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Strategic advertising in the aftermath of a corporate scandal

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Abstract

This paper contributes to the literature on how firms change their advertising strategies after a corporate scandal by providing both a theoretical model and an empirical evaluation based on the idea that advertising acts as a signal of the product quality that is modulated by the number of competing substitutes in the market. This result is new to the literature and helps to explain cases in which, possibly counter-intuitively, a firm affected by a corporate scandal may optimally decide to reduce its advertising expenditures, rather than increase it, in an attempt to restore its reputation as quickly as possible. We find empirical support for this result in the *Volkswagen Group's* response to the *Dieselgate* scandal.

KEYWORDS
corporate scandals, difference-in-differences, signalling, strategic advertising, substitutability

JEL CLASSIFICATION
L62, M37, D82

1 | INTRODUCTION

News of major corporate scandals hit headlines with some frequency. In the last decades, this problem has particularly affected large, highly visible companies in almost every country in the world (*Enron, BP, WorldCom, Lehman Brothers, Parmalat, RBS, Nestlé, Apple, Nike, Volkswagen*....), and has adopted different forms, from corporate fraud or internal misconduct to environmental incidents and labour malpractices (Coffee, 2005; Markham, 2006). Even if a scandal does not affect the final quality of a firm's products or services, it may have an impact on key dimensions of the firm, such as the firm's corporate image, market value, and future plans. Indeed, what most of the aforementioned scandals had in common is that they involved a crisis caused by a behavioural or decision-making error that posed a direct threat to the firm's corporate reputation, putting pressure on the management to find an appropriate response strategy (Barkemeyer et al., 2020).

To best cope with a corporate scandal, both common sense and the economic literature suggest that one of the most natural reactions for a company is to develop a proactive image rebuilding plan (Nelson et al., 2008; Surendranath et al., 2015).[1] Corporate advertising plays an important role in this context, as it clearly has the ability to shape stakeholders' perceptions of the severity of the crisis and how the company deals with it.[2] While the extent to which a company can influence the way a story is played out in the media is limited, a noticeable and strategic increase in advertising for a particular brand or product can convey certain messages or signals that can help undo wrongs and restore reputation. Conversely, a reduction in advertising spending could be sometimes associated with a desire to go unnoticed and let the crisis fade away (Utz, 2019).

Numerous academic papers, best-selling books and press articles about this topic have appeared in recent years. Many of them show that strategic advertising has been used effectively to fix a tarnished corporate image after a negative shock. For instance, Cowden and Sellnow (2002), analysing advertising of *Northwest Airlines* after a pilots' strike, found that it was the airline's primary responding channel, enabling the firm to progressively restore a positive public image. Kim (2013) and Kim and Choi (2014) have also shown that corporate advertising was commonly used to convey messages of social responsibility, brand image and communal relationship building after communication crises in Taiwan. Cormier et al. (2005) and Karpoff et al. (2017) also provided cross-country empirical assessments on how strategic advertising helped brand and reputation rebuilding after different scandals.[3]

While there are clear motives to argue that advertising may help a firm to recover reputation and sales after a negative shock, from a theoretical perspective there are reasons to consider that increasing advertising might not be, at times, the best strategy. For example, if advertising works as a signalling device of a firm's quality and a scandal puts into pressure the public

[1]Other papers in the extensive literature on corporate scandals have focused on the impact of the crisis on capital structure (Bonini & Boraschi, 2012), market value (Giannetti & Wang, 2016; Shahriari et al., 2022) or regulatory changes (Hail et al., 2018).

[2]Advertising campaigns are often accompanied by other complementary strategies such as consumer rewards, discounts or product recalls (Chen et al., 2009; Freedman et al., 2012).

[3]There are other empirical studies that examine how firms change advertising expenditure following adverse events. For instance, Landsman and Stremersch (2020) looked at the effect of unpopular collective layoffs on sales and advertising levels. The complex relationship between quality and advertising is also analysed in numerous works on 'Share of voice/Share of market' (Hansen & Christensen, 2005). A recent empirical contribution for the case of the automotive industry can be found in Rae (2020).

perception of the firm's quality, reducing the firm's market share to a large extent, it might be optimal for the firm to reduce advertising rather than increase it.

In this paper, we propose a model that addresses this question and identifies the degree of substitutability of a product as a key ingredient underpinning the firm's optimal advertising strategy in the aftermath of a scandal. The model draws on the literature of indirect informative (or signalling) advertising, where advertising provides consumers with information about a product in an indirect way as, *in equilibrium*, it is a signal of the firm's quality (Bagwell, 2007; Beattie, 2020; Beattie et al., 2021; Goeree, 2008; Milgrom & Roberts, 1986; Nelson, 1970, 1974; Sahni & Nair, 2018). It requires advertising to be a credible signal—something that differs from the view of advertising as persuasive—and it implicitly considers advertising as an investment, yielding long-term returns.[4]

Inspired by recent scandals, where the debate was not about the quality of a firm's product but about the firm's social and/or responsibility values, we propose a theoretical model where firms differ in two dimensions: the standard quality-dimension and a new responsibility-dimension. This allows for firms that, apart from differing in the quality of their products, may also differ in their *core values* and *corporate responsibility principles*. This includes firms with different levels of commitment to the environment, gender and race equality, sustainable growth, and so. We assume that the product is an experience good in the first dimension; however, the quality of the product in the second dimension cannot be tested by consumers and they have to rely on the information disclosed by an external validation system, for example, a verification agency. This framework allows us to analyse the effects of an *information shock*, for example, the disclosure of negative information from the verification agency, on the advertising strategy of the firms in the market. The reader may well recognise some of the scandals previously referred to (e.g., *BP, Nike, Volkswagen*...) as examples of this type of situation.

The results from the theoretical model show that in the event of a scandal that calls into question a firm's responsibility principles, the firm wrecked by the scandal can no longer use advertising as a signal of quality, in which case it will optimally reduce its advertising expenditure, provided that its product has a large number of substitutes. Otherwise, in equilibrium, it will not reduce advertising. The interest of this result is twofold. First, it is based on a rather simple and intuitive logic. Namely, a scandal reduces a firm's demand (and market share), with the reduction being higher the larger the number of substitutes of the product. Since a higher decrease in demand means lower returns from advertising, it follows that the larger the number of substitutes, the lower the incentives to advertise after a scandal.[5] Second, it helps

[4]Assuming instead that advertising is persuasive would imply that we give advertising the power to change consumers' preferences and affect consumers' behaviour under any circumstance, for example, even if the product has been shown to be bad. It means firms have the ability to fool consumers, a view that we do not fully share. The persuasive approach is also closer to the view of advertising as an operating expense, that is, offering short-term returns, in that a firm's persuasive advertising can be fully offset by a competitor's persuasive advertising. For a discussion of the mechanisms through which advertising operates—advertising as informative (either directly or indirectly), persuasive, and complementary—see Belleflamme and Peitz (2010). For a discussion of the accounting literature on the classification of advertising as an investment or an operating expense, see Enache and Srivastava (2018).

[5]This idea is further developed in Section 2.2. Briefly, when a good has many substitutes, the market share that a firm wrecked by a scandal loses is larger, as consumers can easily move to another firm. The reduction in the firm's demand translates into a reduction of the firm's gross advertising returns and, in the presence of some fixed costs of advertising, of the per unit return on advertising—ROAS metric, c.f. footnote 17. As a result, the incentive of the firm to advertise is reduced.

accommodate both the response of a firm that optimally increases advertising after a scandal and that of a firm that chooses to reduce it, providing a rationale for both reactions.

From an empirical perspective, existing literature (e.g., the aforementioned papers by Cowden & Sellnow, 2002; Kim, 2013; Kim & Choi, 2014; Cormier et al., 2005; Karpoff et al., 2017) has identified numerous situations in which a firm affected by a scandal reacts by increasing advertising. There is, however, scarce evidence of firms that reduce advertising in response to a scandal. This paper also contributes to the literature in this respect, by providing empirical evidence of this behaviour.

The empirical analysis exploits the natural experiment of the *Volkswagen Group* emission fraud, breaking up in September 2015, when the US *Environmental Protection Agency* (EPA) revealed that the *Volkswagen Group* had illegally installed a cheating software to alter the results of technical emission controls on 11 million diesel-engine cars sold between 2009 and 2015. The *Dieselgate* scandal—as the press dubbed it—represented a near 'earthquake' for the reputation of the *Volkswagen Group*; a car manufacturer that till then was generally regarded as strongly committed to high ethical standards and very sensitive to social issues.

We use monthly data on advertising expenditures and sales of the *Volkswagen Group* and other car manufacturers in the Spanish market, during the period January 2014–December 2016. We use a Difference-in-Differences methodology to analyse the causal effect of *Dieselgate* on the advertising strategy of the *Volkswagen Group* and its competitors. In the analysis, we build a control group with firms from sectors other than the automotive industry that meets standard desirable conditions, for example, parallel pre-intervention trends. We find that before *Dieselgate* the *Volkswagen Group* was the carmaker expending the most on advertising and that after the scandal, the group significantly reduced advertising expenditure whereas its competitors increased theirs. We also draw results on the effect of *Dieselgate* on sales of the *VW Group* commercial brands, finding differential effects across commercial brands.

The findings about the advertising behaviour of the *VW Group* and its competitors both before and after *Dieselgate* are in line with our theoretical predictions. We interpret these findings as support to our theory and as suggestive evidence that the *VW Group* might have optimally reacted to the scandal. However, we are cautious about our conclusions and acknowledge that the fact that both theoretical and empirical results point in the same direction does not necessarily imply that the VW Group*'s* response was optimal, nor that its reduction of advertising was primarily due to our argument. In fact, there are other reasons that could help explain the response of the *VW Group*. For example, *VW* might have reduced advertising for a desire to go unnoticed and let the crisis fade away (Utz, 2019), or due to the financial constraints and fines assumed by the *VW Group* after the scandal. Despite these arguments offer plausible explanations for the *VW Group's* reaction—we elaborate on them in Section 5.2.2—they fall short to explain the increase in advertising of *VW's* competitors, which suggests they cannot explain the whole story. In contrast to this, our argument can accommodate both reactions.

Finally, our results have broader implications beyond *Dieselgate*, suggesting a new rationale for the containment of advertising spending after a scandal that can assist managers and policy makers alike. By showing how firms can strategically use advertising in the aftermath of a scandal, we help managers select an appropriate response strategy and policy makers anticipate future actions and respond in a timely manner. This guide may be particularly useful in situations where intervention is necessary to prevent further damage.

The remaining of this paper is organised as follows. Section 2 presents the theoretical framework and results that guides the posterior empirical analysis. Section 3 summarises the background case, introducing the main events of the *Dieselgate* scandal to the reader. Section 4

describes our database and Section 5 presents our empirical approach and results. Section 6 presents some robustness checks and in Section 7 we conclude. The Appendix contains the proofs of the theoretical results.

2 | THEORETICAL FRAMEWORK

2.1 | Model

In this section, we propose a theoretical framework to analyse the possible effects of an information shock on the advertising strategies of firms in a market. To this purpose, we use the framework developed in Belleflamme and Peitz (2010), where a firm that competes in a market for more than one period produces an *experience good* product and uses advertising to signal the quality of the product.[6] This framework is well suited to analysing the car manufacturer industry and the effect of the *Dieselgate* scandal, since cars are experience goods—certain characteristics of cars, such as the quality of the engine and the comfort of the vehicle, are only observed after use—and there is a repeated business effect—consumers consume more than one car in a lifetime and usually change of carmaker after negative experiences. In addition, a rationale for an information shock such as *Dieselgate* can be introduced very naturally, by considering that consumers have preferences not only for quality products, but for environmental policies.

To account for environmental preferences, in this paper we extend the framework in Belleflamme and Peitz (2010) and include a second dimension of product differentiation that goes beyond the standard and aforementioned quality-dimension. By introducing the second dimension we allow firms to differ in core values and/or corporate responsibility principles. Examples are different levels of a firm's commitment to the environment, labourers working conditions, sustainable growth, and so. In line with real world observation, we assume that the quality of the product in this second-dimension cannot be self-experienced. There is however an external agency, for example, the *US EPA* in the *Dieselgate* story, that tests quality in this dimension and informs consumers about it. We will use this setup to study the effects of a scandal such as *Dieselgate* on the advertising strategies of firms in the market. In this sense, we will refer to the second dimension as the environmental dimension.

Before moving on, a short incise to say that despite the theoretical framework that we present is at times framed in terms of the *Dieselgate* scandal, this is done for illustrative purposes. However, the framework is more general and can accommodate other scandals, for example, the *Nike* scandal in the 90s.[7]

The model considers two firms or carmakers ($i = A,B$) that compete in a two-period game. In each period, firms produce a product (car) that is only useful for the period in which it is sold.

[6]The consideration of a repeated game (hence, repeated purchases) helps the authors sustain an equilibrium with advertising, even when the product is an experience good. The reason is that with a repeated business effect, the gains from adopting a certain strategy are different for high-quality and low-quality firms, as low-quality firms that advertise as being high may be punished in the future. This allows for separation of types of firms, which makes advertising be a signal of quality. This is an interesting and convenient feature of this framework that we will use later in our analysis.

