How Does Vehicle Sales Tax Affect Television Advertising Strategies?

Modeling Advertising Intensity Around Emissions-Related Tax Changes

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Abstract

Sales tax has been leveraged by many countries as a way to discourage (or encourage) consumption of socially undesirable (or desirable) products. This paper uses several exogenous vehicle sales tax change events to examine the effect of the low-emission vehicle sales tax rate on automobile brands' TV advertising strategies. Empirical results suggest that firms exhibit procyclical advertising behavior in response to the external tax rate change. In addition, the sales tax rate affects advertisers' selection of TV networks and advertising slots. These results have important economic consequences for the media market, with rich managerial implications for marketers, broadcasters, and policy makers.

Management Slant

- There is a significant relationship between television advertising intensity and the sales tax rate.
- Increases in the tax rate for low-emission vehicles reduced the intensity of TV advertising for these vehicles, while decreases in the tax rate increased the TV advertising intensity.
- Advertisers' demand for advertising slots changes when facing external tax-rate changes.
- With firms' procyclical advertising behavior, sales tax can be a highly effective tool to motivate socially desirable consumption.

1. Introduction

As an effective way to incentivize consumers to alter their purchase behaviors, governments often adjust sales tax in order to discourage (or encourage) consumption of socially undesirable (or desirable) products in many industries (e.g., Allcott, Lockwood, and Taubinsky 2019; Gruber and Poterba 1994; Klier and Linn 2015; Streletskaya et al. 2014). In efforts to battle against climate change, many governments leverage vehicle taxation policy to reduce transport emissions. Such policies involve, for example, increasing sales tax rates for high-emission vehicles, and lowering sales tax rates or providing benefits for low-emission vehicles (Wappelhorst, Mock, and Yang 2018). In the US, a federal income tax credit of up to $3,400 was made available for purchasing a new hybrid vehicle.[1] In Canada, the purchaser or lessee of an eligible new electric- or hydrogen-powered vehicle is entitled to a rebate of up to CA$5,000 on the after-tax cost.[2] Almost all European countries provide benefits for low-emission vehicles upon registration (Wappelhorst, Mock, and Yang 2018). Alternatively, governments can increase the tax rate on high-emission vehicles (D'Haultfœuille, Givord, and Boutin 2014; Knittel 2012). The largest automobile market in the world, China, has witnessed similar efforts, with the Chinese government implementing several tax incentives for low-emission vehicles during the past decade (Qiu, Zhou, and Sun 2019; Xiao and Ju 2014).

On the demand side, it has been demonstrated that tax is an effective tool to incentivize consumers to purchase environmentally friendly vehicles (Diamond 2009; Klier and Linn 2015; Qiu, Zhou, and Sun 2019; Xiao and Ju 2014;). On the supply side, tax changes can also motivate firms to respond with product modifications to qualify for more favorable treatment (e.g., Ito and

[1] https://en.wikipedia.org/wiki/Government_incentives_for_fuel_efficient_vehicles_in_the_United_States
[2] https://en.wikipedia.org/wiki/Government_incentives_for_plug-in_electric_vehicles#Canada

Sallee 2018; Klier and Linn 2015; Sallee and Slemrod 2012). However, less is known about the impact of tax changes on firms' marketing strategies. This paper examines how changes in tax policies affect firms' TV advertising strategies.

Advertising strategies (i.e., advertising spending, frequency, channel selection) are critical not only to firms but also to advertising media, such as TV networks. Advertising is a key source of revenue for companies in the broadcasting industry. In China, advertising revenue accounted for 33% of the total broadcast and television revenue in 2018, and 51.4% of this advertising revenue comes from TV advertising.[3] Advertising can be used as an educational tool to guide the public to increase or decrease the consumption of products (Mitra and Lynch, 1995; Goldberg, 2003; Draganska and Klapper 2011; Sukle et al., 2021). In addition to the direct consequence on sales, tax policy may also affect firms' advertising strategy, which may in turn exert an indirect impact on sales. If firms reduce advertising spending after the increase in the sales tax rate, consumer demand will be further suppressed; in contrast, if firms increase advertising spending after the increase in the sales tax rate, the sales tax rate increase may reduce consumer demand to a lesser degree. Therefore, understanding how sales tax policies affect firms' advertising strategies is crucial for both advertisers and TV networks.

Firms' advertising strategy in response to policy change depends on managers' view of the role of advertising. Two views on advertising are "expense" and "investment" (Danaher and Rust,1994; White and Miles, 1996). If managers regard advertising as a long-term investment instead of an expense, advertising activities must be maintained for a prolonged period to build advertising goodwill and change consumers' brand attitudes and behavior (Danaher and Rust,1994; Deleersnyder et al., 2009). Therefore, the policy change will be less likely to have an impact on

[3] http://www.nrta.gov.cn/art/2019/4/23/art_2178_43403.html

advertising spending in the short term. However, if managers view advertising as an expense instead of an investment, a policy change may affect firms' advertising strategy. The effect of policy changes on advertising is therefore still unclear. Our goal is to understand the effect of the sales tax rate on advertising in the context of the Chinese automobile industry. To the best of our knowledge, this paper is the first empirical study to evaluate the relationship between vehicle sales tax rates and automobile brands' TV advertising strategies.

