification with the highest significance, respectively) exceeds the financial loss of VW by 54.85%. For practitioners, our study holds two important contributions: First, we illustrate that violating environmental regulations to obtain business advantages might not payoff and the downsides might be overwhelming. Second, we conclude that firms that are too interwoven and similar in their business models are subject to becoming "guilty by association" and, thus, should actively ensure a differentiation from industry peers to avoid financial contagion.

The remainder of this paper is organized as follows: Section 2 provides the background of our analysis including the theoretical foundation of the respective stock market reactions as well as the relevant literature, both synthesized to derive the research hypotheses. Section 3 specifies our event study methodology and data. Section 4 presents the empirical findings. Section 5 provides a discussion, critical acknowledgments, and a conclusion.

2 | BACKGROUND

To derive the research hypotheses of this study, we develop a framework that combines two related theories from the school of information economics: agency theory and signaling theory.

2.1 | The direct effect of Dieselgate: An agency theory-based hypothesis

Agency theory assumes that interests and utilities between the principal and the agent, assigned to act on behalf of the principal, are not necessarily aligned, which may lead to agency problems such as moral hazard (Eisenhardt, 1989; Fama, 1980; Jensen & Meckling, 1976; Ross, 1973). Corporate misconduct meant to obtain a competitive advantage over industry peers can be attributed to this notion (Carson, 2003). Industry peers' inability to replicate the emission values of VW diesel vehicles helped VW to penetrate the US market aggressively and to become one of its leading diesel vehicle vendors (Barrett et al., 2015; Fracarolli Nunes & Lee Park, 2016). The embedded quest for aggressive growth within the corporate culture, in line VW's strategy to become the leading automotive firm (Armstrong, 2017), exhibits clear characteristics of shareholder primacy, a corporate maxim well discussed by law scholars (Lee, 2005; Smith, 1998). In settings of shareholder primacy, all corporate actions target the maximization of shareholder value that might imply diminished moral responsibility and "short-termism" (Burkert & Lueg, 2013; Smith & Rönnegard, 2016; Stout, 2013). Supporting the shareholder primacy perspective, a strong performance-driven compensation component for the management fostered VW's quest for aggressive growth. This further created incentives for short-term orientation and unethical behavior to maximize shareholder value and personal compensation (Li, McMurray, Xue, Liu, & Sy, 2018). When tests detected the fraud in 2014 and the EPA initiated the enforcement procedure against VW, investors anticipated the potential financial losses for VW and reacted accordingly. However, the release of value-relevant information did not end with the EPA announcement. During the ongoing course of Dieselgate, the media has disclosed new and relevant information over time and portrayed Dieselgate events prominently and, thereby, VW's misconduct, responsibility, and its consequences credibly. By that, these information become particularly value relevant (Carberry et al., 2018). This myopic perspective on shareholders, which led to Dieselgate, had a significant impact on other stakeholders whose demands fell behind in VW's growth strategy.

Hill and Jones (1992) provided an extensive framework in their stakeholder–agency theory, in which stakeholders assume the principal's role. Thereafter, every single group of stakeholder has specific demands on the management, which, if satisfied, lead to superior business performance because of better access to stakeholders' resources. The inversion of this argument implies that neglecting the demands of stakeholder groups might induce restricted access to resources. Applying this stakeholder-based framework to VW emphasizes that the fraudulent software implemented did not only hurt the shareholders but many other stakeholders as well. Customers had to deal with the issue of resolving the cheating software as well as with the decreased market value of their vehicles (Markowitz, Chapman, Guckian, & Lickel, 2017). Suppliers and retailers faced reduced popularity of diesel engines, which negatively affected their sales figures (Fracarolli Nunes & Lee Park, 2016). Employees had to worry about their jobs for the same reason (Müssgens & Peitsmeier, 2016). The government saw their environmental regulations disregarded as well as major public health and environmental damage as a result of the excess NO_x emissions (Chossière et al., 2017; Dey, Caulfield, & Ghosh, 2018; Holland, Mansur, Muller, & Yates, 2016; Oldenkamp, van Zelm, & Huijbregts, 2016; Tanaka, Lund, Aamaas, & Berntsen, 2018). These consequences led stakeholders to penalize VW with calls for boycotts (customers), penalty fines (government), and other means of stakeholder activism with implications for the stock price. Thus, the stock market reaction to VW in response to the announcement of Dieselgate should be analyzed in a (stakeholder–) agency context.

In accordance with this theoretical framework, researchers provide extensive empirical evidence on the stock market reaction to the announcement of corporate misbehavior, bad environmental performance, and environmental regulation violations. Gunthorpe (1997) found negative abnormal returns (ARs) for firms that have announced that they engaged in any kind of unethical behavior or that they are under investigation for it. Specifying the notion of unethical behavior to environmental issues, Gupta and Goldar (2005) found that the announcement of bad environmental performance in terms of the Green Rating Project by India's Centre for Science and Environment triggered a negative stock price reaction. Hamilton (1995) and Khanna, Quimio, and Bojilova (1998) complemented the examination of environmental issues by looking at the public disclosure of toxic release information. They concluded that the announcement of toxic waste releases negatively affects the stock returns of the firms involved. Klassen and McLaughlin (1996), Dasgupta et al. (2001), and Flammer (2013) examined further corporate environmental misbehavior announcements such as spills and contaminations and consistently derived a negative reaction by investors to these announcements. As an extension of the examinations of environmental misbehavior, Lanoie, Laplante, and Roy (1998) integrated the legal dimension of violating environmental regulations and investigate the information release that a firm is listed on the "out of compliance" and "of concern" list of polluters in Canada. They report a negative stock market reaction, which is even more pronounced for large polluters. Dasgupta et al. (2006) applied a similar methodology and analyzed the announcements of the monthly list of firms that do not comply with environmental regulations in South Korea and came to the same conclusion. Lundgren and Olsson (2010), as well as Xu, Zeng, and Tam (2012), confirmed this finding comprehensively in their examinations of an international and a Chinese sample of environmental standard violation announcements. Although the majority of authors focuses on the environmental issue itself, Bosch and Eckard (1998) investigated the announcement of an EPA pollution control enforcement as the consequence of violating environmental regulations and concluded a strong and negative stock reaction for the targeted firm, as losing a legal case to the EPA is associated with high costs for the polluter. In conclusion, empirical research shares the finding that the announcement of corporate environmental misbehavior and environmental violations affects the stock price of the firm negatively.

Empirical Dieselgate literature complements the extensive evidence on the stock reaction to poor environmental performance and environmental violation announcements and displays similar findings. Barth et al. (2017) conducted a comprehensive event study on Dieselgate using stock, bond, and credit default swap (CDS) data. For VW, they concluded significant financial losses as a result of the EPA announcement, which are robust against variations in event windows and security types. We complement their research approach by considering a longer timeline (i.e., multiple events) in our examination. On a broader scale, Wood et al. (2018) examined the abnormal stock reaction to 41 car manufacturers' environmental failure announcements (i.e., unethical behavior, deception, and failure to meet standards) for an international set of firms. They found highly significant, negative, mean ARs for the announcement of a car manufacturer's environmental failure with results being robust against variation in estimation models. Thereby, stock losses due to environmental failure announcements following Dieselgate are stronger than those resulting from prior announcements as Dieselgate damaged consumer confidence in car manufacturing substantially and increased investors' risk aversion to environmental issues. We address this increase in investors' risk aversion to environmental issues in car manufacturing in our in-depth analysis of VW and illustrate how investors value VW's stock throughout Dieselgate. Thus, as expected, the results suggest that the stock market reacts negatively to the Dieselgate announcement by the EPA. From the agency theoretical context, the ongoing emergence of new and relevant information during Dieselgate, and the extensive empirical evidence, we derive our first research hypothesis:

H1. The announcement of Dieselgate individual events is associated with negative ARs for VW.