[7]The *Nike* scandal, broke up by American labour activist and writer Jeffrey Ballinger, exposed the dramatic working conditions of *Nike* workers in factories in Indonesia—with practices including child labour and below-minimum wages—calling into question *Nike* responsibility principles.

Additionally, in each period, firms set the price of the product and choose the level of advertising expenditure for the period. Firms (alternatively, products) may differ in two dimensions: the quality-dimension and the environmental-dimension. We assume that a product can be either good (G) or bad (B) in the quality-dimension, and eco-friendly (F) or unfriendly (U) in the environmental-dimension. As already mentioned, the product is an experience good in the first dimension. In the second dimension, instead, consumers cannot self-experience quality but must rely on the information from an external agency. We model this idea by means of parameter $\chi \in [0, 1]$ that denotes the probability that the external auditor reveals this information.

Formally, a firm is of type $t \in T = \{GF, GU, BF, BU\}$, with t being private information of the firm. Quite intuitively, GF stands for good-friendly type, GU for good-unfriendly type, BF for bad-friendly type, and *BU* for bad-unfriendly type. We assume that each type occurs with probability $\alpha_t \in (0, 1)$, with $\sum_{t \in T} \alpha_t = 1$. Additionally, we denote by $\alpha_G = \alpha_{GF} + \alpha_{GU}$ the prior probability that a firm is a good type (α_B is the probability it is bad); and by $\alpha_F = \alpha_{GF} + \alpha_{BF}$ the prior probability that a firm is a friendly type (α_U is the probability it is unfriendly). The type of a firm is invariant throughout the game, and types are i.i.d. Relevant for the posterior discussion, note that the larger α_t is, the higher is the probability that the two firms are of type t; hence, the larger is the probability that the two carmakers (and cars) are substitutes for each other. Note also that we can also interpret α_t as the frequency of carmakers of type t in the population.[8] According to this interpretation, the larger α_t is, the higher the number of substitutes for a car of type t.

The representative consumer receives utility u_t from the consumption of a product of type t. We assume that a product of type GF always gives the highest utility to the consumer, and a product of type BU always gives the lowest utility. As for the consumer's preference relationship between types GU and BF, there are two possibilities: in *ordering scenario I*, quality is preferred over environmental aspects and therefore preferences are lexicographic in the first dimension, $u_{GF} > u_{GU} > u_{BF} > u_{BU}$. The opposite occurs in *ordering scenario II*, with $u_{GF} > u_{BF} > u_{GU} > u_{BU}$.[9] Inspired by recent events, for example, new consumption patterns after COVID and the seemingly increasing relevance that consumers and firms place on companies' values and environmental issues nowadays, hereafter we consider ordering scenario II. The analysis in the text is complemented in the Appendix, where we also analyse the game for *ordering scenario I*.

The timing of the game is as follows (Figure 1). First, firms observe their own types. Upon observing the types, firms set their first-period prices and choose their advertising expenditures for period 1. For simplicity, we consider that the advertising expenditure of a firm can only take two values: high and low.[10] Let $a_i \in \{a_h, a_l\}$ denote the advertising expenditure of firm i, with a_h representing high advertising expenditure and a_l low advertising expenditure. With probability $\chi \in [0,1]$, the external auditor discloses information about the firms' environmental practices.

[8] This interpretation implicitly considers a pool of n firms, out of which we draw the 2 firms that compete in the market. Note that under this interpretation, α_t describes the probability that a firm is of type t within the pool of n firms, which further means α_t describes the frequency of carmakers of type t in the population of n firms.

[9] This approach is standard in vertical differentiation models (Shaked & Sutton, 1982).

[10] A more general (and complex) setup would consider advertising as a continuous variable. Our prediction for this case is the existence of a threshold such that firms that advertise higher than the threshold will be perceived as good type; bad type otherwise. We do not expect qualitative results to change much.

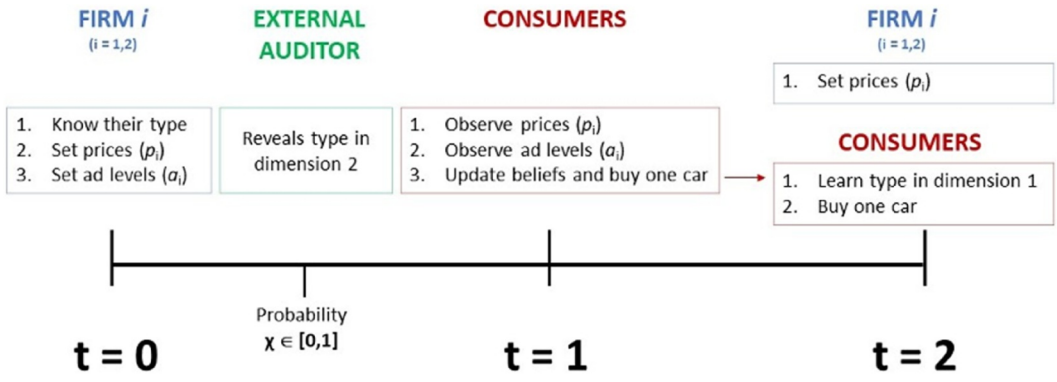

FIGURE 1 Timing of the game.

Consumers observe the announcements (if any), the firms' prices and their advertising expenditures, and choose to buy one car from either firm 1 or 2. By consuming the car in period 1, consumers learn the type of the car in the first dimension. Two comments here. First, cars are experienced-good in the first dimension, so consumers do not learn the type of a car they do not consume. Second, we consider that consumers dislike firms that are shown to have lied and so, stop purchasing the firm's product in the second period if they have been deceived by the firm in the first period.[11] In the second period, firms set their prices and advertising expenditures for the period and then, consumers buy.[12]

Before moving into the analysis of the model, let us introduce some final notation. Let r_h and r_l, with $r_h > r_l > 0$, be the marginal return to a carmaker from selling one car when the firm's type has been publicly observed to be either G or B, respectively. In the case the type of the car has not been disclosed yet, we denote the return by $r > 0$.[13] Additionally, let c_h and c_l be the cost of a high and low advertising campaign. Without loss of generality, we assume $c_l = 0$ and $c_h > 0$, and refer to c_h simply as c. Last, we denote by δ the players' (common) discount factor.

[11]More precisely, in period 1 the representative consumer buys from the firm that best serves his preferences, for example, given by ordering scenario II. The deceptive behaviour of firms affects the consumer's purchasing choice in period 2, conditioned on the consumer being indifferent between the cars produced by the two firms in that period. For example, if the two firms advertise as GF in period 1 and one is shown to have lied, consumers stop purchasing from that firm in period 2. Similarly, if one firm advertises as GF, the other as GU, and the former is shown to have lied, consumers buy from the latter firm in period 2.

[12]Two technical comments. First, since consumers are Bayesian (i.e., rational), once they know that a product is of a certain quality, they buy according to the revealed quality of the product and not according to the firm's advertising strategy. This means we do not allow advertising to persuade a consumer that has hard evidence about the quality of a product. Second, since advertising is costly and the game finishes after period 2, it is not rational for firms to advertise in the second period. Thus, in equilibrium, advertising only occurs in period 1.

[13]Implicitly, it implies carmakers can only price discriminate in period 2 (alternatively, we can easily assume they can price discriminate in period 1 but consumers' beliefs are constant in prices). The possibility to price-discriminate in period 2 increases second period gains of high-quality carmakers with cars consumed in period 1. Because in equilibrium advertising is a signal of quality that increases consumption, the possibility to price-discriminate in period 2 boots the incentives of high-quality firms to advertise in period 1. This assumption is however not crucial for the results. See discussion after **Proposition 1**.

2.2 | Analysis

The objective of this section is to analyse the potential effects of an information shock on the advertising strategies of firms in the market. Note that due to the nature of the model—two-period game—we can only capture short-term implications of the information shock.

Technically, the analysis of this section commands a study of the equilibrium behaviour of the firms both in the absence of an information shock (pre-*Dieselgate* scenario) and in the presence of the shock (post-*Dieselgate* scenario). For the pre-*Dieselgate* scenario, figures of Table 1 will reveal that advertising expenditure was far higher for V*olkswagen Group* than for its competitors. Additionally, evidence discusses in Section 2.3 suggests that *VW* cars were perceived as of higher quality than its competitors. Accordingly, in the present section we will study the conditions under which firms of different quality optimally choose to expend differently in advertising. In particular, we will focus on the conditions under which the strategy profile "good-type firms (G) advertise high and bad-type firms (B) advertise low"—hereafter referred to as SP (standing for separating profile)—constitutes an equilibrium. For the post-*Dieselgate* scenario, findings of Section 5 will show that all carmakers—*VW* and its competitors—changed their advertising strategies in the aftermath of the scandal. Accordingly, in the present section we will study the conditions under which firms optimally react to a scandal by reformulating their advertising strategies.

Next, we present the results for the two aforementioned scenarios. Technically, the first scenario corresponds to $\chi = 0$ (pre-*Dieselgate* scenario), and the second one to $\chi = 1$ (post-*Dieselgate* scenario).

For the pre-*Dieselgate* scenario, we obtain the following result.

Proposition 1 *Consider* $\chi = 0$. If $r - \alpha_B \delta\, r_l \leq 2c \leq r + \alpha_G \delta\, r_h$, *the profile SP is a PBE. In this equilibrium, a firm's advertising expenditure is a signal of its quality.*

Proof See the Appendix.

This result states that if the conditions above hold (briefly, the advertising cost is neither too high nor too low), there is an equilibrium in which independently of a firm's environmental values, it advertises high when its product is good-quality and advertises low otherwise. It also states that this equilibrium is more likely to exist the more patient firms are (high δ) and the higher future returns (high r_h and r_l).

For the post-*Dieselgate* scenario, we obtain the following result, with threshold $\bar{c}$ being derived in the Appendix.[14][15]

[14] Note that, in equilibrium, the situation at hand ($\chi = 1$) is equivalent to a situation in which firms make their advertising choices after the external auditor has disclosed the information. To see it, simply note that in our model, in equilibrium, firms anticipate that their types in the second dimension will be known by consumers by the time they make their purchasing decisions. Since consumers' information is the same in the two setups, consumers' decisions cannot change, neither firms' payoffs.

[15] The value is $\bar{c} = \max\{r - \alpha_B \delta\, r_l, \min\{\alpha_U r + \alpha_{GU} \delta\, r_h, \alpha_F r + \alpha_{GF} \delta\, r_h\}\}$.

Proposition 2 *There exists threshold* $\bar{c}$*, with* $0 \leq \bar{c} \leq r + \alpha_G \delta r_h$*, such that*:

i. *For all c satisfying* $\bar{c} \leq 2c \leq r + \alpha_G \delta r_h$*, the profile SP is a PBE when* $\chi = 0$ *and it is not when* $\chi = 1$*. In the latter case, there is at least one good-type firm that benefits from reducing its advertising expenditure and one bad-type firm that benefits from increasing it.*
ii. *For all c satisfying* $r - \alpha_B \delta r_l \leq 2c \leq \bar{c}$*, the profile SP is a PBE both when* $\chi = 0$ *and* $\chi = 1$.

Proof See the Appendix.

This proposition presents the main result of the theoretical analysis, stated in point *i*. The result describes the equilibrium conditions under which the revelation of (negative) information about a firm's environmental practices breaks down the SP equilibrium, inducing the high-quality firm wrecked by the scandal to reduce advertising and the other firm to increase advertising. The second point of the proposition describes the conditions under which the SP profile remains an equilibrium after the scandal, that is, optimal advertising strategies do not change. Worth noting, whether we are in the first or the second scenario depends on the value of *c*, as compared to $\bar{c}$ (c.f. footnote 15). We note that the smaller $\bar{c}$ is, the more likely we are in the first scenario. Additionally, the more different the groups of environmentally friendly and unfriendly firms in the industry are, the smaller $\bar{c}$ is. This means that the more different α_F and α_U are, the more likely it is that firms' advertising strategies change after a scandal. In words, after a scandal, firms would optimally react by changing their advertising strategies when the proportion of firms with the same environmental values is sufficiently large, that is, when the firm's product has a sufficiently large number of substitutes. In the limit, when all the firms are identical in the environmental dimension (either α_U or α_F tend to 1), the conditions for the profile SP being a PBE when $\chi = 0$ and not when $\chi = 1$, are the same. In this case, a scandal will very likely produce an earthquake in advertising practices.[16]

For a rationale for this result, note that the damage incurred by the firm wrecked by the scandal depends on the elasticity of its demand, which determines how much consumers the firm can lose due to the scandal (market share at risk). Furthermore, note that the higher the number of substitutes of the firm's product, the higher the firm's demand elasticity; hence, the higher the potential damage of the scandal. Besides, a larger loss of market share translates into a larger reduction of the firm's gross revenues from advertising (due to less consumers of the product), which—under some sort of fixed costs of advertising

[16]Related to this idea, **Proposition 3** in the **Appendix** shows that there exists threshold $\underline{c}$, *with* $0 \leq \underline{c} \leq r - \alpha_B \delta r_l$, such that for all $\underline{c} \leq 2c \leq r - \alpha_B \delta r_l$, the profile SP is not a PBE when $\chi = 0$ and it is when $\chi = 1$. We further show that $\underline{c}$ is higher the more different the proportion of friendly and unfriendly firms in the industry is. In the limit, when either $\alpha_F \to 1$ or $\alpha_F \to 0$, we have $\underline{c} \to r - \alpha_B \delta r_l$; that is, it is impossible that the profile SP is not a PBE when $\chi = 0$ and it is when $\chi = 1$. This result reinforces the idea in the text that the eruption of an information shock drives reformulation of firms' advertising strategies.