Prior research has demonstrated that firms may cut advertising spending during recessions (Tellis and Tellis 2009; Quelch and Jocz, 2009) and increase advertising spending during economic expansions (Kim, 2020), implying that firms tend to exhibit *procyclical* TV advertising behavior. Here "procyclical" refers to decisions that reinforce effects of external policies. Because a sales tax rate increase can reduce consumer demand by increase the effective price, it can be regarded as an unfavorable policy change for the manufacturer, but it is not yet known whether firms react to the sales tax in a procyclical or countercyclical way (see Figure 1 where "?" indicates the direction of the effect is unclear). Under the procyclical advertising strategy, manufacturers would reduce advertising spending facing an increase in sales tax rate of their products. However, it has been shown that firms that adopt the procyclical advertising strategy have worse performance than those that keep their advertising investment independent of the business cycle (Deleersnyder et al., 2009; Quelch and Jocz, 2009) or countercyclical advertising. Therefore, we would like to investigate whether firms tend to adopt a procyclical strategy in TV advertising when facing external policy changes in sales tax, and the implications of their strategies.

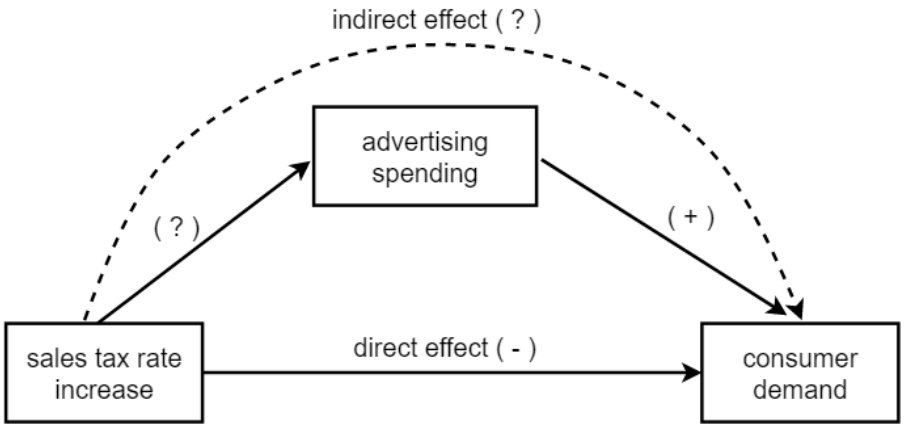

Figure 1. The Effect of Sales Tax Rate on Consumer Demand

We focus on the context of the Chinese automobile industry for several reasons. First, China has been the world's largest automobile producer and market since 2009. Second, the Chinese government has adjusted the vehicle sales tax rate six times during the past ten years, which provides us with exogenous events for examining the effects of tax rate changes on firms' advertising strategies. Finally, although expenditures for digital advertising have overtaken expenditures for TV advertising, people have greater trust in TV advertising,[4] TV is still one of the most effective advertising platform (Findley et al., 2020), and TV remains the preferred advertising medium for many firms (Yao, Wang, and Chen 2017). In 2018, 54.4% of all automotive advertising spending in China was for TV advertising, compared to 22.9% of advertising spending for online advertising.[5]

To identify the effects of tax rates on firms' TV advertising strategies, this research leverages four exogenous policy changes to the sales tax for low-emission vehicles (i.e., vehicles with a displacement lower than or equal to 1.6L) in China between 2009 and 2017. One of these changes was a sales tax rate reduction, and the other three were sales tax rate increases. This paper estimates

[4] https://yougov.co.uk/topics/media/articles-reports/2021/03/05/trust-in-media-ads-global-poll
[5] http://www.199it.com/archives/850097.html

the causal effect of the vehicle sales tax rate on the intensity of TV advertising in a difference-in-difference framework. Several key findings emerge from this research. First, there is a negative relationship between TV advertising intensity and the sales tax rate: For low-emission vehicles, tax rate increases reduced the TV advertising intensity, while tax rate decreases increased the TV advertising intensity. In other words, automobile advertisers exhibit procyclical TV advertising behavior. This finding is robust to a set of robustness checks. Second, sales tax rates influence advertisers' selection of TV networks. Finally, the sales tax rate also affects advertisers' selection of advertising slots. These findings imply that the effectiveness of public policies in encouraging socially desirable consumptions can be further enhanced by firms' advertising strategies, and that these policies can also indirectly affect other industries such as the advertising industry.

The rest of the paper is organized as follows. Section 2 reviews the relevant literature. Section 3 introduces the Chinese sales tax policy for vehicles, as well as the data collection and data processing steps in Section 3. Following that, Sections 4, 5, and 6 explore how the sales tax rate affects advertising intensity and the location of TV advertisements in terms of the TV network and advertising slot. Section 7 concludes with implications and directions for future research.

2. Literature Review

Given our focus on tax and advertising, this paper relates to previous research on the impact of tax regulations, and advertising strategies, which will be discussed in turn.

2.1. The Impact of Tax Regulations

This paper builds upon an emerging stream of research on the impact of tax regulations. On the demand side, tax can be used to discourage consumption of socially undesirable products, such as soda (Allcott, Lockwood, and Taubinsky 2019; Seiler, Tuchman, and Yao 2021), unhealthy

food (Streletskaya et al. 2014), and cigarettes (e.g., Hu, Sung, and Keeler 1995; Wang, Lewis, and Singh 2016). Tax can also be used to encourage consumption of socially desirable products, such as health insurance (e.g., Gruber and Poterba 1994), healthy food (Khan, Misra, and Singh 2016), and environmentally friendly vehicles (Klier and Linn 2015; Qiu, Zhou, and Sun 2019; Xiao and Ju 2014).