2.2 | The contagion effect of Dieselgate: A signaling theory-based hypothesis

Intentional environmental fraud and the corresponding stock market reaction to the fraudulent firm result from existing agency conflicts such as shareholder primacy *inside* the firm. Additionally, understanding the *contagion effect* from VW to industry peers requires the consideration of a complementary theory building on different aspects of the same information asymmetry. According to signaling theory, two parties hold different information bases and, typically, one party has an information advantage over the other. The information sender (signaler) decides how to communicate the information to the recipient. The recipient then interprets this information, processes it, and reacts upon through feedback or other means (Connelly, Certo, Ireland, & Reutzel, 2011; Spence, 1973). Zou, Zeng, Zeng, and Shi (2015) employed the signaling theory to derive a theoretical framework that explains the contagion effect of environmental violations. According to them, the environmental violation announcement of one firm reveals the environmental risks of the whole industry as its members share the same (or very similar) technical conditions and the production output. Therefore, the announcement passively signals the inherent industry risk to stakeholders, making them reassess their assumptions about the attractiveness of the industry and the corresponding resource distribution.

Signaling has direct implications for Dieselgate. Dieselgate revealed issues involving compliance with environmental standards in the United States, which had led to environmental fraud to overcome them. More precisely and in line with the notion of moral hazard, VW simply was not able to meet the environmental standards in the United States with its technic and without exceeding the budget and, therefore, decided for fraud to gain a competitive edge over industry peers (McGrath Goodman, 2015). The public announcement of the EPA passively signals the risk of this environmental fraud within the industry to the stakeholders, causing them to question the integrity of the German automotive industry in general. Laufer and Wang (2018) showed that crisis contagion is most likely when firms are similar and share the country of origin, industry, and organizational type (profit orientation, ownership structure, etc.), as well as positioning strategy (high-end vs. low-end orientation). Ouyang, Yao, and Hu (2020) specified this finding for the context of environmental misconduct and illustrated that stakeholders tend to categorize firms by similarity. Looking at the case of Dieselgate, most of the crisis contagion criteria fit German car manufacturers. They have the same country of origin as well as industry, organizational structure (Barthel et al., 2015; Fasse, 2019), and, to a large extent, positioning strategy (GTAI, 2018; The Economist, 2018); thus, the risk of contagion from VW to other German car manufacturers is high because of their perceived similarity. This financial contagion is, most likely, a consequence of investors' learning. As pointed out by Bebchuk, Cohen, and Wang (2013), investors tend to adapt to changes over time within a learning procedure and take this learning into account in their investment decision. As above mentioned, Dieselgate passively signaled the risk of misconduct and a corresponding EPA enforcement for other German automotive firms emphasized by the strong interlocks between German automotive firms. This passive signal then triggered a learning process at the investors who saw themselves exposed to both the risk of Daimler and BMW being involved in the scandal and the risk of financial losses. This, in turn, led them to sell their stake in these firms. Figure 1 illustrates our underlying theoretical framework composing of agency and signaling elements.

Several authors provide empirical evidence for a contagion effect from corporate scandals or incidents. In 2010, BP's Deepwater Horizon oil platform caught fire, which led to a massive oil spill in the Gulf of Mexico. Event studies on the Deepwater Horizon oil spill by Humphrey, Carter, and Simkins (2016) and Sabet, Cam, and Heaney (2012) illustrate how the incident affects the overall oil and gas industry. Even though the incident does not represent intentional environmental fraud, the studies provide insights into the existence of a contagion effect from environmental incidents. The Deepwater Horizon incident, with its far-reaching consequences on drilling in the Gulf of Mexico, impacts not only the stock of BP and other firms directly involved in the oil spill but also that of unrelated oil and gas exploration, drilling, equipment, and services

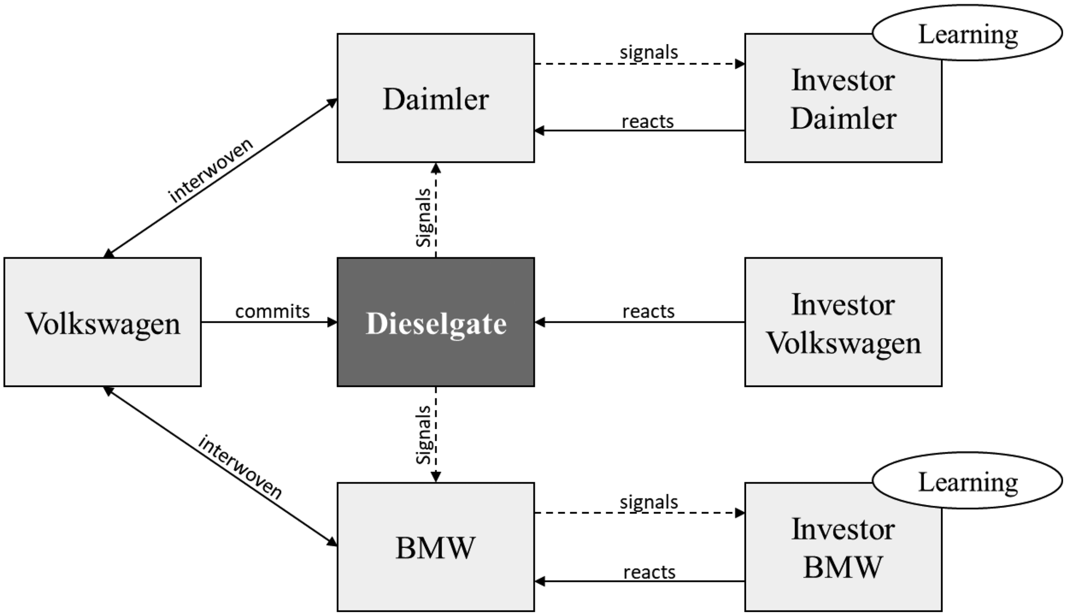

FIGURE 1 This figure displays our theoretical framework. It illustrates how Volkswagen is interwoven with its industry peers, how Dieselgate passively signaled the risk to the investors of Daimler and BMW and triggered a learning process, which, in turn, led to the sellout of Daimler's and BMW's stocks

firms. The market is, however, able to differentiate between firms as the spill affects oil and gas firms not involved in offshore drilling (e.g., pipeline companies) less heavily. Regarding intentional environmental misconduct, Zou, Zeng, Zeng, and Shi (2015) specifically examined the contagion effect from environmental violations using 59 announcements across industries by China's Ministry of Environmental Protection for their event study. They concluded a negative intraindustry contagion effect to 282 industry peers, which is more pronounced for firms in environmentally insensitive business areas (e.g., coal mining). Jin, Cheng, and Zeng (2020) dealt with a similar topic, examined environmental misconduct in environmentally sensitive industries (extractive, chemical, steel, and building materials industries) in China, and derived significant negative reactions to their public announcement by China's Ministry of Ecological and Environmental Protection for the misconducting firm. More interestingly, however, they revealed a notable spillover effect from the misconducting firm to its industry. Hence, an industry peer contagion effect is observable for various incidents and scandals irrespective of the type (environmental scandal, accounting scandal, etc.).