—implies a reduction of the per unit return on advertising spend.[17] In a model where advertising is informative, the reduction of the firm's return from advertising reduces the gain from advertising and so the incentive to advertise.[18]

2.3 | Hypothesis for the empirical analysis

The first prediction of the model comes from **Proposition 1** and says that if before *Dieselgate* carmakers were using advertising as a signal of a car's quality, we should expect higher-quality carmakers to expend larger amounts on advertising than lower-quality carmakers. Our premise is that *Volkswagen Group* was a high-quality carmaker, according to which we should expect *VW* to spend more on advertising than other carmakers before *Dieselgate*. Support for this premise comes from the observation that *VW Group's* campaigns usually appeal to "German engineering" as proof of reliability and they target customers with medium to high purchasing power. It also comes from the observation that the *VW Group* has repeatedly campaigned on the quality of its products, using it as a differentiating feature.[19]

Additionally, also according to **Proposition 1**, we should observe consumers to react to advertising, consuming more from firms that advertise higher. The rationale for the latter result comes from consumers liking quality and advertising being, in equilibrium, a signal of quality.[20] Under these premises, higher advertising signals better quality product; hence advertising attracts consumption. The next statement announces the hypothesis:

H1 *Before Dieselgate,* higher-quality carmakers, for example, *Volkswagen Group,* advertise and sell more than lower-quality carmakers.

Data in Section 4, Table 1, shows that, by large, *Volkswagen Group* is the car manufacturer that spends most on advertising before the scandal, being also the carmaker with the largest

[17]To see why a reduction of the firm's gross revenues from advertising implies a reduction of the per unit return on advertising spend, consider a firm with some sort of fixed costs in advertising. From the Return on Advertising Spend (ROAS) metric, defined as $\text{ROAS} = \frac{\text{Gross revenue from ad campaign}}{\text{Cost of ad campaign}}$, we observe that a decrease in the firm's market share reduces ROAS numerator. If the denominator does not decrease a lot (e.g., for the existence of some sort of fixed costs), then ROAS value decreases, that is, per unit return on advertising spend decreases.

[18]To see why, note that when advertising is informative—not persuasive—advertising cannot affect consumers' preferences and persuade deceived consumers to buy a product that they know it is of bad quality (when there is a product of good quality in the market). It implies that a firm wrecked by a scandal cannot increase its market share by increasing advertising, as it cannot change consumers' preferences (this is in contrast to the view of advertising as persuasive, where this might be the case).

[19]Examples are the 1960s advertising campaign entitled "We pluck the lemons, you get the plums", which left a lasting legacy in America–the use of the word "lemon" to describe poor quality cars is now commonplace in business; or the slogan "Fahrvergnügen" (driving pleasure), promoted in the 1990s in the US to express the unique feeling of driving a *Volkswagen*. Finally, support for the premise that *VW* was perceived as a high-quality carmaker also comes from recognitions, such as *Volkswagen* brand being announced in 2004 by the *Guardian* newspaper to be among the 'Top 10 ethical car brands', or *Volkswagen* singling out on 2011 as a car manufacturer with outstanding environmental, social and governance (ESG) practices by the *Calvert Sustainability Research Department* (Rodhes, 2016).

[20]See the Appendix for a detailed description of the consumer's optimal choice, including the case of ties.

market share.[21] Additionally, equation [1] in Section 5.1 regresses sales over advertising to provide further support for this hypothesis.

The second and most robust prediction of the model comes from **Proposition 2** and says that if the number of substitutes of a (supposedly) environmentally friendly *Volkswagen* car is sufficiently high (in terms of the model, α_F is large enough), we should expect *Volkswagen Group* to reduce its advertising expenditure after *Dieselgate*, and the carmakers not affected by the scandal (hence, indirectly proven friendly) to increase adverting. The next statement announces the hypothesis:

H2 *If the number of environmentally friendly cars is large, the Volkswagen Group* will reduce advertising after *Dieselgate* and its competitors will increase it.

To test this hypothesis, first we provide evidence to support the premise that the *Volkswagen Group* had a large number of substitutes. Then, we use a Difference-in-Differences methodology to analyse the response of the *Volkswagen Group* and its competitors to the *Dieselgate* scandal, finding that after the scandal the *Volkswagen Group* decreased advertising and its competitors increased it. This analysis is done in Section 5.2.

3 | BACKGROUND: THE *DIESELGATE* SCANDAL

Although early warnings about the pollution control standards of several car manufacturers had appeared both in the EU and US since 1998, it was not until September 18th, 2015, that the scandal broke out. The trigger for posterior events was the announcement of the US *EPA* that the *Volkswagen Group* had deliberately modified the results of their diesel vehicles emission tests. The modification consisted of installing an illegal software that detected the driving conditions of the vehicles to produce smaller noxious emissions, when it guessed that the vehicle was passing an emission control; artificially reducing by almost 40 times its emissions of nitrogen oxide, as compared to usual driving conditions.

The announcement of the EPA came as a shock, as only some years before, in 2008, the *Volkswagen Group* had launched an innovative 'Clean Diesel' advertising campaign with the aim of convincing consumers that their new diesel vehicles were environmentally friendly (Guckian et al., 2017). Just a few days after the scandal broke, on September 20th, the CEO of the company, Martin Winterkorn, reacted to the scandal and the increasing public concern by posting a video regretting the dishonest behaviour. Three days after, he resigned. At the same time, on September 22nd, the group admitted the installation of illegal software in more than 10 million vehicles sold around the world and made a provision of 6.5 billion dollars to face potential penalties and revision costs. That date, the stock of the company plummeted by 35%, losing 30 billion dollars in capitalization in less than a week.

The *Dieselgate*—as the press dubbed it—caused significant reputational damage to the company and soon became one of the biggest public image scandals that any multinational company has faced in recent years.[22] Apart from its legal and financial repercussions—the 14.7

[21] We also observe that the *Volkswagen Group* is the carmaker spending the most after the scandal. However, advertising patterns change after *Dieselgate*. For more discussion, see Section 4.

[22] An interesting summary of the case, including a detailed legal perspective, can be found in Frigessi (2017).

billion dollar settlement agreed to pay by the *VW Group* in 2016 was one of the largest civil settlements in the history of environmental law—the scandal led to one of the largest mandatory review and buyback programmes in the automobile history.[23] This process affected more than 11 million diesel vehicles sold between 2009 and 2015, which represented approximately 18% of the *Volkswagen Group* sales, and it implied the cessation of sales of all the company's diesel models in the United States, as well as significant changes in the production lines of other countries. The scandal also made that the *Volkswagen Group* experienced losses for the first time in 15 years, ceding its position as the world's leading vehicle producer (in terms of market value) to its arch-rival, *Toyota*. Finally, the *Dieselgate* scandal also had repercussions on legislation of firm's social and legal responsibility. It contributed to the EU redefining legislation on repurchasing and retrofitting cars from consumers and to the introduction of more effective collective measures of redress for consumers.[24]

In Spain—the country of the empirical analysis—the scale of the *Dieselgate* scandal was not smaller than in other countries in the world. According to the company, 683,626 automobiles were affected in Spain, where 257,479 were *Volkswagens*, 221,783 *Seats*, 147,095 *Audis*, 37,082 *Skodas*, and 20,187 *Volkswagen* Commercial Vehicles. This was a hard hit on the *Volkswagen Group*, which by the end of September 2015 was the Spanish automobile market leader, having registered sales growth of more than 28%, above the industry average.[25] However, the hit on sales in the posterior moths differed between *VW* commercial brands: while sales of *Volkswagen* and *Audi* dropped, sales of *Seat* increased (see Table 2). This differential effect on *Seat* might be partially explained by the Spanish origin of this brand and the *VW Group* being a significant employer in Spain, which could have translated into a "home bias" loyalty effect that endures nowadays. We discuss these ideas in more detail in Section 5.2.3.

Beyond these particular features, there is no other aspect that makes the Spanish market different from the other European national markets. For example, the response to the scandal in Spain both from national authorities and the public was similar than in other countries. Note that in terms of legislation and the judicial system, Spain is under the umbrella of the EU law, which guarantees some common regulation within the EU. Additionally, Spanish authorities did not limit the sales of polluting vehicles, in line with other EU and Western countries.[26] On the other hand, in terms of public debate, the *Dieselgate* scandal coped Spanish media outlets and transcended to public opinion, sparking public debate as much as it did in other countries. We support this claim in the results from an analysis of public sentiments about *Dieselgate* that we performed for Spain, Germany and the region 'All over the world'. Using Google Trends frequency searches of the term '*Dieselgate*' for the period January 2014–December 2016, we

[23] In 2023, the case is still far from over from a judicial point of view. The opening of a trial against *Audi* executives was announced in 2020, paving the way for further compensation for the affected consumers. In countries such as Spain, the legal proceedings continue nowadays, with the *Spanish Supreme Court* having imposed in June 2021 a substantial fine on *Volkswagen* for this reason. Even the *European Union* accused *Volkswagen* of 'playing for time' and not compensating all victims of the *Dieselgate* scandal. A recent review of the lasting effects of this case can be found in Alberini and Vance (2023).

[24] The EU law has responded to *Dieselgate* by reviewing the controversial EU Regulation No. 2016/646 that introduced a "temporary conformity factor" of 2.1 (equivalent to a 110% increase on the current limit), to be applied for NOx in the new testing cycle, and the works of the EU committee of inquiry into Emissions Measurements in the Automotive Sector (EMIS).

[25] See "*Volkswagen* admits 683,626 vehicles affected by emissions scandal in Spain", *El País*, 1st October 2015.

[26] As far as we know, exceptions are Switzerland and the US, where governmental authorities imposed limits to sell the recalled product.

obtained similar frequencies for all the regions: Pearson correlations of 0.76 for Spain-Germany, and 0.8 for Spain-All over the world.[27] These facts suggest that—with the usual caveat—the use of Spanish data should not limit the generality of our results.

4 | DATA

The empirical analysis uses monthly data for the Spanish market for the period January 2014–December 2016, which makes 20 months before the *Dieselgat*e scandal (September 2015) and 16 months after the scandal. For data about advertising, we used **INFOADEX** (www.infoadex.es)—a privately developed webtool containing detailed information of the Spanish advertising market and covering different sectors and media outlets. In particular, we collected monthly data on advertising expenditure in Spanish media outlets of the *Volkswagen Group* (which includes its main commercial brands: *Volkswagen*, *Audi*, *Seat* and *Skoda*), the other German carmakers (that includes *Mercedes-Benz*, *BMW* and *Porsche*),[28] and the most relevant non-German car manufacturers (that includes firms such as *Renault, Ford, Fiat, Hyundai, Kia, Peugeot,* etc). We also collected data from **INFOADEX** on advertising expenditure by over 100 firms operating in other sectors (banks, airlines, retailers, etc.), to be used as a control in the posterior analysis.

For data about sales, we collected data from **FACONAUTO** (www.faconauto.com)—the official association of car dealers in the Spanish market—on monthly sales by the *Volkswagen Group* and the other car manufacturers. Data on advertising is aggregated at the manufacturer level—for the *VW Group*, data is aggregated in two levels: *VW-Audi* and *Seat*—whereas data on sales is available at the commercial brand level. Table 1 presents descriptive statistics of the dataset.[29]

It can be noted that, by large, the *Volkswagen Group* is the car manufacturer that on average spent the most on advertising before the scandal. We also observe that after the scandal the *Volkswagen Group* spent more on advertising than its competitors. However, in this period, the *Volkswagen Group* reduced its advertising expenditure (from a monthly average of 788,211 euros before the shock to 562,333 euros after), whereas other carmakers increased theirs. In the case of the other German manufacturers, average expenditure rose from 212,240 euros per month before to 243,262 euros per month after, whereas for non-German car manufacturers it rose from 139,634 to 151,598 euros. It is also worth noticing that the standard deviation of the *Volkswagen Group's* expenditure after the scandal sharply increased, which is a clear hint of instability, whereas the standard deviation of the other car manufacturers remained quite stable. This discussion can be completed with figures of advertising expenditure per car sold. We observe that *Volkswagen Group's* expenditure per car is lower than its competitors, both before and after the scandal, probably due to some economies of scale. However, the decrease in

[27]The average index in Spain is 24% percentage points lower than in Germany, and 16.7 percentage points higher than in the region 'All over the world'.