On the supply side, firms often respond to tax regulations. Taking the automobile industry as an example (Table 1), such strategic responses include manipulating the fuel economy rating to qualify for more favorable treatment (Sallee and Slemrod 2012), modifying the emissions rates of vehicles supplied to the market (Klier and Linn 2015), manipulating curb weights (Hao et al. 2016; Ito and Sallee 2018), increasing the vehicle size (Ullman 2016), and so forth. Collectively, this line of literature suggests that under externally formulated industry policies, automakers have incentives to modify policy-related product configurations to qualify for more favorable treatment.

Table 1. Marketing Literature on Automakers' Strategic Responses to Tax or Regulations

Country	Tax / Regulations	Firms' Strategic Response	Representative Studies
United States	Gas guzzler tax; Mandatory fuel economy labels	Manipulate fuel economy ratings	Sallee and Slemrod (2012)
France	CO_2 tax	Change emission rates of the vehicles supplied to the market	Klier and Linn (2015)
Japan	Fuel-economy regulations	Increase vehicles' weight, size, or engine power characteristics	Ito and Sallee (2018)
China	Stepped fuel consumption rate	Manipulate curb weight	Hao et al. (2016)
United States	Fuel-economy regulations	Increase vehicles' size or modify engine power characteristics	Klier and Linn (2012); Knittel (2011); Ullman (2016); Whitefoot and Skerlos (2012)

However, there is a related, but previously unexplored question concerning automakers' TV advertising reactions to external changes in tax policy. The present paper aims to fill this gap by estimating the effects of vehicle sales tax rates on automakers' TV advertising strategies. The research most closely related to ours is Seldon and Doroodian's (1989) study, which finds that the cigarette industry reacts to government health warnings by increasing its advertising. Our study

differs from Seldon and Doroodian's study in three ways. First, while all firms in the cigarette industry are affected by the government policy in their study, only low-emission vehicles are affected in the context of this study, and the responses of affected and unaffected products are examined separately. Second, in addition to advertising spending, the author also considers the effect of the sales tax rate on firms' selection of the TV networks and advertising slots for their TV advertisements. Third, the panel data and multiple sales tax change events allow us to estimate the causal effects of both unfavorable and favorable policy changes.

2.2. Advertising Strategy

Firms' advertising strategies center around the questions of advertising spending and advertising scheduling (i.e., advertising time and frequency, as well as the advertising channel) (García-Villoria and Salhi 2015; Ghassemi Tari and Alaei 2013). A related stream of literature has identified various factors that affect firms' advertising spending. As summarized in Table 2, the identified factors include product reviews (Chen and Xie 2005; Hollenbeck, Moorthy, and Proserpio 2019), advertisement memorability (Aravindakshan and Naik 2015), top executives' compensation (Currim, Lim, and Kim 2012), managers' style (Bertrand and Schoar 2003), market share retention magnitude (Freimer and Horsky 2012), financial development (Bahadir and Bahadir 2020), geographical diversification (Kim and Mathur 2008), shareholder's complaints (Wies et al. 2019), competitors' advertising (Gijsenberg and Nijs 2019), business-cycle fluctuations (Deleersnyder et al. 2009), and national culture (Bahadir and Bahadir 2020; Deleersnyder et al. 2009; Jacobson and Nicosia 1981). In addition, another strand of literature investigates advertising scheduling decisions (e.g., Dubé, Hitsch, and Manchanda 2005; Ephron and McDonald 2002; Freimer and Horsky 2012; Guitart, Hervet, and Gelper 2020; Mesak and

Ellis 2009; Sasieni 1989; Villas-Boas 1993). This research adds to this literature by exploring the effect of externally formulated industry policy on advertising strategy.

Table 2. Marketing Literature on Factors Affecting Advertising Strategies

Dependent Variable	Participants	Antecedent Variables	Representative Studies
Advertising Spending	Consumers	Product reviews	Chen and Xie (2005); Hollenbeck, Moorthy, and Proserpio (2019)
		Advertisement memorability	Arayindakshan and Naik (2015)
	Firm	Top executives' compensation	Currim, Lim, and Kim (2012)
		Manager's style	Bertrand and Schoar (2003)
		Market share	Chintagunta and Vilcassim (1992); Freimer and Horsky (2012)
		Financial development	Bahadir and Bahadir (2020)
		Geographical diversification	Kim and Mathur (2008)
		Percentage of sales heuristic (A/S ratio)	Bigne (1995); Piercy (1987); Wang and Zhang (2008)
		New product release	Martín-Herrán and Sigué (2017)
	Competitors	Competitors' advertising spending	Gijsenberg and Nijs (2019)
	Shareholders	Shareholder complaints	Wies et al. (2019)
	Market structure	Local market concentration	Chandra and Weinberg (2018)
	Macro environment	Business-cycle fluctuations	Deleersnyder et al. (2009); Tikoo and Ebrahim (2010)
		National culture	Bahadir and Bahadir (2020); Deleersnyder et al. (2009); Jacobson and Nicosia (1981)
Advertising Scheduling	Competitors	Competitors' advertising scheduling	Guitart, Herver, and Gelper (2020); Park and Hahn (1991); Villas-Boas (1993)
	Firm	Program ratings	Bearden et al. (1981)
		Market share	Freimer and Horsky (2012); Park and Hahn (1991)
		Market potential	Mesak and Ellis (2009)
		Sale response function	Bronnenberg (1998); Dubé, Hitsch, and Manchanda (2005); Ephron and McDonald (2002); Mahajan and Muller (1986); Sasieni (1989); Villas-Boas (1993)
		Advertising cost structure	Hahn and Hyun (1991)
		Advertising type	Bass et al. (2007)