Several authors detect a contagion effect from Dieselgate using the EPA announcement event. Fracarolli Nunes and Lee Park (2016) examined 33 automotive firms in a US-based event study. Based on the EPA announcement event, they divided their sample of firms into car manufacturing and supplier companies. They found large and significant abnormal stock losses for two US car manufacturing firms and eight out of 27 suppliers. Both findings are robust to variation in event windows and so confirm the existence of a financial contagion effect from VW to car manufacturers and suppliers in the United States, which is however limited to the EPA announcement. Providing further evidence for the contagion effect from the EPA announcement, Griffin and Lont (2018) employed an international sample of 16 car manufacturers including VW. They found negative average ARs for the announcement event of Dieselgate. The results are robust against variation in event windows and illustrate that the EPA announcement, on average, damages the overall automotive industry. However, their analysis does not allow for conclusions about the contagion effect on specific industry peers of VW following the EPA announcement. Barth et al. (2017) enhanced this finding comprehensively by analyzing the contagion effect from Dieselgate using stock, bond, and CDS data of 25 industry peers and 101 suppliers of VW. Thereby, they limited their study to the EPA announcement event. The analysis of industry peers displays negative stock and bond, as well as positive CDS spread reactions, for a variety of event windows. The analysis of the suppliers, however, leads to less pronounced findings. Hence, the extant literature on the contagion effect of Dieselgate concludes that the EPA announcement generated a financial loss for VW's suppliers and industry peers, confirming the existence of a contagion effect for this event. By that, Dieselgate literature falls in line with other contagion effect analyses of corporate scandals. On the basis of the signaling theoretical context and the prevailing empirical literature, which confirm the existence of a contagion effect on industry peers (e.g., car manufacturers), we derive our second hypothesis:

H2a. The announcement of Dieselgate group events is associated with negative ARs for Daimler.

H2b. The announcement of Dieselgate group events is associated with negative ARs for BMW.

H2c. The announcement of Dieselgate group events is associated with negative ARs for the group of car manufacturers (Daimler, BMW, and VW).

3 | METHODOLOGY

3.1 | Events study methodology

According to Fama (1970), in conditions of semistrong information efficiency, stock prices adjust to the announcement of publicly available, relevant information (e.g., stock split announcements; Fama, Fisher, Jensen, & Roll, 1969). Exploiting this information efficiency to test our research hypotheses, we apply event study methodology (Brown & Warner, 1985; MacKinlay, 1997) based on daily stock returns (Brown & Warner, 1980).

In line with the underlying hypotheses, we divide this study into two parts: The first represents the event study on VW based on individual events (H1), and the second represents the event study on Daimler (H2a), BMW (H2b), and the group of car manufacturers (H2c) based on group events. We apply the event study methodology proposed by MacKinlay (1997) and accordingly define event windows, estimate normal stock returns, calculate ARs, and test statistical significance.

We first calculate stock returns for the market index and the firms based on the stock prices using the following formula:

$$R_{it} = \frac{P_{it}\text{-}P_{it\text{-}1}}{P_{it\text{-}1}}, \tag{1}$$

where R_{it} represents the stock return for i on day t and P_{it} represents the stock price of i on day t. To estimate the expected stock returns, we employ the widely used market model using the broad German "Prime All Share" index as the underlying market:

$$E(R_{it}) = \alpha + \beta_i R_{mt} + \varepsilon_{it}, \tag{2}$$

where $E(R_{it})$ represents the expected stock return for i on day t; R_{mt}, the market return on day t; β_i, the beta factor (risk); and ε_{it}, the disturbance term. As proposed by MacKinlay (1997), the estimation window ranges from −120 to −21 days before the event date. To assure the robustness of our findings, we include six event windows in the calculation to obtain robust results, two to capture short-term effects [−1, +1 and −3, +3], two to capture long-term effects [−10, +10 and −20, +20], one to capture any potential information leakage [−10, −1], and another to capture any potential lagged effect [+1, +10]. Next, we calculate the ARs with the following formula:

$$AR_{it} = E(R_{it})\text{-}R_{it}, \tag{3}$$

where AR_{it} refers to the AR for i on day t. The ARs, being the residuals between expected and realized stock returns, display returns that one cannot explain using the market model and, thus, are a result of the event announcement (Martin Curran & Moran, 2007). Then we accumulate these ARs over multiple days to produce cumulative abnormal returns (CARs) for evaluating the time series for i using the following equation with t_1,t_2 being the event window boundaries:

$$CAR_i(t_1, t_2) = \sum_{t=t_1}^{t_2} AR_{it}. \tag{4}$$

Cumulative abnormal portfolio returns (CAPRs) enable conclusions on the average effect of an event on the examined portfolio. Therefore, we compound each security's ARs within the regarded portfolio and calculate their mean (Kothari & Warner, 2008):

$$CAPR_t = \frac{1}{N}\sum_{i=1}^{N} CAR_t, \tag{5}$$

where $CAPR_t$ refers to the CAPRs and N to the number of securities within the portfolio. We use this portfolio technique, treating the portfolio as a single security, in the upcoming analysis to evaluate the impact of Dieselgate events on the aggregated, average stock returns of VW, Daimler, and BMW. It allows us to conclude whether, on average, investing in this portfolio was economically useful and, thus, on how the events affect the portfolio stock returns. To derive an indication of the absolute change in stock value, we multiply ARs by respective market capitalizations on the event date. For the portfolio analysis, we use the average portfolio market capitalization to calculate the absolute ARs.

We test the CARs for statistical significance using parametric and nonparametric test statistics. To overcome the overrejection of the null hypothesis due to event-induced variance and cross-sectional correlation, we employ the t-statistic by Boehmer, Masumeci, and Poulsen (1991) adjusted by Kolari and Pynnönen (2010). For nonparametric testing, we apply the generalized rank test by Kolari and Pynnönen (2011), which offers advantages in testing aggregate data (such as CARs) as it is robust against the autocorrelation of ARs and event-induced volatility.

3.2 | Data and event description

For this study, we obtain stock price and market capitalization data for the German "Prime All Share" index, VW, Daimler, and BMW from Thompson Reuters' Eikon. We select Daimler and BMW as they represent VW's major industry peers in Germany, which are listed on the same stock exchange.

We hand-collect event data using the continuous Dieselgate chronicle published in the most important German business newspaper Handelsblatt (Handelsblatt, 2019a). We select events from the presented timeline based on their potential financial impact. To obtain an indication of the impact of an event, we look at how meaningful media portrays the respective events as media portrayal plays an important role in the public perception of corporate scandals (Carberry et al., 2018; Clemente & Gabbioneta, 2017; Xu et al., 2016).