[28]Porsche belongs to the *Volkswagen Group*. However, it has been separately considered because its relevant market segment (luxury cars) is quite different from the rest of the group.

[29]The descriptive statistics of sales correspond to the period January 2015–December 2016, which is the period we consider in our estimations of sales. See Section 5.2.3.

TABLE 1 Descriptive statistics of advertising expenditure and sales.

Sample	Before				After				
Panel A: Advertising expenditure									
Advertising expenditure (obs: 6656)	**Mean**	**S.D.**	**Min.**	**Max.**	**Mean**	**S.D.**	**Min.**	**Max.**	**V.R. (%)**
VW Group (2 brands)	788,211	269,619	155,732	1,304,710	562,333	396,938	182,239	1,732,813	−28.7
Other German car manufacturers (3 carmakers)	212,240	185,324	663	917,108	243,262	175,580	58	685,346	14.6
Non-German car manufacturers (15 carmakers)	139,634	146,907	41	822,426	151,598	144,911	3299	682,533	8.6
Control group (208 firms)	148,495	224,922	0	2,431,722	164,623	293,391	0	3,718,855	10.9
Panel B: Sales									
Sales (obs: 624)	**Mean**	**S.D.**	**Min.**	**Max.**	**Mean**	**S.D.**	**Min.**	**Max.**	**V.R. (%)**
VW Group	17,534	4848	8859	26,001	18,518	4529	11,051	26,628	5.6
Volkswagen	7054	1791	4109	9963	6885	2448	663	13,353	−2.4
Audi	3193	1290	183	4904	3680	1791	304	7428	15.3
Seat	5705	2457	305	9329	6592	2624	61	11,535	15.5
Skoda	1580	648	113	2885	1802	756	209	3852	14.1
Other German car manufacturers (2 brands)	1694	1354	1	4136	2240	1807	0	5403	32.2
Non-German car manufacturers (20 brands)	1065	1892	0	10,827	1288	2179	0	12,361	20.9

Notes: The table presents descriptive statistics of the variables: mean, standard deviation (S.D.), minimum, maximum, and mean variation rate before/after (V.R.). Panel A presents data on advertising expenditure, aggregated at the manufacturer level, with frequencies: *Volkswagen Group* ($N = 72$), other German carmakers ($N = 108$), non-German carmakers ($N = 521$), and control group firms ($N = 5955$). Data on advertising corresponds to the period January 2014–December 2016. Panel B presents data on sales, disaggregated at the commercial brand level, with frequencies: *Volkswagen Group* ($N = 96$), other German carmakers ($N = 48$), and non-German carmakers ($N = 480$). Data on sales corresponds to the period January 2015–December 2016.

expenditure is much larger for the *VW Group* than for its competitors: 32% points decrease for the *VW Group,* versus 13 and 10% points decrease for the other German and non-German carmakers, respectively.[30]

With regard to sales, Table 1 shows that *Volkswagen Group* was also the group with the largest market share in Spain before the scandal. For the post-scandal period, we observe that all car manufacturers increased their monthly sales, which can be explained by Spain's better economic indicators in 2016, as compared to those in 2015 (Spanish GDP per capita increased from 25,789 USD in 2015 to 26,616 USD in 2016); with *Volkswagen Group* still being the group with the largest market share. However, we observe that while the increase in sales in the *Volkswagen Group* amounts to a mere 5.6% (with a decrease of 2.4% in the *Volkswagen* brand), the sales of the other German car manufacturers increased by 32.2%, and those of the non-German carmakers by 20.9%.

5 | EMPIRICAL ANALYSIS

In this section, we analyse how the *Dieselgate* scandal affected the advertising expenditures of the *Volkswagen Group* and the other car manufactures in the Spanish market, and whether the empirical results support our theoretical predictions of Section 2, stated in hypothesis **H1** and **H2**. We start exploring the relationship between advertising and sales, looking for support for **H1**. This is done in Section 5.1. The empirical test of **H2** is done in Section 5.2.

5.1 | The relationship between advertising and sales

Hypothesis H1 states that before *Dieselgate*, high-quality carmakers advertise and sell more than low-quality carmakers. Our premise is that before the scandal, the *Volkswagen Group* was perceived as a high-quality carmaker. As previously discussed in Section 3, we find support for this premise in the observation that the *VW Group* repeatedly campaigned on the quality of its products, using it as a differentiating feature (c.f. footnote 19), frequently appealed to "German engineering" as proof of reliability, and targeted customers with medium to high purchasing power.

Given this support and according to **H1**, we should observe the *Volkswagen Group* to advertise higher and sell more cars than the other carmakers before *Dieselgate*. The underlying argument is the informative role that advertising has in our theoretical framework, a feature that requires firms to spend differently on advertising (as it is the case in the separating equilibrium of **Proposition 1**) so that advertising is a credible signal of a firm's quality.[31]

[30] Expenses per car sold were 45, 125, and 131 euros for *VW Group*, other German, and non-German car manufacturers, respectively, before the scandal. After the scandal these figures are 30, 109, and 118 euros, respectively. This makes a change of 32 percentage points decrease for the *VW Group*, 13 percentage points decrease for other German carmakers, and 10 percentage points decrease for non-German carmakers.

[31] Recall that a strategy profile is a PBE if the following two conditions hold: i) the strategy profile is sequentially rational given the beliefs, and ii) beliefs are consistent with the strategy profile. In other words, for advertising to be a signal of quality it should be the case that i) consumers perceive firms that advertise higher as of better quality and ii) firms of better quality indeed choose to advertise higher than firms of lower quality. When these conditions hold, there is a separating equilibrium where advertising is a signal of a firm's quality. For the argument to work we also need that ceteris paribus, consumers prefer products of better quality, which is a natural assumption.

A first piece of evidence in favour of this hypothesis comes from Table 1, where we observe that before *Dieselgate*, the *Volkswagen Group* was the car manufacturer that on average spent the most on advertising and had the larger market share (higher frequency of sales). This suggestive evidence translates into the correlation coefficient, obtaining a correlation value of 0.63 points between advertising expenditure and sales. A similar result is obtained if we compute correlation values for the period before *Dieselgate* (0.7 points) and the period after *Dieselgate* (0.54 points).

To explore the relationship between advertising expenditure and sales a bit more in detail, next we estimate the number of registered cars at the brand level as a function of advertising expenditure. In the estimation we control for per capita gross domestic product in Spain,[32] include a trend variable—that increases monthly, in order to control for potential seasonal tendencies in this market—and monthly fixed effects. The estimated equation is:

$$\text{Sales}_{it} = \beta_0 + \beta_1 \text{Advertising Expenditure}_{it} + +\beta_2 \text{GDPpc}_t + \beta_3 \text{Trend}_t + \sum_i \text{Monthly FE}_{it} + \varepsilon_{it} \quad (1)$$

We use the ordinary least squares (OLS) method, robust to heteroskedasticity and clustered by brand, and report the estimates in Table 3 below. We estimate three models. In **Model 1** we

TABLE 2 Difference-in-differences estimations. (Ln) Sales of the *VW Group* brands years 2015 and 2016.

	Model 11
Audi	0.78*** (0.19)
Seat	0.77*** (0.19)
VW	1.47*** (0.19)
Skoda	−0.14 (0.20)
After	0.08 (0.09)
DiD estimator *Audi*	−0.15* (0.09)
DiD estimator *Seat*	0.43*** (0.09)
DiD estimator *VW*	−0.24** (0.09)
DiD estimator *Skoda*	0.03 (0.09)
Monthly fixed effect	Yes
Year dixed effect	Yes
Constant	7.28*** (0.23)
Observations	624
F test	-
R^2	0.12

Notes: Difference-in-Differences estimations of sales of the *Volkswagen Group* brands in logarithms. Robust Standard errors clustered at the brand level in parenthesis.

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

[32] In thousands of euros per person (yearly data). **Models 2** and **3**, which consider shorter periods, do not present the coefficient for this variable. Source: *Instituto Nacional de Estadística* (www.ine.es).

use the whole sample, whereas **Models 2** and **3** use the subsamples corresponding to the pre- and post-*Dieselgate* periods, respectively. In the three models we obtain a positive and significant relationship (at the one percent level) between the number of registered cars of a manufacturer and its advertising expenditure. We interpret these results as further evidence of correlation between advertising and sales, which provides additional support for hypothesis **H1**. We are however cautious and do not draw causality implications. For a literature that identifies causality from advertising to sales, see Clarke (1976), Lambin (1976), and Bagwell (2007).

5.2 | The effect of *Dieselgate*

Next, we proceed to test **H2**, which states that if the number of substitutes of the *VW Group* cars is sufficiently high, we should observe the *Volkswagen Group* to reduce advertising after *Dieselgate* and its competitors to increase it. Prior to testing this hypothesis, in the next paragraph we provide evidence from related literature to support the premise that the number of substitutes for the *VW Group* cars was sufficiently high.

In a highly relevant work, Berry et al. (1995) use data for the US automotive market for the period 1971–1990 to analyse, among others, own- and cross-price car elasticities, along with elasticities of demand with respect to vehicle attributes. They found that the demands for all the 2217 car models they considered in the sample were elastic (p. 879). They also found that cross-price elasticities were larger for cars with similar characteristics, as expected, and that the most elastically demanded cars were those in the most popular market segments, that is, the compact and subcompact models. Their posterior work Berry et al. (2004) provides more recent evidence for the US market, as Qin (2014) also does. The newer findings also point to the same direction. For the European market, Brenkers and Verboven (2006) estimate automobile demands, finding also significant cross-price elasticities between groups and segments. Only for luxury cars they find low substitution rates. Deng and Ma (2010) use data from China for the period 1995–2001 and compute within- and cross-group-price elasticities. Similar to previous works, they find that within-group-price elasticities are much higher than cross-group elasticities, and that the segments with the highest elasticities are those of compact cars, in line with Berry et al. (1995). As a side comment, note that the *VW Group* produces many models in the compact and subcompact categories—for example, *Golf, Polo* and *Tiguan* in *Volkswagen; A1, A3,* and *A5* in *Audi; Ibiza* and *León* in *Seat*; and *Fabia* and *Yeti* in *Skoda*—with many of these models having been affected by *Dieselgate* in Spain.[33] Finally, Jiménez et al. (2019) showed that by the time of the *Dieselgate* scandal, car manufacturers such as *Toyota*, *Nissan* were producing cars with similar characteristic to those of *VW* affected by the scandal.[34]

Given this support for the premise, next we aim to identify the effect of *Dieselgate* on the advertising strategies and sales of the *VW Groups* and its competitors. We do this in the coming sections. In particular, in Section 5.2.1 we describe the empirical strategy that we use to identify the effect of *Dieselgate* on firms' advertising strategies. Then, in Section 5.2.2 we study the effect of *Dieselgate* on advertising and in Section 5.2.3 we analyse the effect on sales.

[33]See https://www.diariomotor.com/2015/09/25/lista-vehiculos-afectados-dieselgate-volkswagen/ for a list of the models affected in the Spanish market.

[34]The authors proceed by mining data from *Emissions Analytics* (https://www.emissionsanalytics.com/)—a British independent company that tests real vehicle emissions. Also, Trump and Newman (2017) showed that in the aftermath of *Dieselgate*, consumers perceived other German carmakers as being 'similar competitors' to *VW*.

5.2.1 | Empirical strategy

To analyse the effects of the *Dieselgate* scandal on the advertising strategies of the *Volkswagen Group* and its competitors, we propose a Difference-in-Differences (DiD) approach. The DiD methodology looks for causal inference, by comparing a group affected by an intervention or shock (i.e., the treated group) with the counterfactual group (i.e. the treated group, had the shock not occurred). When the counterfactual scenario does not exist, as is quite often the case, the DiD methodology requires to find an unaffected group with similar behaviour to the treated group in the pre-shock scenario.

As a first approach, we might consider the *Volkswagen Group* as the treated group and its competitors as the control group. However, this specification presents two drawbacks. First, it would not allow us to identify possible effects of the *Dieselgate* scandal on *VW* competitors, something that we are interested in. Second, had the *Dieselgate* also affected *Volkswagen*'s competitors, the estimation might be bias. Then, we build the control group with firms from sectors other than the automotive sector. To select these firms, we use data from INFOADEX and perform a 'matching analysis' to identify which manufacturers for sectors other than the automotive, exhibited similar advertising expenditures to the *Volkswagen Group* and its competitors in the period before *Dieselgate*.[35] We order the programme to choose 15 firms for each firm in the treated group (the *VW Group*, the other German carmakers, and the non-German carmakers, depending on the estimation). To select the firms in the control group, we ask them to meet two conditions: (i) the firm's average monthly advertising expenditure in the pre-scandal period was similar to that of the firm in the treated group and; (ii) the firm's average monthly advertising variation rate during the pre-scandal period was also similar to that of the firm in the treated group.[36] Thus, our sample contains 15 control pairs for each of the car brands we considered, which approximately represents 6600 observations in total.[37] The control group —including Spanish firms from several sectors such as banking (*Banco Santander*, BBVA, BANKINTER, etc), finance (COFIDIS), air transport (IBERIA, AIR EUROPA, etc.), public administration (CORREOS, *Loterías*, etc.), and hotels (NH group), among others—remains the same for each car brand during the whole period. We check the robustness of this group in Section 6.