3. Institutional Setting and Data

This research focuses on the automobile industry in China, which is the largest automobile market in the world.[6] To reduce automobile emissions, the Chinese government has implemented a number of regulations that adjust taxes and provide subsidies to incentivize purchases of low-emission vehicles, such as electric vehicles, hybrid electric vehicles, and traditional vehicles with small engine emissions displacements (Qiu, Zhou, and Sun 2019; Xiao and Ju 2014). Between

[6] http://www.gov.cn/xinwen/2021-01/15/content_5580088.htm

2009 and 2017, the Chinese government adjusted the vehicle sales tax rate for low-emission vehicles six times (Table 3). These exogenous policy changes allow us to examine the effects of the sales tax rate on automakers' TV advertising strategies. This research focuses on the second to fifth policy changes, because the first policy change coincides with a government subsidy policy, and the author does not have data after the sixth policy change.

Table 3. Vehicle Sales Tax for Low-emission Vehicles

Policy Index	Announcement Date	Period	Rate
Baseline	December 22, 2000	January 1, 2001- January 19, 2009	10%
1st change	January 17, 2009	January 20, 2009- December 31, 2009	5%
2nd change	December 22, 2009	January 1, 2010- December 31, 2010	7.5%
3rd change	December 27, 2010	January 1, 2011- September 30, 2015	10%
4th change	September 29, 2015	October 1, 2015- December 31, 2016	5%
5th change	December 13, 2016	January 1, 2017- December 31, 2017	7.5%
6th change	December 26, 2017	After January 1, 2018	10%

The author constructs a rich set of data from two sources: CTR and Autohome. In the following two subsections, this research describes the dataset construction procedure in detail.

3.1. CVSC-TNS Research (CTR)

The author collects TV advertising data from CTR Market Research, which was established in 1995 as a joint venture of the Kantar Group and China International Television Corporation (CITVC) and is presently the largest market research and media research company in China. In the Chinese TV advertising market, TV commercials are usually purchased at least three weeks before the scheduled airing time, and can be broadcasted for one month, three months, six months, or more. The price of an advertisement depends on many factors, such as TV network, airing time, and the position within a commercial break. In general, the average advertising price is higher in the central TV networks, during the prime time, and in the first and last slots within a commercial break. When making advertising decisions, advertisers mainly focus on the total budget, the total number of advertisements, the airing time, and the associated program. The airing time can be

slightly adjusted by the TV network. For example, for the central TV networks, an adjustment that is within 60 minutes of the agreed time is considered normal. In case of emergencies, advertisers can negotiate with TV stations to increase or decrease advertising immediately. The TV advertising data the author obtains from CTR TV include all automotive company TV advertisements from January 1, 2008 to December 10, 2017. For each advertising spot, we observe the date, start time, end time, duration, advertiser, advertised brand, advertised product, TV network, pod position, and cost. There are 13,884,144 observations (advertising spots) in the data. Because our focus is automobiles but the data include all advertisements related to automotive products, such as vehicle accessories and vehicle services, the author excludes advertisements that are not advertised by automakers as well as advertisements of non-passenger vehicles (e.g., motorcycles). This leaves us with 7,910,213 observations.

The data allow us to compute the advertising intensity for each brand and product at the daily level. The author considers three measures of advertising intensity: the number of TV advertisements, TV advertising spending, and total seconds of TV advertising. The top 20 brands in terms of TV advertising spending during the years 2008–2017 are presented in Appendix A (see Table A 1).

The author defines the "product" as the automobile model in the advertisement. For example, for Bayerische Motoren Werke (BMW), the brand is "BMW," and there are over 30 advertised products, such as "BMW," "BMW 1 series," "BMW 3 series," "BMW 7 series," and "BMW X5 & BMW X6." The author generates a binary variable to indicate the level of the advertisement: If the advertised product is a brand, such as "BMW," then the advertisement is at the brand level, and if the advertised product is a specific model, such as "BMW 1 series," then the advertisement is at the product level. In 251,240 observations, the advertisement contains two or more products,

such as “BMW X5 & BMW X6.” In such cases, the author divides the advertising spending measure by the number of products in the advertisement.

3.2. Autohome

In order to identify products to which the sales tax policy for low-emission vehicles applies, the author collects detailed vehicle characteristics from Autohome,[7] a company that tracks the automobile industry. The author presents in Figure 2 and Figure 3 screenshots of a webpage on Autohome (original language version on the left, and Google-translated English version on the right), which show the models under the brand “SAIC Volkswagen”, the Manufacturer Suggested Retail Price (MSRP) for each model, and details for each model by year.