Our event selection follows the premise: We select those events for our analysis, which have the potential to affect automotive sales figures (e.g., diesel vehicle bans) or directly diminish the available cashflow (e.g., penalty fines). Then, we use the publishing dates of the articles as the announcement date for each corresponding event. We cross-check these publishing dates concerning potential prior publishing by other media sources to ensure the use of the earliest announcement date for this event study. For all selected events, we find the earliest publication date in the Handelsblatt. Furthermore, we check all events for the existence of confounding events in Google and Google News in the respective event windows to avoid ARs driven by other events taking place at the same time (Dyckman, Philbrick, & Stephan, 1984). In general, we only select events that do not confound with other events. Only for one event for VW (ID 4), we detect a confounding event that we identify as such in the results section. In total, we identify 10 events meaningful enough for this study, which we assign to two event panels (A/B) according to their implications: Event panel A contains the individual events relevant to VW (H1), and panel B contains the group events (H2a/H2b/H2c). Each panel consists of six events. We employ the first two Dieselgate events (IDs 1 and 2) for both analyses, even though they only refer to VW, as they represent the primary events, providing potential conclusions on the immediate contagion effect of Dieselgate. We provide event IDs to facilitate the readability of upcoming findings tables in the next section. Table 1 depicts the event data.

4 | RESULTS

4.1 | H1: The effects on Volkswagen's stock

For VW, we report strong, negative ARs for the first Dieselgate event (EPA announcement) in Table 2, which are significant on a 1% level for most of the event window specifications using parametric and nonparametric test statistics: The CARs range between −18.02% [−1, +1] and −38.56% [+1, +10]. That the largest market reaction occurs in the [+1, +10] event window shows that most of the stock selling happened with a time lag. At the same time, findings for the [−1, −10] specification do not indicate any potential information leakage. Based on VW's market capitalization on the event date, CARs are equivalent to an absolute, abnormal loss in market value of EUR −13.9 billion to EUR −29.7 billion, illustrating the tremendous financial impact of the announcement event. Thus, our findings for VW are in line with prior event studies on Dieselgate (Barth et al., 2017; Fracarolli Nunes & Lee Park, 2016; Griffin & Lont, 2018; Wood et al., 2018). However, the additional analysis of subsequent

TABLE 1 Event description

Event ID	Event panel	Announcement date	Event	Event description
1	A/B	18.09.2015	Announcement of the scandal	The US-EPA announces VW's fraud publicly.
2	A/B	04.01.2016	US lawsuit announcement	US authorities file suit against VW for violating the US Clean Air Act.
3	A	28.06.2016	Penalty fee announcement in the United States	VW has to pay more than 15 billion US dollars in compensation in the United States.
4	A	29.12.2016	Class action lawsuit announcement	"My-Right" announces the filing of a class-action lawsuit against VW on behalf of affected individuals in Germany.
5	B	04.04.2017	Negative EU statement on the future of diesel engines	The EU Commission announces a rapid end to diesel engines.
6	B	28.12.2017	Announcement of diesel vehicle bans	The "Deutsche Städtetag" ("The German Association of Cities") demands diesel vehicle bans in highly polluted urban areas to reduce air pollution in cities (although cleaner diesel vehicles that conformed to EURO6 regulation were exempted).
7	B	27.02.2018	Ruling that vehicle bans are legal	Germany's federal administrative court declares bans on diesel vehicles legal.
8	B	17.05.2018	EU lawsuit announcement	The EU files suit against Germany at the European Court of Justice for exceeding the EU limits on nitrogen oxides emissions.
9	A	13.06.2018	Penalty fee announcement in Germany	The court of Braunschweig imposes a penalty fee of EUR 1 billion on VW in Germany.
10	A	22.02.2019	Material defect announcement	Germany's federal supreme court declares VW's cheating software to be a material defect.

Note: Table 1 depicts the event data and assigns an event ID to each event. We assign events to event panels according to their implications. We assign events 1 and 2 to both event panels, even though they only refer to VW, as they enable conclusions on how Dieselgate immediately spilled over to VW's industry peers. We obtain the announcement date and the event description from Handelsblatt's Dieselgate chronicle.

TABLE 2 CARs for VW for the Dieselgate individual events

		[−1, +1]			[−3, +3]			[−10, −1]		
	Event	CAR	KP	GR	CAR	KP	GR	CAR	KP	GR
Volkswagen	1	−18.02%***	(.0000)	(.0000)	−23.43%***	(.0000)	(.0000)	5.74%	(.3415)	(.3415)
	2	−6.49%	(.3036)	(.3036)	−11.79%	(.2316)	(.2316)	6.47%	(.5821)	(.5821)
	3	−3.38%	(.4566)	(.4566)	−6.04%	(.3897)	(.3897)	−7.24%	(.3913)	(.3913)
	4	−2.96%	(.1742)	(.1742)	0.68%	(.8400)	(.8400)	2.53%	(.5381)	(.5381)
	9	2.16%	(.4853)	(.4853)	−4.81%	(.3185)	(.3185)	−1.60%	(.7840)	(.7840)
	10	2.22%	(.5416)	(.5416)	5.67%	(.3174)	(.3174)	2.29%	(.7417)	(.7417)

Note: Table 2 illustrates Volkswagen's cumulative abnormal returns (CARs) for multiple event window specifications generated by the Dieselgate individual events. We accumulate abnormal returns over the defined event windows to generate the respective CARs (first column of each event window). We employ two test statistics for significance testing. KP represents the parametric *t*-test by Boehmer et al. (1991) adjusted by Kolari and Pynnönen (2010). GR represents the nonparametric generalized rank test by Kolari and Pynnonen (2011). The *p* values (second and third columns of each event window) are stated in parentheses.
***Statistical significance at the 1% level.
**Statistical significance at the 5% level.
*Statistical significance at the 10% level.

Dieselgate events following the EPA announcement did not yield any significant results, indicating that these events are not relevant for VW. Despite their financial implications, neither the penalty fee announcements (IDs 3 and 9) nor the announcement that the fraudulent software represents a material defect (ID 10) leads to any abnormal stock returns. According to Bhattacharya, Daouk, Jorgenson, and Kehr (2000), this surprising finding may have different reasons: Markets may be inefficient; markets are efficient but, the news is not value relevant; or markets are efficient, and the news is value relevant, but the market already anticipated these events and priced them beforehand. As the market processes the information of the Dieselgate announcement and reacts accordingly, the nonefficient hypothesis does not appear to be fully convincing. On the basis of the potential financial losses for VW, we assume that these events certainly are value relevant. Thus, we conjecture that the market was able to anticipate Dieselgate's having legal, financially damaging consequences for VW. Accordingly, the market instantly priced the subsequent events with the Dieselgate announcement. We conjecture that investors were able to anticipate the consequences of Dieselgate as it does not represent the first EPA enforcement in consequence of using a defeat device in the United States, making the fallout for VW predictable. The immediate, heavy sale of VW's stocks supports this argument. Concerning our H1, we conclude that the majority of events do not result in any significant findings. Still, we cannot fully reject the H1, as the EPA announcement leads to significant, negative ARs. The announcement of good sales figures (Weinzierl, 2017) in the event window [+1, +10] of event 4 is, most likely, responsible for the positive ARs.