For the control group that results from the matching analysis, we check the 'parallel pre-trends hypothesis.' This test states the validity of the control group by requiring the advertising expenditure trends of the treated and the control groups in the pre-intervention period to be statistically not different. To test the 'parallel pre-trend assumption' we follow the procedure by Galiani et al. (2005). The procedure requires to estimate the following OLS model (equation [2] below) and then use the estimates to perform the parallel pre-trends test (Ho: $\beta_3 = \beta_4$).

[35] As explained, we use other sectors as a control to avoid the possible interdependence between *Volkswagen* and other companies. Other key assumptions for the Difference-in-Differences are also met in order to produce consistent estimates. In particular, with respect to the 'Stable Unit Treatment Value Assumption' or SUTVA, which requires no spillovers between units' outcomes (i.e., that *Dieselgate* did not affect non-*Volkswagen*). We assume this is true when including non-automotive firms as the control group.

[36] We use average treatment effect and impose that condition i) must satisfy 'exactly'. We also implemented two robustness checks in order to test the validity of the matching outcome.

[37] When a firm in the control group is matched with more than one firm in the treated group, the programme eliminates this firm from the control group. This explains why the number of observations in the control group is approximately 6600. It implies there are no repeated observations in the control group; hence, no concerns with the standard errors of the estimation.

$$\begin{aligned}\mathrm{Ln(Adv)_{it}} = {} & \beta_0 + \beta_1 \mathrm{TreatedBefore}_i + \beta_2 \mathrm{ControlBefore} + \beta_3 \mathrm{TreatedBefore} * \mathrm{Trend}_i \\ & + \beta_4 \mathrm{ControlBefore} * \mathrm{Trend}_i + (\text{similar variables for After period}) + \varepsilon_{\mathrm{it}}\end{aligned} \tag{2}$$

We perform the test for all the treated groups that we consider. The results of the tests reveal that we can always accept the null hypothesis, which means we can assert that the results of the DiD estimation will reflect the specific effect of the shock and not a different previous evolution of the two groups.[38] Figure 2 below provides a graphical representation of the pre-trends both for the treated group (all carmakers) and the control group (firms from sectors other than the automotive). As we can see, both groups behave in a similar way in the pre-scandal period. Similar patterns are obtained for the other treated groups.

Once verified that the trends are similar, in the next section we apply the Difference-in-Differences model to estimate the effect of *Dieselgate* on the evolution of the treated group with respect to the control group. We also carry out different robustness checks to check the validity of the estimated models.

5.2.2 | The effect of *Dieselgate* on advertising expenditure

This section tests the main prediction of the theoretical model, formulated in **H2**, which states that after *Dieselgate,* the *Volkswagen Group* reduced its advertising expenditure and its competitors increased it. Figure 3 below provides a graphical description of all carmakers advertising expenditure, differentiating between the *Volkswagen Group* and its competitors. A first observation is that the pre-*Dieselgate* trends between the *VW Group* and its control group are similar. A second observation is that after *Dieselgate*, advertising expenditure decreased for the *Volkswagen Group* and slightly increased for the other car manufacturers. Despite the drop in advertising of the *VW Group*, its trend is upwards, mainly due to large advertising expenditures in November–December 201.

Following the procedure described in the previous section, we use monthly data from **Infoadex** (in logarithms), to estimate the following Difference-in-Differences model:

$$\begin{aligned}\mathrm{Ln(Adv)}_{it} = {} & \beta_0 + \beta_0 \mathrm{Treated}_i + \beta_2 \mathrm{After}_t + \beta_3 \mathrm{DiD}_{it} + + \sum_{j=4}^{15} \beta_j \mathrm{Month} + \sum_{j=16}^{17} \beta_j \mathrm{Year} \\ & + \sum_{j=18}^{225} \beta_j \mathrm{Advertiser} + \varepsilon_{\mathrm{it}}\end{aligned} \tag{3}$$

where *i* refers to the firm (treatment or control) and t ∈ {1,...,36} to the time (in months). We include month fixed effects, year fixed effects, and advertiser fixed effects. To test for potential effects of the *Dieselgate* scandal on other carmakers, we consider separately the *Volkswagen Group*, the other German car manufacturers (*Mercedes-Benz*, *BMW,* and *Porsche*), and the other non-German car manufacturers (that includes firms such as *Renault, Ford, Fiat, Hyundai, Kia, Peugeot,* etc).

[38] All the estimations have as control group the group of firms resulting from the matching analysis previously described. The results of the parallel trend tests are: i) Treated group is "All carmakers": *Prob* > *F* = 0.79; ii) Treated group is "*VW*": *Prob* > *F* = 0.9407; iii) Treated group is "Other German carmakers": *Prob* > *F* = 0.74; and iv) Treated group is "Non-German carmakers": *Prob* > *F* = 0.89.

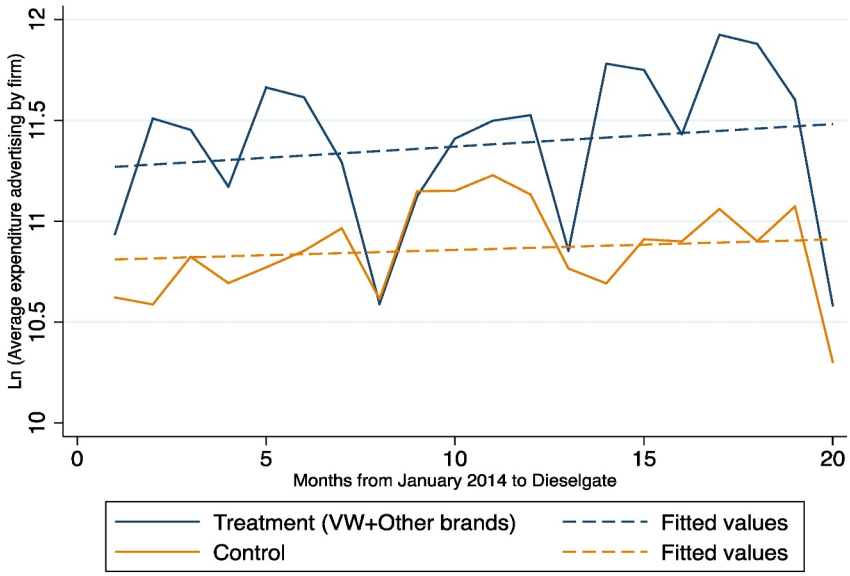

FIGURE 2 Advertising expenditure trends *before Dieselgate* (in monthly logs). Advertising expenditure trends from January 2014 to *Dieselgate* (September 2015) for the treated and the control group. The source of data is **INFOADEX**.

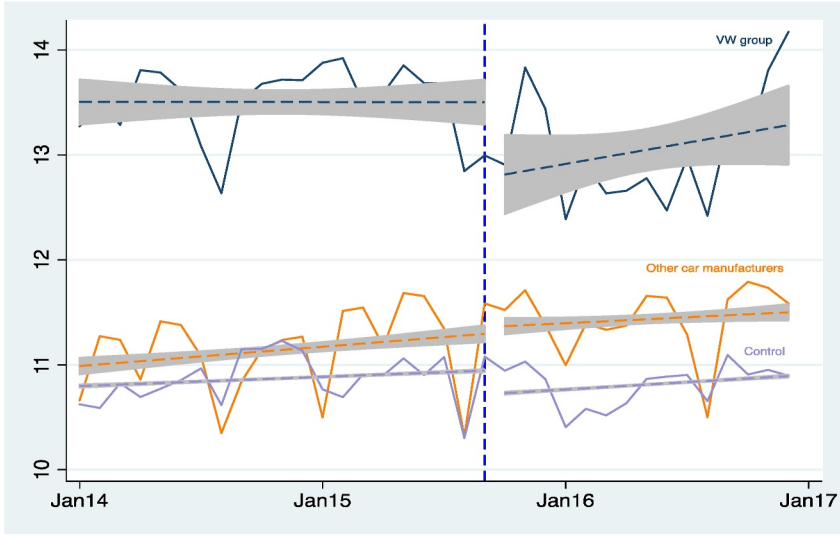

FIGURE 3 Advertising expenditure trends before Dieselgate (in monthly logs)—disaggregated by treated groups. Advertising expenditure trends from January 2014 to December 2016 for the *VW Group* and the other car manufacturers. The dashed-blue-vertical line corresponds to the shock (*Dieselgate* scandal). The dashed-horizontal lines represent fitted values, with confidence intervals. The source of data is **INFOADEX**.

We estimate three models, which are shown in Table 2. **Models 4** and **5** differ in the inclusion of month and year fixed effects. **Model 6** aims to closely understand the temporal effect of *Dieselgate* on advertising expenditures, as it might be that the effect is not constant throughout the post-scandal period. To test this hypothesis, in **Model 6** we divide the post-

Dieselgate sample into three sub-periods of 5 months each, differentiating between the short, the medium, and the long run. We observe that the results across the three models are consistent and robust, and they confirm that the *Volkswagen Group* significantly reduced its advertising expenditure after *Dieselgate*, whereas the other carmakers increased theirs. These results are in accordance with **H2**.[39]

With respect to the temporal evolution of the effect, the estimates of **Model 6** for the *Volkswagen Group* suggest that this group significantly reduced its advertising expenditure in the first and second periods, by 42% and 64%, respectively (the effect in the third period is not significant). Regarding the other German car manufacturers, we find that they significantly increased their advertising expenditure in the first and second periods, by 58% and 62%, respectively (again, the effect in the third period is not significant). Lastly, non-German car manufacturers significantly increased their advertising expenditure in the second and third period, by 33% and 16%, respectively (the effect in the first period is not significant). These results suggest that *Dieselgate* had a strong and immediate effect on the advertising strategy of the *Volkswagen Group*, and a smaller and delayed effect on *VW's* competitors. The latter sought to take advantage of the momentum by increasing their advertising expenditure, with German carmakers being the first group to react, then followed by non-German carmakers.

Our theoretical framework provides a plausible rationale to explain these reactions, in particular why the *VW Group* decreased advertising whereas its competitors increase theirs. Briefly, when advertising is informative and the good has many substitutes, a firm wrecked by a scandal loses a large market share, which reduces its returns from advertising and the incentive to advertise. Its competitors, instead, can use advertising to position their products and steal deceived consumers.

Despite it, we acknowledge there are other reasons that might also help explain the observed changes in advertising patterns after the scandal. For example, the decrease in advertising of the *Volkswagen Group* could be due to the desire of *VW* to go unnoticed and let the crisis fade away (Utz, 2019). Although we consider it is a plausible argument that helps explain the reaction of the *VW Group*, the fact that it remains silent as for the reaction of its competitors suggests that it cannot fully explain the whole story. Another possible argument behind the decrease in advertising of the *Volkswagen Group* could be the financial restrictions imposed by *Dieselgate*. This explanation suggests that the decision to reduce advertising was not a *strategy* of the business group but it was somehow imposed. Here too, we see some drawbacks. In particular, we consider that the sequence of events and the evolution of the *Volkswagen Group* advertising spending after *Dieselgate* does not seem to match very well this alternative explanation. On the one hand, the *Volkswagen Group* did not have to face fines or payments to consumers immediately, so the company could have maintained (or even increased) its advertising spending during the first months of the scandal. As can be seen in Figure 3, the decrease in advertising spending of the *Volkswagen Group* occurred immediately, despite not suffering any financial restrictions in the first periods. On the other hand, the group's advertising spending gradually recovered, despite the fact that in these later periods the group did have to face fines and sales restrictions on some models, such as in the United States. This situation of greater financial stress did not, however, represent a restriction on advertising spending recovering to practically

[39]To strengthen the validity of these conclusions, we matched only the *Volkswagen Group* and two neighbours, re-estimating equation [3]. The new estimation had fewer observations than the previous one (only 216), but it also showed a significant and negative Difference-in-Differences coefficient.

TABLE 3 OLS estimation of advertising expenditure on car sales.

Sample:	Model 1 Whole period	Model 2 Before *Dieselgate*	Model 3 After *Dieselgate*
Advertising expenditure (monthly)	0.006*** (0.001)	0.007*** (9e-4)	0.006*** (0.001)
GDP per capita (yearly)	488.6 (897.4)	-	-
Trend	33.12** (10.41)	18.28 (15.2)	−0.14 (15.4)
Monthly fixed effect	Yes	Yes	Yes
Constant	−9186.11 (18,476.1)	1019.8** (427.1)	1938.7 (1052.1)
Observations	629	356	273
F test	579.59***	132.5***	63.09***
R^2	0.44	0.52	0.34

Notes: OLS estimates of the effect of advertising expenditure on car sales, clustered at the brand level. **Model 1** considers the whole sample (January 2014–December 2016), **Model 2** considers the sample corresponding to the pre-*Dieselgate* period (January 2014–*Dieselgate*), and **Model 3** considers the sample corresponding to the post-*Dieselgate* period (*Dieselgate*–December 2016). Robust standard errors clustered at the brand level in parenthesis.