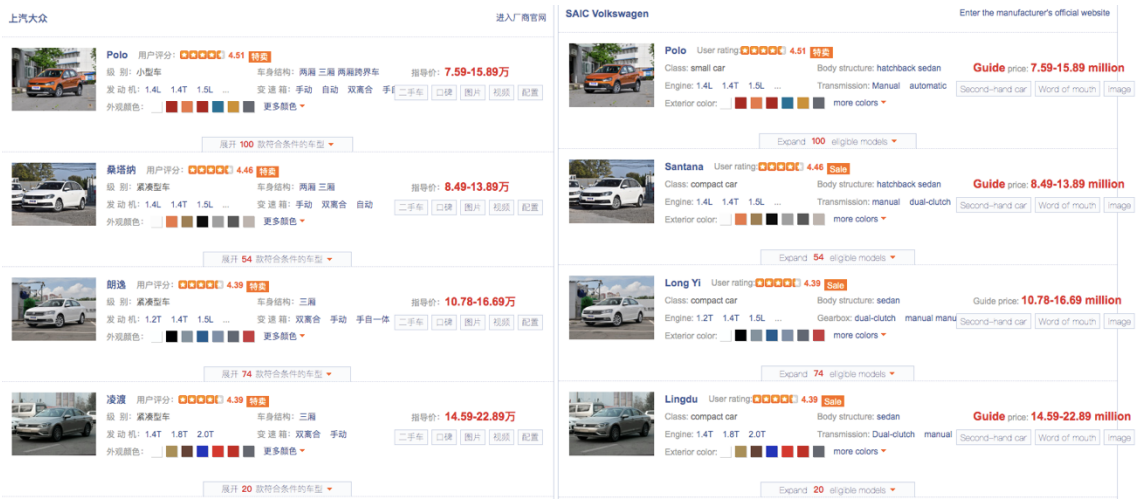

Figure 2. Autohome Screenshot 1

[7] Autohome is the largest vehicle portal in China: https://www.autohome.com.cn/

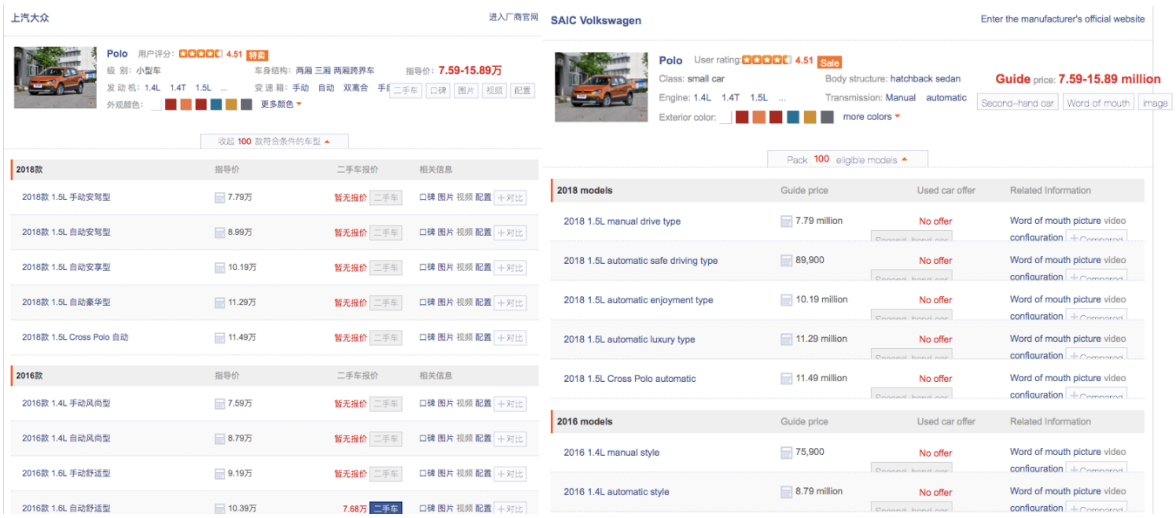

Figure 3. Autohome Screenshot 2

Because the tax policy applies to vehicles with emissions displacements lower than or equal to 1.6L, the author manually collects the emissions displacement of each body type from Autohome. In the advertising data, products can only be identified at the model level. However, within a model, there can be products with different emissions displacements. Therefore, the author computes the fraction of qualified products within each model and define a model as a low-emission vehicle if at least half of the products within the model are low-emission vehicles. In the example in Figure 3, in 2018, model "Polo" under brand "SAIC Volkswagen" has five body types, all with a 1.5L displacement. Thus, the fraction of qualified products of model "Polo" in 2018 is 1, and the model is defined as a low-emission model.