4.2 | H2a–H2b: The industry peer contagion effect

Table 3 depicts the results of the industry peer analysis. The stock reaction for Daimler illustrates an immediate stock selling with the Dieselgate announcement. For the announcement event (ID 1), Daimler experiences significant ARs in the amount of −8.42% for the [−3, +3] event window specification, representing an absolute loss in market value of EUR −6.5 billion. The announcement that VW faces a penalty fine in the United States (ID 2) generates even greater abnormal stock losses, which are significant at the 5% level for the [−3, +3] event window specification. Significant losses range between −11.39% (EUR −9.0 billion) and −12.59% (EUR −9.9 billion) over the different event windows. Despite both of these events seemingly targeting VW alone, this shows an immediate contagion effect on Daimler. For the first group event, the statement by the EU that diesel engines are not sustainable in the long run (ID 5), Daimler again experiences major negative ARs, which are even significant at the 1% level for the [−3, +3] event window specification. Once again, we identify a range of CARs from −3.09% (EUR −2.2 billion) to −7.77% (EUR −6.8 billion). Although the announcement of diesel vehicle bans in German cities (ID 6) does not have any significant impact on Daimler's stock, the legal approval of vehicle bans by the German federal administrative court (ID 7) has the greatest impact of all group events. We find highly significant abnormal stock returns in the amount of −17.42% (EUR −13.1 billion) for Daimler for the long-term event window [−20, +20], which holds across variation in event window specification. Finally, the EU lawsuit announcement against Germany for exceeding legal thresholds of NO_x emissions (ID 8) has a significant impact on Daimler's stock: For the event window [+1, +10], we find a lagged stock loss of −8.48% (EUR −6.2 billion). Concluding the analysis of Daimler, both primary and three out of four group events generated strong, statistically significant, negative ARs, illustrating that Dieselgate harmed Daimler's market value immensely. Unlike with VW, the market was not able to anticipate the group events and their implications for Daimler, allowing investors to sell Daimler's stock continuously with the emergence of new, relevant information. Thus, we can mainly confirm our H2a.

The analysis of BMW's stock returns provides a similar picture although there are a few differences. The Dieselgate revelation

TABLE 2 Continued

	[+1, +10]			[−10, +10]			[−20, +20]		
	CAR	KP	GR	CAR	KP	GR	CAR	KP	GR
Volkswagen	−38.56%***	(.0000)	(.0000)	−36.41%***	(.0001)	(.0001)	−14.46%	(.2969)	(.2969)
	−9.70%	(.4124)	(.4124)	−6.34%	(.7234)	(.7234)	1.24%	(.9635)	(.9635)
	1.58%	(.8515)	(.8515)	−2.13%	(.8686)	(.8686)	−10.50%	(.5872)	(.5872)
	8.85%**	(.0310)	(.0310)	9.41%	(.1315)	(.1315)	17.70%*	(.0629)	(.0629)
	−7.96%	(.1842)	(.1842)	−9.13%	(.3057)	(.3057)	−17.60%	(.1887)	(.1887)
	−7.95%	(.7004)	(.7004)	−5.49%	(.7939)	(.7939)	−7.66%	(.7374)	(.7374)

Note: Table 2 illustrates Volkswagen's cumulative abnormal returns (CARs) for multiple event window specifications generated by the Dieselgate individual events. We accumulate abnormal returns over the defined event windows to generate the respective CARs (first column of each event window). We employ two test statistics for significance testing. KP represents the parametric *t*-test by Boehmer et al. (1991) adjusted by Kolari and Pynnönen (2010). GR represents the nonparametric generalized rank test by Kolari and Pynnonen (2011). The *p* values (second and third columns of each event window) are stated in parentheses.
***Statistical significance at the 1% level.
**Statistical significance at the 5% level.
*Statistical significance at the 10% level.

event (ID 1) does not generate any significant ARs for BMW, whereas the second Dieselgate event (ID 2, US penalty fee announcement) has a meaningful impact on its stock returns. Despite the information leakage window specification [−10, −1], all event window specifications lead to statistically significant ARs ranging from −6.29% (EUR −3.7 billion) to −27.42% (EUR −16.3 billion). Thereby, ARs for the [−3, +3] event window are significant at the 1% level. Comparing this finding with Daimler, we can conclude that Dieselgate contaminated BMW at a later stage as the announcement event (ID 1) already affected Daimler. However, the impact of the US penalty fee announcement (ID 2) is even greater for BMW than for Daimler. The next difference is that the EU statement on the future of diesel engines (ID 5) does not affect BMW's stock significantly, whereas Daimler is affected strongly. Like Daimler, the announcement of diesel vehicle bans in German cities (ID 6) does not affect BMW. However, with the legal approval of diesel vehicle bans by the German federal administrative court (ID 7), BMW's stock loses between −3.89% (EUR −2.2 billion) and −14.57% (EUR −8.31 billion) in value depending on the event window specification. Finally, the announcement of the EU lawsuit against Germany for exceeding the legal thresholds on NO_x emissions (ID 8) has a highly significant impact on the stock returns of BMW. The loss ranges between −3.86% (EUR −2.3 billion) and −9.13% (EUR −6.17 billion), whereas most of the stock losses occur with a time lag [+1, +10]. Similar to Daimler, the analysis of BMW provides evidence that the Dieselgate events spilled over and contaminated its stock returns. BMW shows major, statistically significant stock losses for the majority of Dieselgate events. However, compared with Daimler, BMW does not experience abnormal losses for event IDs 1 and 5, which demonstrates that Dieselgate affected BMW to a lesser extent. These differences in stock market reactions might be due to Daimler and VW sharing more similarities concerning their business models: Both manufacturers offer commercial vehicles such as trucks, buses, and vans in their product portfolio, which are usually highly reliant on diesel fuel. For both firms, commercial vehicles take a major part of the sales figures (Daimler Group, 2019; Volkswagen Group, 2019), making their sales more exposed to any threats to the sustainability of diesel engines. BMW, however, is not present in the commercial car business and focuses on private transportation (BMW Group, 2019), which is less reliant on diesel technology. Accordingly, the contagion effect of Dieselgate on Daimler is stronger than on BMW. Nevertheless, the significant CARs for BMW are comparable with those of Daimler. Regarding our H2b, the majority of events led to significant results in the individual contagion effect analysis of BMW. Therefore, we are mainly able to confirm our H2b.

4.3 | H2c: The group effect

Table 3 depicts the results of the group analysis. Using the Dieselgate group events in the event study on the portfolio's stock returns provides a similar, value-destructive picture. For the announcement by the EPA (ID 1), the portfolio experiences large, highly significant, negative ARs. Losses range between −8.20% and −17.43%, and most of the stock selling occurs with a time lag. The application of the CAPRs on the average market capitalization of the portfolio allows the derivation of absolute stock losses in the range of EUR −5.7 billion to EUR −12.2 billion. Thus, the announcement of Dieselgate instantly affected the portfolio. The US penalty fee announcement (ID 2) again has a severe impact on the portfolio stock returns. Yielding large, statistically significant CAPRs of −12.69% to −13.16%, the penalty fee event wipes out market value of the portfolio in the range of EUR −8.7 billion to EUR −9.0 billion. Thus, both VW-related events have a severe average impact on the stock returns of the whole portfolio, highlighting the immediate contagion effect on the overall automotive industry. The EU statement on the