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

reach pre-*Dieselgate* levels. If the *Volkswagen Group* had really modified its level of advertising spending solely because it had less financial capacity, we should expect that as fines were imposed and sales decreased, advertising spending would decrease, thus having a negative trend during the post-scandal period. However, what we observe is a sharp drop right at the time of the scandal, when the financial constraint would be weaker, and a subsequent recovery later, when the financial constraint would be stronger. Finally, as for *VW Group's* competitors, not directly involved in the scandal, they benefit from a positive shock in sales—as we show in the next section—so they could perfectly have kept the level of advertising constant. If they increased it, it is because *strategically* it was the best option, since the greater market share—due to deceived consumers—generated a greater return from advertising.

5.2.3 | The effect of *Dieselgate* on car sales

Last, in this section we study the effect of *Dieselgate* on car sales. To this aim, we use monthly data from **Faconauto** (in logarithms) that is available at the commercial brand level. We estimate the following Difference-in-Differences model:

$$\text{Ln(Sales)}_{it} = \beta_0 + \beta_1 \text{Treated}_i + \beta_2 \text{After}_t + \beta_3 \text{DiD}_{it} + \sum_{j=4}^{15} \beta_j \text{Month} + \sum_{j=16}^{17} \beta_j \text{Year} + \varepsilon_{it} \quad (4)$$

where i refers to the commercial brand and t ∈ {1,...,36} to the time (in months). We include month fixed effects and year fixed effects. We exclude from the sample commercial brands with market shares for the whole period lower than 0.5%–mainly, luxury cars. Our reduced sample covers 95% of total sales, which means that the limitation is not very restrictive.

The estimates of equation [4] are reported in Table 4. **Models 7** and **8** consider the post-*Dieselgate* period as one unit, whereas **Models 9** and **10** disaggregate this period into three periods: the short, the medium, and the long run. Additionally, in **Models 7** and **9** the treated

TABLE 4 Difference-in-differences estimations. (Ln) Sales. Years 2015 and 2016.

	Model 7	Model 8	Model 9	Model 10
VW group	0.73* (0.37)	0.73* (0.37)	0.73* (0.37)	0.73* (0.37)
Other German carmakers		0.14 (0.25)		0.14 (0.25)
After	0.05 (0.10)	0.03 (0.10)		
After period 1 (0–5 months)			0.32** (0.15)	0.26* (0.15)
After period 2 (6–11 months)			0.06 (0.22)	0.05 (0.21)
After period 3 (12–16 months)			0.39 (0.29)	0.30 (0.28)
DiD estimator *VW Group*	0.06 (0.16)	0.06 (0.16)		
DiD estimator other German carmakers		0.55*** (0.09)		
DiD (*VW* group) period 1			−0.28 (0.21)	−0.28 (0.21)
DiD (*VW* group) period 2			0.31 (0.21)	0.31 (0.21)
DiD (*VW* group) period 3			0.14 (0.15)	0.14 (0.15)
DiD (other German carmakers) period 1				0.44*** (0.09)
DiD (other German carmakers) period 2				0.50** (0.16)
DiD (other German carmakers) period 3				0.67*** (0.12)
Month fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Constant	7.26*** (0.24)	7.26*** (0.24)	7.16*** (0.30)	7.17*** (0.29)
Observations	576	624	576	624
Control group	Non-German carmakers	Other German and non-German carmakers	Non-German carmakers	Other German and non-German carmakers
F test	14.77***	-	-	-
R^2	0.10	0.10	0.10	0.11

Notes: Difference-in-Differences estimations of sales in logarithms. **Models 7** and **8** consider the whole post-scandal period. **Models 9** and **10** split the post-*Dieselgate* period into three subperiods: short (0–5 months), medium (6–11 months), and long run (12–16 months). Robust Standard errors clustered at the brand level in parenthesis.

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

group is the *VW Group*, whereas in **Models 8** and **10** the treated group is the *VW Group* and the other German carmakers. We observe that in **Model 7**, the DiD coefficient of the *VW Group* is not significant, which implies that the *Dieselgate* had no effect on the sales of the *Volkswagen Group* in the post-scandal period. Same in **Model 8**, where the DiD coefficient of the other German carmaker is however positive and statistically significant. It implies that the *Dieselgate* scandal had a positive and significant effect on the sales of the other German carmakers in Spain over the aforementioned post-scandal period.[40] **Models 9** and **10** consider shorter periods of time, to allow for the possibility that the effect of *Dieselgate* might not be constant throughout the post-scandal period. We find no statistically significant effect of the *Dieselgate* scandal on the sales of the *Volkswagen Group*, in any of the periods. However, in **Model 10** we find a positive and statistically significant effect of the scandal on the sales of other German car manufacturers. Although with cautiousness, the increase in sales of other German carmakers after *Dieselgate* suggest some degree of substitutability between the *Volkswagen Group* cars and these other carmakers in the Spanish case.[41]

Finally, in Table 2 (**Model 11**) we investigate whether the effect of the *Dieselgate* scandal on the sales of the *Volkswagen Group* was the same across all its commercial brands: *VW, Audi, Seat*, and *Skoda*.

We observe that the *VW* commercial brands strongly hit by *Dieselgate* in Spain were *Volkswagen* and *Audi,* in this order, both with drop of sales that are statistically significant. Sales of *Skoda* did not change and sales of *Seat*, instead, increased after the scandal. Noteworthy, the reduction in sales of the *VW* commercial brand in Spain—by 24% points—is similar to other drops in sales of *VW* cars in other markets. Ater and Yoseph (2022) found a reduction in sales of *Volkswagen* vehicles in Israel by 18% points, and Kuo and Shu (2021) obtained a reduction of sales of 20% points in Taiwan. The similarity of the results that we find for Spain with these other markets suggests that our results, although derived for the Spanish case, are quite general and can also be applied to other countries. Finally, according to Barrage et al. (2020)—who found that the sales of *BP* after the spill fell by 4.2% points, but significantly less in the regions where the company had previously strongly invested in green advertising—we could argue that drop in sales of the *VW Group* might have been higher had the group not invested in green advertisement before *Dieselgate*. The validity of this argument is however difficult to check; hence, it should be taken with caution. Despite it, had it been true, it suggests that companies may have incentives to invest in green advertising without it necessarily translating into real environmental policies.[42]

[40]This result is at odds with the finding in Bachmann et al. (2023) for the US market, obtaining that carmakers with 'made in Germany' label experienced significant reductions in sales (34.6%) and market value in the US during the first months after the scandal. Note that in contrast to Spain, US Authorities imposed limitations on the sales of polluting vehicles, which might affect consumers' behaviour.

[41]Two comments here. First, this result could be seen as further support to the premise behind hypothesis **H2**. However, we acknowledge that advertising expenditure changed during this period, so part of the change in sales could be due to the increase in expenditure, further to the *Dieselgate* scandal. Second, regarding the effect of the scandal on the sales of the *Volkswagen Group*, an interesting and complementary analysis would be to differentiate between the sales of gasoline and diesel vehicles, as it might be the case that the scandal had different effects on these vehicles. Unfortunately, there is no data available to test this hypothesis.

[42]In the second-had market, the literature has found that while *Volkswagen* vehicles affected by *Dieselgate* increase their offer significantly, lowering the price, unaffected vehicles (especially those with a higher price) decrease their offer. See Strittmatter and Lechner (2020) for a study of the German market, and Van de Bijgaart and Cerruti (2020) for a study of The Netherlands.

Before concluding, we elaborate on the reasons why the effect of *Dieselgate* on sales might have been different across *VW* commercial brands and, in particular, why the negative consequences were primarily concentrated on the *VW* brand. We see a number of reasons for this. First, out of the 683,626 automobiles affected by the scandal in Spain, 257,479 vehicles were of the *Volkswagens* commercial brand. This amounts to 37,7% points of the total number of affected cars, being the first commercial brand in terms of affected vehicles. This feature might have driven the attention of the media towards the *VW* brand, mostly referring to this brand and to the *VW Group* when talking about the scandal, and significantly less to the other affected commercial brands. This is the second reason. Indeed, text-analysis data for the Spanish public TV news *RTVE*, data available from *Verba* (*Civio*), provides supports for this claim. We use data for the period January 2014–December 2016 and compute the number of times that the Spanish public TV news mentioned a combination of the terms 'brand X', 'emissions', 'scandal', and 'fraud'. We find the following frequencies: 147 times for *Volkswagen*, 10 times for *Audi*, 15 times for *Seat*, and 3 times for *Skoda*.[43] Third, the *Volkswagen* commercial brand is the iconic commercial brand of the group, to the extent that it gives the name to the group. This fact might had further confused some consumers, leading them to see the scandal as exclusively or mostly affecting the *Volkswagen* commercial brand. Fourth, it might be that within the *VW* commercial brands, *VW* was the one mostly perceived by consumers as producing environmentally friendly vehicles—in terms of the model, it was mostly perceived as GU. We consider that all these reasons might help explain why the effect on sales was primarily concentrated on the *VW* brand.

Regarding the other commercial brands, the most striking fact is about *Seat*. Indeed, *Seat* vehicles were, in number, the second most affected by the fraud, only after the *VW* brand. In fact, out of the 683,626 *VW* automobiles affected in Spain, 221,783 were *Seat*, which amounts to 32,4% points of the total number. Despite it, sales of *Seat* increased in Spain after the scandal. We see two reasons for this. First, the aforementioned argument that the scandal might be understood by consumers as only (or mostly) affecting the *VW* brand, an argument that is in line with the ideas discussed by Guckian et al. (2017) for generic corporate scandals. Second, the Spanish origin of *Seat*, together with the close attachment that still nowadays Spanish consumers have with this brand—many models of this brand have names that evoke Spanish cities and monuments: *Leon*, *Toledo*, *Ibiza*, *Alhambra*, and *Tarraco*; and the production of these models is highly concentrated in Spain, with makes the *VW Group* a significant employer in Spain—might have produced a higher loyalty of Spanish consumers towards this brand, explaining the effect on sales of *Seat* vehicles.

6 | ROBUSTNESS CHECKS

Finally, in this section we test the validity of our main empirical results that refer to the effect of the *Dieselgate* scandal on the advertising expenditure of the *VW Group* and its competitors. We propose three robustness checks. Firstly, we modify the number of pairs used in the matching analysis for the control group of each car manufacturer. Secondly, we use as control group the group of non-German carmakers. Thirdly, we re-estimate the model using a group of 'fake' companies as the treated group.

[43]Data available from https://verba.civio.es/.

Regarding the first robustness test, we repeat the matching analysis considering now 3 and 9 neighbours, instead of the 15 neighbours initially considered. Then, we re-estimate equation [3]. Tables 5 and 6 below provide the results, where we can observe that the sign and the significance level of the estimates are maintained (with respect to results of Table 7). Table 5 presents the estimates of equation [3] using 3 neighbours, and Table 6 the estimates using 9 neighbours.

TABLE 5 Difference-in-differences estimations. (Ln) Advertising. Robustness check: Matched groups of 3 neighbours.

	Model 12	**Model 13**	**Model 14**
VW Group	2.1738*** (0.20)	2.1906*** (0.18)	2.22*** (0.18)
Other German carmakers	−1.5192*** (0.32)	−1.5024*** (0.31)	−1.57*** (0.31)
Non-German carmakers	−3.52*** (0.51)	−3.46*** (0.50)	−3.46*** (0.50)
After	−0.13*** (0.07)	−0.14*** (0.08)	
DiD estimator *VW Group*	−0.32*** (0.14)	−0.32*** (0.13)	
DiD estimator other German carmakers	0.46(*) (0.32)	0.46(*) (0.30)	
DiD estimator Non-German carmakers	0.25*** (0.09)	0.25*** (0.08)	
After period 1 (0–5 months)			−0.03 (0.11)
After period 2 (6–11 months)			−0.19 (0.22)
After period 3 (12–16 months)			0.01 (0.23)
DiD (*VW Group*) period 1			−0.49*** (0.16)
DiD (*VW Group*) period 2			−0.56*** (0.17)
DiD (*VW Group*) period 3			−0.18 (0.18)
DiD (other German carmakers) period 1			0.57* (0.32)
DiD (other German carmakers) period 2			0.83** (0.33)
DiD (other German carmakers) period 3			0.35 (0.56)
DiD (non-German carmakers) period 1			0.001 (0.11)
DiD (non-German carmakers) period 2			0.41*** (0.13)
DiD (non-German carmakers) period 3			0.23** (0.11)
Advertiser fixed effect	Yes	Yes	Yes
Month fixed effect	No	Yes	Yes
Year fixed effect	No	Yes	Yes
Constant	11.34*** (0.17)	11.01*** (0.18)	11.01*** (0.19)
Observations	2286	2286	2286
F test	94.21***	86.51***	82.60***
R^2	0.62	0.63	0.63

Notes: Difference-in-Differences estimations of advertising expenditure in logarithms, using 3 neighbours. **Models 12** and **13** consider the whole post-scandal period. **Model 14** splits the post-*Dieselgate* sample in three subperiods: short (0–5 months), medium (6–11 months), and long run (12–16 months). Robust Standard errors clustered at the brand level in parenthesis. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$, (*) $p < 0.12$.