4. Descriptive Evidence

Before the formal econometric analysis, general patterns in the advertising data are presented in Table 4. There is an increase in both the number of advertised brands and the number of advertised products. Despite the increase in the number of products, there is a decrease in the TV advertising intensity: The total number of TV advertisements dropped by nearly 50%, from 903,008 to 458,320, and the total hours of TV ads dropped nearly 55%, from 5,170 hours to 2,364.5

hours. This is consistent with the notion that digital advertising has become increasingly important over the past decade (Advertising Age, 2019). However, there is an increase in the total advertising spending (from 1,423.8 million USD to 2,410.1 million USD) because of an increase in the advertising price per slot.[8]

Table 4. Summary Statistics for 2008 and 2017

	Vehicle category	2008	2017
Number of brands	——	125	179
Number of advertised products	Low-emission vehicles	156	613
	High-emission vehicles	335	683
Number of TV advertisements	Low-emission vehicles	345,723	243,580
	High-emission vehicles	557,285	214,740
Total hours of TV advertisements (hours)	Low-emission vehicles	1,875.7	1,224.3
	High-emission vehicles	3,294.3	1,140.2
TV advertising spending (million CNY)	Low-emission vehicles	3,577.6 (around 511.1 million USD)	8663.2 (around 1,287.3 million USD)
	High-emission vehicles	6,389.1(around 912.7 million USD)	7,556.4 (around 1,122.8 million USD)
Average number of advertisements per product	Low-emission vehicles	2,216.2	397.4
	High-emission vehicles	1,663.5	314.4
Average hours of advertisements per product	Low-emission vehicles	12.0	2.0
	High-emission vehicles	9.8	1.7
Average advertising spending per product (million CNY)	Low-emission vehicles	22.9 (around 3.28 million USD)	14.1 (around 2.1 million USD)
	High-emission vehicles	19.1 (around 2.72 million USD)	11.1 (around 1.64 million USD)

Now look at the TV advertising intensity separately for high- and low-emission vehicles. The average annual number of TV advertisements (panel a), annual TV advertising spending (panel b), and annual TV advertising time (panel c) for low- and high-emission vehicles (see Figure 4). There is an overall decreasing trend.

[8] For example, on January 1, 2008, the price of an advertising slot on CCTV1 at 21:45 was 100,000 CNY/15s (around 14,286 USD/15s), while on January 1, 2017, the price of an advertising slot on CCTV1 at 21:21 was 159,000 CNY/15s (around 23,626 USD/15s).

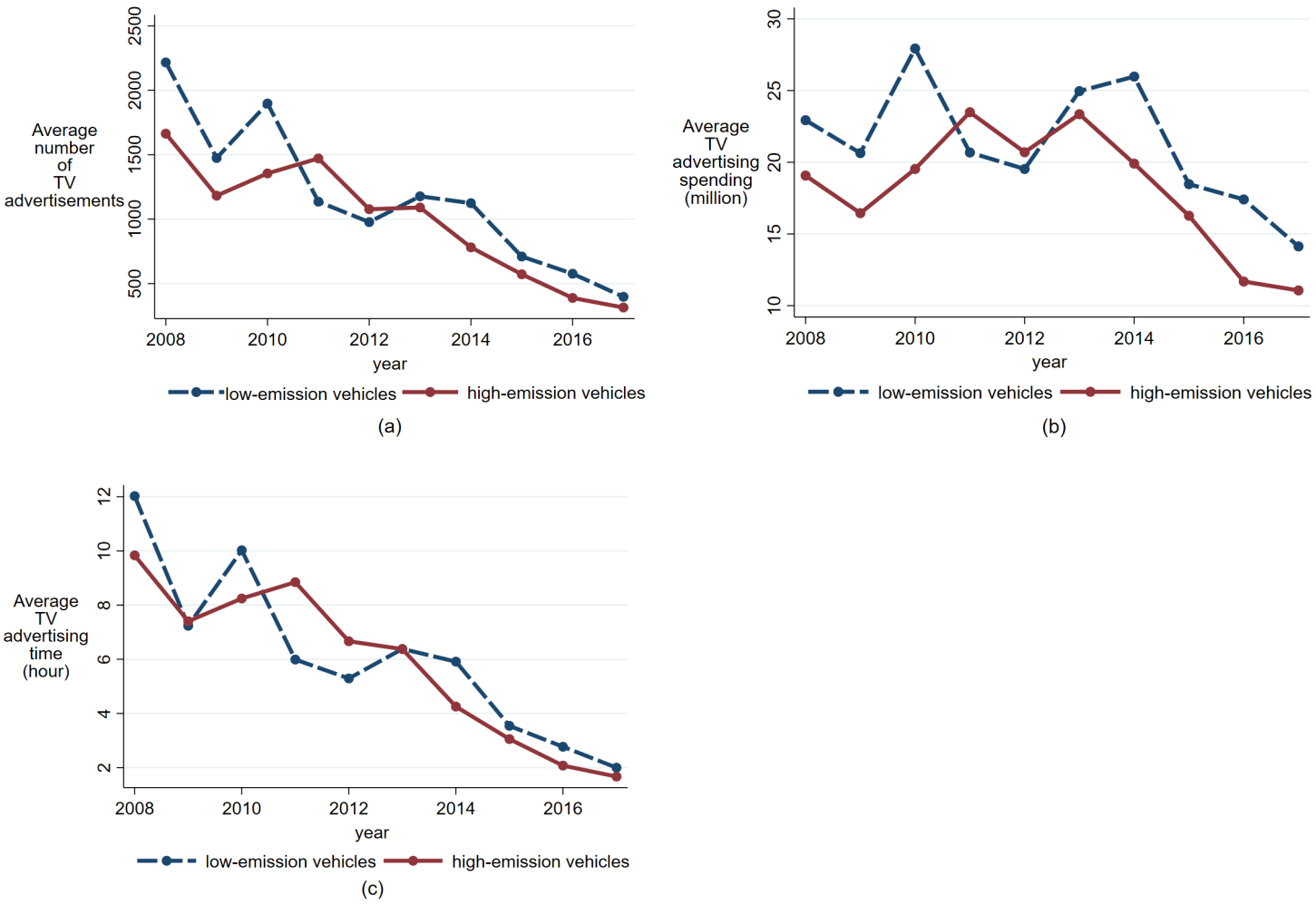

Figure 4. Average annual number of TV advertisements, TV advertising spending, and TV advertising time by displacement