TABLE 3 CARs for Daimler, BMW, and the group for the Dieselgate group events

	Event	[−1, +1] CAR	KP	GR	[−3, +3] CAR	KP	GR	[−10, −1] CAR	KP	GR
Daimler	1	−4.65%	(.1461)	(.1461)	−8.42%*	(.0869)	(.0869)	6.51%	(.2696)	(.2696)
	2	−4.50%	(.2197)	(.2197)	−12.59%**	(.0280)	(.0280)	2.13%	(.7557)	(.7557)
	5	−3.09%*	(.0855)	(.0855)	−7.77%***	(.0055)	(.0055)	−5.37%	(.1137)	(.1137)
	6	−1.21%	(.4397)	(.4397)	−1.64%	(.4977)	(.4977)	−0.22%	(.9403)	(.9403)
	7	−1.56%	(.2099)	(.2099)	−4.77%**	(.0124)	(.0124)	−2.73%	(.2319)	(.2319)
	8	0.95%	(.6351)	(.6351)	2.70%	(.3855)	(.3855)	1.18%	(.7561)	(.7561)
BMW	1	−1.94%	(.5357)	(.5357)	−2.79%	(.5630)	(.5630)	10.42%*	(.0713)	(.0713)
	2	−6.29%*	(.0786)	(.0786)	−15.11%***	(.0069)	(.0069)	1.28%	(.8472)	(.8472)
	5	−2.99%	(.1584)	(.1584)	−2.68%	(.4163)	(.4163)	0.81%	(.8390)	(.8390)
	6	−1.23%	(.4855)	(.4855)	−1.74%	(.5226)	(.5226)	1.58%	(.6322)	(.6s322)
	7	−0.50%	(.7477)	(.7477)	−3.89%*	(.0999)	(.0999)	−0.76%	(.7881)	(.7881)
	8	−3.86%**	(.0338)	(.0338)	−2.14%	(.4500)	(.4500)	−0.91%	(.7921)	(.7921)
Group	1	−8.20%***	(.0070)	(.0070)	−11.55%**	(.0134)	(.0134)	7.56%	(.1771)	(.1771)
	2	−5.76%	(.1536)	(.1536)	−13.16%**	(.0370)	(.0370)	3.29%	(.6616)	(.6616)
	5	−2.70%	(.1234)	(.1234)	−4.69%*	(.0857)	(.0857)	−2.37%	(.4747)	(.4747)
	6	−1.24%	(.4556)	(.4556)	−1.84%	(.4735)	(.4735)	−0.30%	(.9237)	(.9237)
	7	−1.61%	(.2891)	(.2891)	−5.12%**	(.0277)	(.0277)	−2.17%	(.4368)	(.4368)
	8	−0.89%	(.6547)	(.6547)	0.78%	(.8022)	(.8022)	−0.93%	(.8054)	(.8054)

Note: Table 3 illustrates Daimler's, BMW's, and the group's cumulative abnormal returns (CARs) for multiple event window specifications generated by the Dieselgate group events. We accumulate abnormal returns over the defined event windows to generate the respective CARs (first column of each event window). We employ two test statistics for significance testing (second and third columns of each event window). KP represents the parametric *t*-test by Boehmer et al. (1991) adjusted by Kolari and Pynnönen (2010). GR represents the nonparametric generalized rank test by Kolari and Pynnonen (2011). The *p* values (second and third columns of each event window) are stated in parentheses.
***Statistical significance at the 1% level.
**Statistical significance at the 5% level.
*Statistical significance at the 10% level.

future of diesel engines (ID 5) triggers abnormal losses of −4.69% (EUR −3.1 billion) for the [−3, +3] event window, which, however, are only significant at the 10% level. Similar to the individually conducted analyses of Daimler and BMW, the announcement of diesel vehicle bans in German cities (ID 6) does not generate any significant results. However, their legal approval (ID 7) leads to large, highly significant stock losses for a variety of event windows. Ranging between −5.12% and −19.60%, CAPRs increase in line with the size of the event window. In its broadest specification [−20, +20], market value falls by up to EUR −14.1 billion. Finally, the announcement of the EU lawsuit against Germany (ID 8) is again of value relevance for the portfolio and led to CAPRs of −8.05%, significant at the 5% level, thereby representing an absolute loss in market value of EUR −5.9 billion. In conclusion, we can mainly confirm our H2c as, similar to the individual analyses of Daimler and BMW, most of the events lead to significant, negative ARs for the portfolio, illustrating the average financial damage to the German automotive industry by Dieselgate. Hence, both of our contagion effect analyses demonstrate that most of our identified Dieselgate events cause a contagion effect from VW to the German industry peers.

5 | DISCUSSION

5.1 | Research contributions

Concerning our research question: "How do Dieselgate announcements affect the stock returns of VW and its industry peers (contagion effect)?", the results of our event study on VW display large, statistically significant, negative ARs for the first Dieselgate event, whereas all the subsequent events remain statistically insignificant (H1). In the contagion effect analysis (H2a–H2c), the majority of the Dieselgate group events yield significant, negative ARs for Daimler and BMW on an individual level as well as for the portfolio. By that, the findings illustrate that the financial impact of Dieselgate expresses itself in a value-destructive intraindustry contagion effect rather than in an individual stock selling of VW. Both analyses demonstrated that Dieselgate events wiped out up to EUR 29.7 billion in market value (Figure 2).

Our findings come with four major research contributions: First, we add a horizontal contagion effect dimension to the extensive knowledge on contagion effects of Dieselgate, which mostly covers the vertical

TABLE 3 Continued

	[+1, +10]			[−10, +10]			[−20, +20]		
	CAR	KP	GR	CAR	KP	GR	CAR	KP	GR
Daimler	−8.55%	(.1468)	(.1468)	−5.89%	(.5111)	(.5111)	9.03%	(.5046)	(.5046)
	−11.39%*	(.0977)	(.0977)	−13.95%	(.1806)	(.1806)	−18.34%	(.2431)	(.2431)
	−3.33%	(.3287)	(.3287)	−9.38%*	(.0684)	(.0684)	−6.43%	(.4071)	(.4071)
	3.13%	(.2897)	(.2897)	2.20%	(.6217)	(.6217)	2.84%	(.6722)	(.6722)
	−5.37%**	(.0184)	(.0184)	−8.33%**	(.0155)	(.0155)	−17.42%***	(.0011)	(.0011)
	−8.48%**	(.0248)	(.0248)	−6.33%	(.2696)	(.2696)	−0.38%	(.9648)	(.9648)
BMW	−5.19%	(.3692)	(.3692)	3.12%	(.7223)	(.7223)	19.69%	(.1378)	(.1378)
	−16.99%**	(.0114)	(.0114)	−20.95%**	(.0394)	(.0394)	−27.42%*	(.0737)	(.0737)
	−1.33%	(.7418)	(.7418)	−1.95%	(.7481)	(.7481)	−4.27%	(.5723)	(.5723)
	2.17%	(.5139)	(.5139)	3.65%	(.4665)	(.4665)	9.63%	(.2025)	(.2025)
	−5.17%*	(.0673)	(.0673)	−6.80%	(.1110)	(.1110)	−14.57%**	(.0276)	(.0276)
	−9.13%***	(.0078)	(.0078)	−10.17%*	(.0509)	(.0509)	−8.02%	(.3082)	(.3082)
Group	−17.43%***	(.0018)	(.0018)	−13.06%	(.1249)	(.1249)	4.75%	(.7116)	(.7116)
	−12.69%*	(.0938)	(.0938)	−13.75%	(.2309)	(.2309)	−14.84%	(.3910)	(.3910)
	−1.12%	(.7355)	(.7355)	−4.32%	(.3897)	(.3897)	−4.27%	(.5723)	(.5723)
	2.90%	(.3544)	(.3544)	2.32%	(.6242)	(.6242)	3.76%	(.3507)	(.3507)
	−6.69%**	(.0161)	(.0161)	−9.99%**	(.0174)	(.0174)	−19.60%***	(.0026)	(.0026)
	−8.05%**	(.0330)	(.0330)	−8.70%	(.1288)	(.1288)	−4.69%	(.5874)	(.5874)