TABLE 6 Difference-in-differences estimations. (Ln) Advertising. Robustness check: Matched groups of 9 neighbours.

	Model 15	Model 16	Model 17
VW Group	2.17*** (0.20)	2.18*** (0.18)	2.21*** (0.18)
Other German carmakers	−1.52*** (0.32)	−1.51*** (0.32)	−1.58*** (0.20)
Non-German carmakers	1.29*** (0.19)	1.30*** (0.17)	1.30*** (0.17)
After	−0.14*** (0.04)	−0.24*** (0.08)	
DiD estimator *VW Group*	−0.32*** (0.13)	−0.32*** (0.12)	
DiD estimator other German carmakers	0.47(*) (0.31)	0.46(*) (0.30)	
DiD estimator non-German carmakers	0.26*** (0.07)	0.25*** (0.06)	
After period 1 (0–5 months)			−0.23*** (0.08)
After period 2 (6–11 months)			−0.24 (0.15)
After period 3 (12–16 months)			−0.17 (0.17)
DiD (*VW Group*) period 1			−0.40*** (0.16)
DiD (*VW Group*) period 2			−0.55*** (0.15)
DiD (*VW Group*) period 3			−0.23 (0.17)
DiD (other German carmakers) period 1			0.67*** (0.32)
DiD (other German carmakers) period 2			0.84*** (0.32)
DiD (other German carmakers) period 3			0.29 (0.56)
DiD (non-German carmakers) period 1			0.09 (0.09)
DiD (non-German carmakers) period 2			0.42*** (0.09)
DiD (non-German carmakers) period 3			0.17** (0.08)
Advertiser fixed effect	Yes	Yes	Yes
Month fixed effect	No	Yes	Yes
Year fixed effect	No	Yes	Yes
Constant	11.34*** (0.17)	10.95*** (0.17)	10.96*** (0.18)
Observations	4728	4728	4728
F test	151.26***	129.18***	125.78***
R^2	0.62	0.64	0.64

Notes: Difference-in-Differences estimations of advertising expenditure in logarithms, using 9 neighbours. **Models 15** and **16** consider the whole post-scandal period. **Model 17** splits the post-*Dieselgate* sample in three subperiods: short (0–5 months), medium (6–11 months), and long run (12–16 months). Robust Standard errors clustered at the brand level in parenthesis. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$, (*) $p < 0.12$.

Regarding the second robustness test, we use as control group the group of non-German carmakers. This is why the number of observations is lower. Then, we re-estimate equation [3]. Table 8 below presents the results, where we observe that qualitative results do not change much with respect to results of Table 7.

TABLE 7 Difference-in-differences estimations. (Ln) Advertising. Matched groups.

	Model 4	Model 5	Model 6
VW Group	2.16*** (0.19)	2.17*** (0.18)	2.21*** (0.18)
Other German carmakers	1.10*** (0.21)	1.11*** (0.20)	1.07*** (0.20)
Non-German carmakers	1.30*** (0.18)	1.31*** (0.17)	1.32*** (0.17)
After	−0.11*** (0.03)	−0.24*** (0.07)	
DiD estimator *VW Group*	−0.35*** (0.13)	−0.35*** (0.12)	
DiD estimator other German carmakers	0.40** (0.21)	0.39** (0.20)	
DiD estimator non-German carmakers	0.22*** (0.06)	0.21*** (0.06)	
After period 1 (0–5 months)			−0.22*** (0.07)
After period 2 (6–11 months)			−0.21 (0.13)
After period 3 (12–16 months)			−0.21 (0.14)
DiD (*VW* group) period 1			−0.42*** (0.15)
DiD (*VW* group) period 2			−0.64*** (0.15)
DiD (*VW* group) period 3			−0.24 (0.17)
DiD (other German carmakers) period 1			0.58*** (0.21)
DiD (other German carmakers) period 2			0.62*** (0.24)
DiD (other German carmakers) period 3			0.28 (0.37)
DiD (non-German carmakers) period 1			0.05 (0.09)
DiD (non-German carmakers) period 2			0.33*** (0.08)
DiD (non-German carmakers) period 3			0.16** (0.08)
Advertiser fixed effects	Yes	Yes	Yes
Month fixed effects	No	Yes	Yes
Year fixed effects	No	Yes	Yes
Constant	11.33*** (0.17)	10.90*** (0.17)	10.90*** (0.17)
Observations	6622	6622	6622
F test	145.82***	131.08***	128.33***
R^2	0.61	0.63	0.63

Notes: Difference-in-Differences estimations of advertising expenditure in logarithms. **Models 4** and **5** consider the whole post-scandal period. **Model 6** splits the post-*Dieselgate* period in three subperiods: short (0–5 months), medium (6–11 months), and long run (12–16 months). Robust Standard errors clustered at the brand level in parenthesis.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Finally, regarding the third robustness check, we conduct a placebo test consisting of randomly selecting 16 companies, other than those in the automotive sector, to be in the treated group. In **Model 21** we added these firms to the treated group of carmakers. In **Model 22** the treated group is exclusively composed of the fake firms. Our hypothesis is that the DiD coefficients of these new estimations should not be significant. Otherwise, it would suggest the existence of some event, other than *Dieselgate*, taking placed in the period and affecting

TABLE 8 Difference-in-difference estimations. (Ln) Advertising robustness check: Control group of non-German carmakers.

	Model 18	Model 19	Model 20
VW Group	1.01*** (0.14)	5.63*** (0.49)	5.67*** (0.49)
Other German carmakers			4.50*** (0.50)
After	0.14*** (0.06)	−0.13 (0.11)	
DiD estimator *VW Group*	−0.60*** (0.14)	−0.57*** (0.12)	
DiD estimator other German carmakers		0.18 (0.20)	
After period 1 (0–5 months)			−0.02 (0.13)
After period 2 (6–11 months)			−0.05 (0.27)
After period 3 (12–16 months)			0.20 (0.29)
DiD (*VW Group*) period 1			−0.47*** (0.15)
DiD (*VW Group*) period 2			−0.97*** (0.15)
DiD (*VW Group*) period 3			−0.40** (0.16)
DiD (other German carmakers) period 1			0.53** (0.23)
DiD (other German carmakers) period 2			0.29 (0.24)
DiD (other German carmakers) period 3			0.11 (0.37)
Advertiser fixed effects	Yes	Yes	Yes
Month fixed effect	No	Yes	Yes
Year fixed effect	No	Yes	Yes
Constant	12.50*** (0.10)	7.37*** (0.50)	7.39*** (0.52)
Observations	701	701	701
F test	115.45***	84.81***	79.22***
R^2	0.73	0.77	0.78

Notes: Difference-in-Differences estimations of advertising expenditure in logarithms, using non-German carmakers as control group. **Models 18** and **19** consider the whole post scandal period. **Model 20** splits the post-*Dieselgate* period in three subperiods: short (0–5 months), medium (6–11 months), and long run (12–16 months). Robust standard errors clustered at the brand level in parenthesis.

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

advertising expenditures of the companies outside the automotive sector. It would imply that the effects we assigned to the *Dieselgate* scandal in equation [3] might be due to some other event. The results of this placebo test are presented in Table 9 and they support our results.

7 | CONCLUSIONS

In addition to strengthening a company's marketing capacity to sell its products or services, advertising has become an indispensable tool for crisis communication managers in the event of a public relations scandal, when it seriously affects a company's reputation. This strategic role of advertising has been previously studied in the literature, but it is still unclear to many

TABLE 9 Difference-in-differences estimations. Robustness check: Fake treatment group.

	Model 21	Model 22
Fake treated group	−1.09*** (0.19)	1.15*** (0.18)
After	−0.23*** (0.06)	−0.24*** (0.07)
DiD estimator fake treated group	0.11 (0.09)	0.13 (0.09)
Advertiser fixed effect	Yes	Yes
Month fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
Constant	10.90*** (0.17)	10.91*** (0.17)
Observations	6622	5957
Sample:	Whole sample	Sample of fake treated group
F test	131.72***	132.05***
R^2	0.63	0.61

Notes: Difference-in-Differences estimations of advertising expenditure in logarithms, using a random treated group. **Model 21** considers as treated group the group of all carmakers plus the fake group. **Model 22** exclusively considers the fake group as treated group. Robust standard errors in parenthesis.

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

organisations how to make the most of it, especially during a crisis, and what particular elements make it work for some companies and not for others.

This paper provides guidance in this regard. By considering advertising as a strategic investment that can inform consumers about the quality of the firms' products and generate benefits in the long run (see Enache & Srivastava, 2018), we identify the conditions under which the optimal response of a firm wrecked by a scandal is to increase or decrease this investment; the same applies to its competitors. We identify a key element in this decision, namely the substitutability of the product. The idea is that the larger the number of substitutes of the product that the firm wrecked by the scandal has, the more costly the scandal will be for the firm—the larger its loss of market share is. The prospect of lower market share reduces the firm's returns from advertising, hence its incentives to advertise. We believe that this simple intuition sheds light on the rationale behind firm's reactions after a scandal. An example is the *Dieselgate* scandal.

This is the purpose of the empirical part of the paper, where we analyse the response of the *Volkswagen Group* and its competitors to the *Dieselgate* scandal. In line with the theoretical framework, we find that while the *Volkswagen Group* reduced its advertising expenditures in the aftermath of the scandal, its competitors increased it. This result supports the theoretical finding, suggesting that the reaction of the *Volkswagen Group*—far from being irrational or suboptimal, as it might look at first sight—could have been rational and optimal. Besides, the empirical findings on the behaviour of the *VW Group's* competitors provide further support for the theoretical results.

We acknowledge there might be other reasons that could also help explain the decrease in advertising of the *VW Group*. An alternative argument that we discuss in the paper is that the *VW Group* may have reduced this expenditure in the provision of important fines to pay. As we argue in the paper, we do not consider this to be a very plausible argument—the sequence of

events tells that the *VW Group* strongly decreased advertising right after the scandal, when litigation costs and fines were less important, and increased it afterwards. Despite it, we would like to be cautious in this respect and so do not fully discard this possibility. Same for the argument that *VW* decreased advertising in an attempt to go unnoticed and let the crises fade away. In our view, the latter argument also presents some flaws, but it may well add to the more rational argument that we propose.

Beyond this limitation, we consider there are other aspects that should be considered before generalising our finding. They mainly refer to two issues. On the one hand, the theoretical framework considers a two-period game, capturing only short-term implications of the information shock and lacking a more dynamic analysis of the interactions in the long run. On the other hand, the empirical analysis considers data from Spain that, although quite general, may present some particularities that could explain some of the results. We are thinking, for example, on the result about the increase in sales of *Seat*. However, despite these limitations, we consider that the research offers valuable insights for firm managers and policymakers alike. On the one hand, they propose a *taxonomy* that can help managers understand how they should react to a scandal. On the other hand, they provide a *guide* for policymakers and authorities to understand how firms can make a strategic use of advertising in the aftermath of a scandal, a guide that in the need for intervention, might be used to anticipate forthcoming movements and react in a timely manner.

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CONFLICT OF INTEREST STATEMENT

The code and other materials used in this paper is available from the authors upon request. We have no conflict of interest.

DATA AVAILABILITY STATEMENT

Unfortunately, data is under licencing. Authors do not declare financial support for this project.

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APPENDIX

Proof of Proposition 1

According to Bayes' rule, the consumers' consistent beliefs about firm i being type t' after observing advertising expenditure a_i is:

$$P_i(t_i'|a_i) = \frac{P_i(a_i|t_i')P_i(t_i')}{\sum_{t_i \in T_i} P_i(a_i|t_i)P_i(t_i)},$$

with $t_i', t_i \in T_i = \{\text{GF}, \text{GU}, \text{BF}, \text{BU}\}$, and $a_i \in \{a_h, a_l\}$.

Then, in the (partially) separating SP profile:

$$\text{P}_i(\text{GF}|a_h) = \frac{\alpha_{\text{GF}}}{\alpha_{\text{G}}}, \text{P}_i(\text{GU}|a_h) = \frac{\alpha_{\text{GU}}}{\alpha_{\text{G}}}, \text{P}_i(\text{BF}|a_l) = \frac{\alpha_{\text{BF}}}{1-\alpha_{\text{G}}}, \text{P}_i(\text{BU}|a_l) = \frac{\alpha_{\text{BU}}}{1-\alpha_{\text{G}}},$$

according to which a consumer who observes $a_i = a_h$ will believe firm i to be a good-type firm, as $P_i(\text{G}|a_h) = P_i(\text{GF}|a_h) + P_i(\text{GU}|a_h) = 1$. Analogously, a consumer who observes $a_i = a_l$ will believe that firm i is a bad-type firm. Given the consistent beliefs, the optimal choice of the representative consumer is to purchase the product from firm 1 (alternatively, 2) when the profile observed is $(a_1,a_2)=(a_h,a_l)$, (alternatively, (a_l,a_h)), and to buy the product from any firm when the profile observed is either (a_h,a_h) or (a_l,a_l).