Next, the author explores whether the TV advertising intensity is sensitive to the sales tax policy for low-emission vehicles. Figure 5 plots the advertising spending during the 30-day period before and the 30-day period after the implementation of each policy respectively for low-emission vehicles, high-emission vehicles, and plot the difference between the two. There seems to be a negative relationship between the directions of tax rate changes and TV advertising spending changes. For all but the 4th sales tax policy, there is a reduction in TV advertising spending after

the policy change. In addition, after the 2nd and the 3rd sales tax policy changes, there appears to be a reduction in the difference between high- and low-emission vehicles' TV advertising spending.

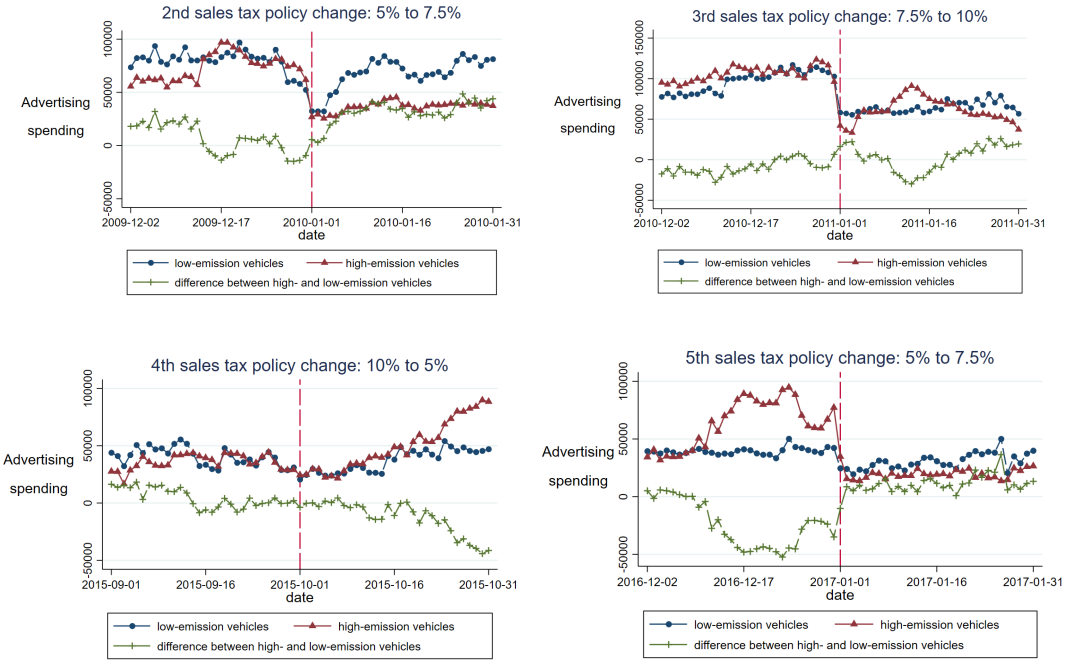

Figure 5. TV advertising spending before and after each sales tax policy change

Appendix A presents a case study on FAW-Volkswagen to illustrate the relationship between the sales tax policy and advertising intensity. Results indicate a negative relationship between TV advertising spending and the sales tax rate for most models of FAW-Volkswagen.

5. Effect of Sales Tax on TV Advertising Spending

This section formally assesses how TV advertising spending for high- and low-emission vehicles were differently affected by the sales tax rate in a difference-in-difference framework.

5.1. Model Specification

The model is specified as follows:

$$Ln\ Ad\ Spending_{it} = \alpha_0 + \beta_1 \cdot Low\ emission_i + \beta_2 \cdot post_t + \beta_3 \cdot tax_t + \beta_4 \cdot Low\ emission_i \cdot post_t + \beta_5 \cdot Low\ emission_i \cdot tax_t + \beta_6 \cdot post_t \cdot tax_t + \beta_7 \cdot Low\ emission_i \cdot post_t \cdot tax_t + \beta_8 \cdot \#New\ types_{it} + \beta_9 \cdot \#New\ models_{it} + f_i + \delta_t + \varepsilon_{it}\ , (1)$$

where i and t represent the product and the day, respectively. The dependent variable, $Ln\ Ad\ Spending_{it}$, is the logarithm of the total TV advertising spending for product i on day t. $Low\ emission_i$ is an indicator variable for whether product i is a low-emission vehicle; $post_t$ is an indicator variable for whether day t is after the policy implementation date. tax_t represents the magnitude of the change during the time window that day t falls into (tax_t = 0 if no tax change, tax_t =2.5 if tax rate increases by 2.5 percentage points, and tax_t = -5 if tax rate decreases by 5 percentage points). The coefficient β_7 on the interaction term $Low\ emission_i \cdot post_t \cdot tax_t$ is the standard difference-in-difference estimator (e.g., Duflo 2001). Theoretically, one could argue that advertising spending for a product may be affected by the number of new body types or new models within the same brand because of the brand's strategic advertising planning. Hence, this model also controls for the number of new body types ($\#New\ types_{it}$) and the number of new models ($\#New\ models_{it}$) added each year within a brand. All specifications include product fixed effects f_i and day fixed effects δ_t. The analysis is replicated with the number of TV advertisements and the total time of the TV advertisements as dependent variables.