Note: Table 3 illustrates Daimler's, BMW's, and the group's cumulative abnormal returns (CARs) for multiple event window specifications generated by the Dieselgate group events. We accumulate abnormal returns over the defined event windows to generate the respective CARs (first column of each event window). We employ two test statistics for significance testing (second and third columns of each event window). KP represents the parametric *t*-test by Boehmer et al. (1991) adjusted by Kolari and Pynnönen (2010). GR represents the nonparametric generalized rank test by Kolari and Pynnonen (2011). The *p* values (second and third columns of each event window) are stated in parentheses.
***Statistical significance at the 1% level.
**Statistical significance at the 5% level.
*Statistical significance at the 10% level.

dimension (Fracarolli Nunes & Lee Park, 2016). We demonstrate that investors immediately target industry peers with the stock selling as a consequence of the scandal (horizontal contagion effect). The multitude of significant ARs suggests that processual scandals like Dieselgate imply continuous contamination of industry peers as the investors follow the ties in the industry and react accordingly. At the same time, VW's single stock selling for the EPA announcement provides the opposite picture and demonstrates that the market can anticipate the consequences for VW right from the beginning of the scandal.

Second, we demonstrate that subsequent events of a corporate scandal matter as well. Although several authors analyze the spillover effects of Dieselgate (Barth et al., 2017; Fracarolli Nunes & Lee Park, 2016; Griffin & Lont, 2018), they limit their event studies to the primary event of the scandal—assuming that Dieselgate has ended with this event. The case of Dieselgate illustrates that the EPA announcement is a triggering rather than a single event, followed by a general questioning of the diesel engine and a chain of subsequent Dieselgate events in Germany. Thus, considering multiple events (a longer timeline) and data on industry peers in the analysis of major corporate scandals can yield more extensive results, which would remain overlooked by limiting the analysis to the primary event and the violating firm.

Third, we combine existing theoretical frameworks for understanding the stock market reaction to opportunistic corporate scandals and the resulting contagion effect. Our framework considers two complementary theories building on information asymmetries. Major, opportunistic corporate scandals like Dieselgate have their source in an existing agency conflict and management control systems that lack a sustainability perspective (Lueg & Radlach, 2016). This combination manifests itself in incentives for moral hazard (Eisenhardt, 1989). Thereafter, the management exploits information asymmetries at the expense of the principal, acts unethically (e.g., by violating environmental regulations), and, thus, obtains a business advantage ultimately resulting in higher management compensation (Li et al., 2018). This agency conflict cannot be limited to a pure shareholder–management relationship but rather has to be extended to a stakeholder–agency approach (Hill & Jones, 1992). Dieselgate affects several stakeholders negatively, which leads to pressure on VW's stocks. The emergence of Dieselgate comes with a passive release of information on environmental risks to the stakeholders (Lueg, Krastev, & Lueg, 2019; Zou, Zeng, Zeng, & Shi, 2015), which enhances a learning process at the investors and triggers the financial contagion effect.

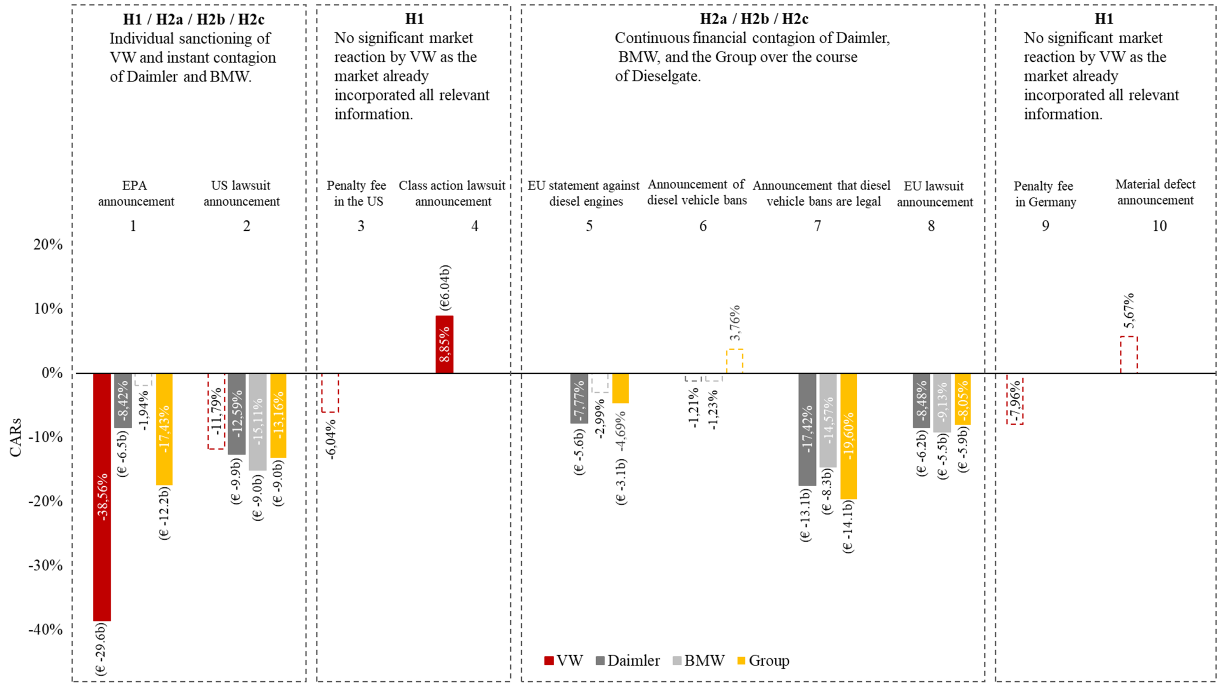

FIGURE 2 This figure denotes cumulative abnormal returns (CARs) on the y-axis and the events on the x-axis. We display significant CARs centered in colored and filled bars and insignificant CARs in dashed, uncolored bars. For all events and firms, we select the most significant CARs, respectively. For significant CARs, we display the absolute loss in market capitalization in parenthesis below or above each bar. We assign the events to the respective hypotheses and provide a short explanation of the findings [Colour figure can be viewed at wileyonlinelibrary.com]

Fourth, our findings suggest that being "guilty by association" pronounces when firms are interwoven and have many similarities in their business models.

5.2 | Practical contributions

For practitioners, our analyses provide two important insights into the business advantages from environmental violations and the financial impacts once they are uncovered.

First, we show that violating environmental regulations for business purposes might not have the potential for significant negative financial impact. VW's environmental violation helped it penetrate the US market effectively. However, when fraud in these dimensions is the driver for this success, downsides can be high. Dieselgate illustrates that these scandals damage not only the fraudulent firm(s) but also the reputation of industry peers with financially damaging consequences (Zou, Zeng, Zhang, Lin, & Shi, 2015). Therefore, VW and the German automotive industry serve as a good example that complying with environmental regulations matters and that violating them is costly. Hence, as pointed out by Dasgupta et al. (2001), stock markets provide financial incentives for firms to act in an environmentally conscious way and to avoid pollution, making stock markets a functioning external corporate governance mechanism for environmental compliance (Lueg, Pedersen, & Clemmensen, 2015; Velte, Stawinoga, & Lueg, 2020).