Given the consumers' optimal choices, we next derive the conditions under which no firm gains by deviating from the profile SP. It requires a good-type firm to optimally choose a_h, and a bad-type firm to optimally choose a_l.

We first consider a good-type firm (the argument applies to both types GF and GU). The expected payoff to this firm when choosing high advertising expenditure is

$$\frac{1}{2}\alpha_{\text{G}}(r + \delta\, r_h) + (1-\alpha_{\text{G}})(r + \delta\, r_h) - c,$$

where as its payoff for low advertising expenditure is

$$(1-\alpha_{\text{G}})\left(\frac{1}{2}r + \delta\, r_h\right),$$

from where a good-type firm finds it optimal to choose a high advertising level, a_h, whenever

$$r + \alpha_{\text{G}}\delta\, r_h \geq 2\text{c}.$$

Similarly, we proceed for a bad-type firm (again, the argument applies to both types BF and BU). Here, we assume that when indifferent at period 2, the representative consumer purchases the product from the firm that has not been found cheating in period 1. Under this assumption, the payoff to a bad-type firm that advertises high is

$$\frac{1}{2}\alpha_G r + (1-\alpha_G)r - c,$$

where as its payoff for advertising low is

$$\frac{1}{2}(1-\alpha_G)(r+\delta\, r_l),$$

from which a bad-type firm finds it optimal point to choose a low advertising level whenever

$$2c \geq r - (1-\alpha_G)\delta\, r_l.$$

Proof of Proposition 2

The proof consists of three differentiated parts: First, we obtain the conditions under which the profile SP is (is not) part of a PBE when $\chi = 1$. Second, we combine these conditions with those guaranteeing that the profile SP is a PBE when $\chi = 0$ (c.f. **Proposition 1**). This yields the conditions in **Proposition 2**. Third and last, we assume ordering scenario I and derive the conditions for the results of **Proposition 2** to hold in this case. Note that except for this last part, we consider ordering scenario II, that is, $u_{GF} > u_{BF} > u_{GU} > u_{BU}$.

First, we obtain the conditions under which the profile SP is (is not) part of a PBE when $\chi = 1$. To this aim, note that when $\chi = 1$, consumers receive information from two sources: firms' advertising strategies and the external auditor. According to Bayes' rule, the consumers' beliefs on firm i being type t_i' after observing advertising expenditure a_i and external report m_i are given by:

$$P_i(t_i'|a_i,m_i) = \frac{P_i(m_i|a_i,t_i')P_i(a_i|t_i')P_i(t_i')}{\sum_{t_i\in T_i} P_i(m_i|a_i,t_i)P_i(a_i|t_i)P_i(t_i)},$$

with $t_i', t_i \in T_i = \{GF, GU, BF, BU\}$, $a_i \in \{a_h, a_l\}$ and $m_i \in \{m_f, m_u\}$.

For the profile SP, formally $(\sigma_1;\sigma_2) = (a_h,a_h,a_l,a_l;\ a_h,a_h,a_l,a_l)$, the consistent beliefs are:

$$P_i(GF|a_h,m_f) = 1, \quad P_i(GU|a_h,m_u) = 1, \quad P_i(BF|a_l,m_f) = 1, \quad P_i(BU|a_l,m_u) = 1,$$

according to which a consumer that observes the pair $(a_i,m_i) = (a_h,m_f)$ (alternatively, (a_h,m_u)) believes that firm i is a good-friendly type (alternatively, good-unfriendly type), and so on and so forth. Given the consistent beliefs, the consumer will purchase the product from firm 1 when the profile $(a_1,m_1;a_2,m_2)$ observed is either $(a_h,m_f;a_h,m_u)$, $(a_h,m_f;a_l,m_f)$, $(a_h,m_f;a_l,m_u)$, $(a_l,m_f;a_l,m_u)$, and so on and so forth. When the profile is, for example, $(a_h,m_u;a_l,m_f)$, the consumer's optimal choice is to purchase the product from firm 2 (this will change under ordering scenario I).

Next, we check the conditions under which firms gain by deviating from the profile SP. This defines the conditions for scenario (i) of **Proposition 2**. This analysis will also serve us to obtain the conditions for scenario (ii) of this proposition.

First, let us consider a firm of type GF. The payoff to this type for advertising high is $\frac{1}{2}\alpha_{GF}(r+\delta r_h) + \alpha_{GU}(r+\delta r_h) + \alpha_{BF}(r+\delta r_h) + \alpha_{BU}(r+\delta r_h) - c$, whereas its payoff for advertising low is $\alpha_{GU}(r+\delta r_h) + \alpha_{BF}\left(\frac{1}{2}r+\delta r_h\right) + \alpha_{BU}(r+\delta r_h)$. Then, a firm of type GF gains by deviating whenever

$$2c > \alpha_F r + \alpha_{GF}\delta r_h.$$

Similarly, a firm of type GU that advertises high receives a payoff of $\frac{1}{2}\alpha_{GU}(r+\delta r_h) + \alpha_{BU}(r+\delta r_h) - c$, whereas its payoff for advertising low is $\alpha_{BU}\left(\frac{1}{2}r+\delta r_h\right)$. Then, a firm of type GU gains by deviating whenever

$$2c > \alpha_U r + \alpha_{GU}\delta r_h.$$

Let us now consider a firm of type BF. Its payoff for advertising low is $\alpha_{GU}(r+\delta r_l) + \alpha_{BF}\frac{1}{2}(r+\delta r_l) + \alpha_{BU}(r+\delta r_l)$, whereas its payoff for advertising high is $\frac{1}{2}\alpha_{GF}r + \alpha_{GU}(r+\delta r_l) + \alpha_{BF}r + \alpha_{BU}(r+\delta r_l) - c$. Then, a firm of type BF gains by deviating whenever

$$2c < \alpha_F r - \alpha_{BF}\delta r_l.$$

Last, a firm of type BU that advertises low receives $\frac{1}{2}\alpha_{BU}(r+\delta r_l)$, whereas its payoff for advertising high is $\frac{1}{2}\alpha_{GU}r + \alpha_{BU}r - c$. Then, a firm of type BU gains by deviating whenever

$$2c < \alpha_U r - \alpha_{BU}\delta r_l.$$

Second, we combine the conditions we have just derived with those for the existence of a PBE when $\chi = 0$ (c.f. **Proposition 1**).

On the one hand, we have that the profile SP constitutes a PBE when $\chi = 0$ if and only if $r - (1-\alpha_G)\delta r_l \le 2c \le r + \alpha_G\delta r_h$.

On the other, we have that the profile SP is not a PBE when $\chi = 1$ if either $2c > \min\{\alpha_F r + \alpha_{GF}\delta r_h, \alpha_U r + \alpha_{GU}\delta r_h\}$ or $2c < \max\{\alpha_F r - \alpha_{BF}\delta r_l, \alpha_U r - \alpha_{BU}\delta r_l\}$ holds. In contrast, the profile SP is a PBE when $\chi = 1$ if $\max\{\alpha_F r - \alpha_{BF}\delta r_l, \alpha_U r - \alpha_{BU}\delta r_l\} \le 2c \le \min\{\alpha_F r + \alpha_{GF}\delta r_h, \alpha_U r + \alpha_{GU}\delta r_h\}$.

It is straightforward to show that $0 \le \alpha_F r + \alpha_{GF}\delta r_h < r + \alpha_G\delta r_h$ and $0 \le \alpha_U r + \alpha_{GU}\delta r_h < r + \alpha_G\delta r_h$ (also, that $0 \le \alpha_F r - \alpha_{BF}\delta r_l < r - \alpha_B\delta r_l$ and $0 \le \alpha_U r - \alpha_{BU}\delta r_l < r - \alpha_B\delta r_l$). Then, if we define

$$\bar{c} = \max\{r - \alpha_B\delta r_l, \min\{\alpha_U r + \alpha_{GU}\delta r_h, \alpha_F r + \alpha_{GF}\delta r_h\}\},$$

we have that for all c such that $\bar{c} \le 2c \le r + \alpha_G\delta r_h$, the profile SP is a PBE when $\chi = 0$ and it is not when $\chi = 1$. Similarly, we obtain the conditions for the profile SP being a PBE both when $\chi = 0$ and $\chi = 1$.

Third, and last, we derive the conditions for the result of **Proposition 2** holding when we assume instead ordering scenario I. The analysis shows that:

A firm of type GF that advertises high receives the same payoff as before, whereas if advertising low its payoff is $\alpha_{BF}\left(\frac{1}{2}r+\delta r_h\right) + \alpha_{BU}(r+\delta r_h)$. Then, this type gains by deviating from SP whenever $2c > \alpha_F r + \alpha_{GF}\delta r_h + 2\alpha_{GU}(r+\delta r_h)$.

A firm of type GU that advertises high receives now a payoff $\frac{1}{2}\alpha_{GU}(r+\delta r_h) + \alpha_{BF}(r+\delta r_h) + \alpha_{BU}(r+\delta r_h) - c$, whereas if advertising low its payoff does not change. Then, this type gains by deviating from SP whenever $2c > \alpha_U r + \alpha_{GU}\delta r_h + 2\alpha_{BF}(r+\delta r_h)$.

A firm of type BF that advertises low receives a payoff $\alpha_{BF}\frac{1}{2}(r+\delta r_l) + \alpha_{BU}(r+\delta r_l)$, whereas if advertising high its payoff is $\frac{1}{2}\alpha_{GF}r + \alpha_{GU}r + \alpha_{BF}r + \alpha_{BU}(r+\delta r_l) - c$. Then, this type gains by deviating from SP whenever $2c < \alpha_F r - \alpha_{BF}\delta r_l + 2\alpha_{GU}r$.

A firm of type BU that advertises low receives the same payoff as before, whereas if advertising high its payoff is $\frac{1}{2}\alpha_{GU}r + \alpha_{BF}r + \alpha_{BU}r - c$. Then, this type gains by deviating from SP whenever $2c < \alpha_U r - \alpha_{BU}\delta r_l + 2\alpha_{BF}r$.

From here, the conditions for the SP profile not being a PBE when $\chi = 1$ are $r - \alpha_B\delta\ r_l \le 2c \le \underline{c}'$ or $\overline{c}' \le 2c \le r + \alpha_G\delta\ r_h$, with $\underline{c}' = \max\{\alpha_F r - \alpha_{BF}\delta r_l + 2\alpha_{GU}r, \alpha_U r - \alpha_{BU}\delta r_l + 2\alpha_{BF}r\}$ and $\overline{c}' = \min\{\alpha_F r + \alpha_{GF}\delta r_h + 2\alpha_{GU}(r+\delta r_h), \alpha_U r + \alpha_{GU}\delta r_h + 2\alpha_{BF}(r+\delta r_h)\}$.

Similarly, we can obtain the conditions for the profile SP being a PBE.

Proposition 3 *There exists threshold* $\underline{c}$, *with* $0 \le \underline{c} \le r - \alpha_B\delta r_l$, *such that for all* $\underline{c} \le 2c \le r - \alpha_B\delta r_l$, *the profile SP is a PBE when* $\chi = 1$ *and it is not when* $\chi = 0$.

Proof From the proof of **Proposition 2**, the conditions for the firms not finding it profitable to deviate from the profile SP are given by condition ii). Similarly, from the proof of **Proposition 1**, the conditions for a type of firm finding it profitable to deviate from the profile SP are the reverse. Bearing this in mind, we can argue that:

On the one hand, the profile SP does not constitute a PBE when $\chi = 0$ if either $2c < r - \alpha_B\delta\ r_l$ or $2c > r + \alpha_G\delta r_h$.

On the other, the profile SP is a PBE when $\chi = 1$ if and only if $\max\{\alpha_F r - \alpha_{BF}\delta r_l, \alpha_U r - \alpha_{BU}\delta r_l\} \le 2c \le \min\{\alpha_F r + \alpha_{GF}\delta r_h, \alpha_U r + \alpha_{GU}\delta r_h\}$.

Since $\alpha_F r - \alpha_{BF}\delta r_l \le r - (1-\alpha_G)\delta\ r_l$ and $\alpha_U r - \alpha_{BU}\delta r_l \le r - (1-\alpha_G)\delta r_l$, then, if we define $\underline{c} = \max\{\alpha_F r - \alpha_{BF}\delta r_l, \alpha_U r - \alpha_{BU}\delta r_l\}$,

we have that for all c such that $\underline{c} \le 2c \le r - \alpha_B\delta r_l$ the profile SP is a PBE when $\chi = 1$ and it is not when $\chi = 0$.

Lastly, note that $\lim_{\alpha_F \to 1}\underline{c} = \lim_{\alpha_U \to 1}\underline{c} = r - \alpha_B\delta r_l$.