Second, this analysis shows that industry peers might be "dragged along" by corporate scandals when they cannot effectively differentiate themselves from the fraudulent firm or are not perceived as separate by stakeholders, basically confirming our signaling-based assumption in the background section. Even though Dieselgate affected Daimler and BMW heavily, BMW was able to avoid some of the stock selling because of its greater differences from VW's business model. Thus, firms have to consider that the more similar they become to their competition (e.g., by operating the same business model) and the stronger the interlinkage between them is, the higher the probability will be that an industry peer's scandal will affect them. This, in the second step, implies the contagion effect whereby related industry peers might even suffer stronger financially damaging consequences than the fraudulent firm. Therefore, firms should avoid extensive overlaps in business models and interrelations to assure an effective differentiation should an industry peer be involved in a devastating corporate scandal. A differentiation by explicitly stipulating the environmentally responsible principles in corporate strategy might be a good mean to protect oneself from the scandal-driven contagion effect (Lueg, Lueg, Andersen, & Dancianu, 2016). Thus, the case of Dieselgate provides important lessons for firms regardless of the industry and illustrates that violating environmental regulations to obtain business advantages should be omitted by firms as legal and financial consequences can be devastating. The violating firm, as well as its industry peers, might have to deal with a long-term reputational loss that has the potential to transform formerly highly reputable firms into despised entities in the society.

5.3 | Limitations and future research

The interpretation of our findings is subject to five limitations: These include the limited generalizability to other scandals, our theoretical framework, the potential bias arising from the interdependence of German car manufacturers and the involvement of Daimler and BMW in the Dieselgate scandal, the circumstance that our subsequent events do not represent surprises to market participants, and the negligence of long-term effects as well as investor characteristics.

First, it is questionable whether one can apply our findings to other cases in which the fraudulent firm has rather unrelated industry peers, distinct stakeholders, and in which they serve different customer needs (i.e., different business models). As pointed out, we derived our findings using German car manufacturers in the analysis of Dieselgate, which are deeply interrelated, have a large overlap in stakeholders, and have many similarities with regard to organizational type, market positioning, and so forth. Thus, we conjecture that one can generalize our findings but only to firms with similar business models.

Second, we employ an information economics perspective (agency and signaling) in the analysis of Dieselgate. Our underlying theories, building on how Dieselgate revealed environmental risks to the stakeholders, are able to provide a theoretical explanation for the stock market reaction to VW and the contagion effect. However, diminished legitimacy might be the pivotal issue in other scandals, for example, in the fashion industry (Lueg et al., 2015). As shown by Jonsson, Greve, and Fujiwara-Greve (2009), corporate scandals imply legitimacy losses for the firm involved, which eventually spill over to industry peers when the firms are similar but not necessarily interrelated. Hence, a legitimacy theoretical lens might be more suitable to explain the "undeserved losses" when examining the contagion effect of scandals for similar but unrelated firms.

Third, our statistically significant, negative stock returns for the German automotive industry could partially be a consequence of the interdependence of German car manufacturers and the involvement of Daimler and BMW in Dieselgate itself. In our analyses, we stick to the legal perspective that all three car manufacturers are independent, legal entities. From a business administration perspective, one might argue that the long-term cooperation between German car manufacturers (Barthel et al., 2015) blurs the legal boundaries and reveals discernible interdependence. This might, partly, explain the contagion effect as VW's problems automatically become a problem for the German industry peers through interdependence. Besides, legal authorities later found other German car manufacturing firms guilty of violating environmental regulations. This is truer for Daimler (Delamaide, 2018) than for BMW (Handelsblatt, 2019b), although both are subject to legal prosecution for irregularities with their diesel vehicles. Thus, the involvement of both firms in Dieselgate might have implications for our findings on the contagion effect. However, we favor the interpretation that a substantial part of the contagion effect is rather built on the "guilty by association" effect: The individual analyses of BMW and Daimler reveal that both firms were immediately targeted for the first two Dieselgate events when, at that time, nobody associated them with the scandal. Furthermore, we checked that none of the allegations against Daimler and BMW took place at the same time as any of our defined events. Hence, we conjecture that the risk of a bias coming from scandal involvement is relatively small.

Fourth, following the premise of market efficiency strictly, one might argue that our subsequent events do not hold any new information and that considering them is thus unnecessary. However, we counterargue that, indeed, these events do not represent real surprises as media already portrayed them and they followed the initial announcement; still, our findings provide evidence that investors, in line with our learning argument, had problems to fully grasp the potential consequences for their firms right from the beginning. This, most likely, led them to rethink their investment decision over time as they could not evaluate their risk of being dragged along upfront. Hence, we strongly argue that our subsequent events are necessary for the analysis of Dieselgate.

Fifth, we critically assess that we limit ourselves to short-term effects and do not examine the potential recovery following the financial fallout for VW and its industry peers. Finally, we do not distinguish between different groups of investors and assume homogeneity. Future research should clarify how VW and other automotive firms performed in the long-run following Dieselgate and if different investor groups reacted differently to the scandal.

5.4 | Conclusion

Based on 10 identified Dieselgate-related events, we examine the impact of Dieselgate on the stock returns of German car manufacturers to understand how Dieselgate affects the stock returns of VW and other German car manufacturers (contagion effect). The analysis reveals that the financial impact of Dieselgate expressed itself in a strong contagion effect rather than in an individual sale of VW's stock. Using the individual analysis of VW to test our H1, we find statistically significant, negative ARs for the revelation event by the EPA (ID 1), whereas none of the subsequent individual events generated any significant losses. Thus, we partially confirm our H1 as one individual event caused statistically significant, negative ARs for VW.

We apply the analyses of Daimler and BMW individually and of the group of car manufacturers to test our H2a, H2b, and H2c. The results for Daimler demonstrate that, apart from the announcement of diesel vehicle bans (ID 6), all the Dieselgate group events generate significant, abnormal losses for the firm. Despite event IDs 1, 5, and 6, which do not lead to any significant findings, the analysis of BMW provides a similar picture and displays significant stock losses for all the remaining Dieselgate events. Aggregating the stock returns of VW, Daimler, and BMW in the portfolio analysis illustrated that, on average, the portfolio of publicly listed German car manufacturers suffers significant stock losses for all of the group events except for event ID 6. On the basis of the individual analysis of Daimler and BMW and the group analysis, we mainly confirm our H2a and H2b as the majority of the group events had significant value relevance for Daimler, BMW, and the group. This finding suggests that Dieselgate's financial impact was far worse for VW's industry peers than for VW itself.

ACKNOWLEDGMENTS

We would like to thank Judith C. Schneider and Patrick Velte for their helpful remarks on previous versions of this manuscript. Results of this study have also been presented at the 36th EGOS Colloquium–"Organizing for a Sustainable Future: Responsibility, Renewal & Resistance" in the sub-theme "Studying Organizational Wrongdoing, Corruption, and Scandals: Where Are We and Where Should We Go?".

FUNDING INFORMATION

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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How to cite this article: Bouzzine YD, Lueg R. The contagion effect of environmental violations: The case of Dieselgate in Germany. *Bus Strat Env*. 2020;29:3187–3202. https://doi.org/10.1002/bse.2566