The model is estimated with observations within the time window of 30 days on either side of each policy change. This is because the author wishes to limit the time period for this research in order to minimize the impact of other potential changes on the analysis. Subsection 5.4 reports robustness using different time windows.

5.2. Comparing Time Trends for Low- and High-emission Vehicles

A potential challenge to use of the difference-in-differences strategy is that differential changes between low-emission vehicles and high-emission vehicles may be driven by pre-existing differences in the TV advertising time trends. To address this issue, for each policy change, the author estimates Equation (2) with observations within the time window of 30 days on either side of the policy change, allowing β_t to vary by day:

$$Ln\ Ad\ Spending_{it} = \alpha_0 + \sum_t(\beta_t \cdot Low\ emission_i \cdot day_t) + \gamma_1 \cdot \#New\ types_{it} + \gamma_2 \cdot \#New\ models_{it} + f_i + \delta_t + \varepsilon_{it}, (2)$$

Where day_t is a binary variable that equals 1 on day t and 0 on all other days. This test reveals no systematic differences in pre-trends between low-emission vehicles and high-emission vehicles (see Figure A 1 in Appendix B).

5.3. Main Results

Table 5 shows the estimation results. The results indicate that there is a decreasing trend in TV advertising spending (as indicated by the negative coefficient of *post)* and the trend is stronger for low-emission vehicles (as indicated by the negative coefficient of *low emission· post*). The coefficient of the triple interaction term *Low emission · post · tax* indicates that tax rate changes affect low-emission vehicles and high-emission vehicles differently. When the sales tax rate increased by 2.5% (the 2nd, 3rd and 5th sales tax policy), TV advertising spending decreased more for low-emission vehicles than for high-emission vehicles (the difference is 0.057*2.5=14.25%). The total time of TV advertisements also decreased much more for low-emission vehicles than for high-emission vehicles (the difference is 0.022*2.5=5.5%). When the sales tax rate decreased by 5% (the 4th sales tax policy), TV advertising spending increased more for low-emission vehicles (the difference is 0.057*5=28.5%). The total time of TV advertisements also increased more for low-emission vehicles (the difference is 0.022*5=11%).

Table 5. Estimation Results for the Difference-in-difference Model

VARIABLES	(1) ln (Advertising spending + 1)	(2) ln(Number of advertisements+1)	(3) ln(Total time of advertisements+1)
post	-1.521***	-0.315***	-0.707***
	(0.146)	(0.031)	(0.065)
Low emission	-0.195	-0.075	-0.123
	(0.275)	(0.062)	(0.126)
Low emission · post	-0.215***	-0.023	-0.072**
	(0.078)	(0.017)	(0.035)
tax	0.194***	0.041***	0.091***
	(0.029)	(0.006)	(0.013)
Low emission · tax	0.113***	0.022***	0.047***
	(0.032)	(0.007)	(0.014)
post· tax	-0.341***	-0.073***	-0.159***
	(0.032)	(0.007)	(0.015)
Low emission · post · tax	-0.057**	-0.009*	-0.022**
	(0.024)	(0.005)	(0.011)
#New Types	-0.000	-0.000	-0.001
	(0.002)	(0.000)	(0.001)
#New Models	-0.053	-0.008	-0.023
	(0.033)	(0.007)	(0.014)
Constant	2.890***	0.555***	1.279***
	(0.165)	(0.037)	(0.075)
Observations	376,860	376,860	376,860
R-squared	0.383	0.354	0.378
product_id FE	YES	YES	YES
day FE	YES	YES	YES
Number of products	1297	1297	1297

Notes. The dependent variables in columns (1) – (3) are respectively the logarithm of advertising spending, the logarithm of number of advertisements and the logarithm of total time of advertisements. All columns are based on observations within the time window of 30 days before to 30 days after each policy change. Robust standard errors clustered at the product level are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

5.4. Robustness Checks

This section presents three robustness checks, including a placebo test, redefining low-emission vehicles, and alternative time windows.

5.4.1. Placebo Test

To rule out the explanation that what this research identifies is a time trend, the author randomly draws a placebo treatment date for each policy change and re-estimate Equation (1) with the placebo dates. The coefficient of interest (Low emission · post · tax) is statistically insignificant (see Table A 4 in Appendix C), implying that the effect identified is indeed driven by changes in the sales tax.

5.4.2. Redefining Low-emission Vehicles

Recall that a product is defined as a low-emission vehicle if at least half of the body types within the product have an emissions displacement of 1.6L or lower. To test whether the results are sensitive to this definition, the author selects 40% and 75% as alternative thresholds for defining low- and high-emission vehicles. Our results are robust (Table A 5 in Appendix C). Our results are also robust when replacing the dummy variable for low-emission vehicles to the fraction of body types classified as low-emission vehicles (Table A 6 in Appendix C).

5.4.3. Alternative Time Windows

Our earlier results are based on a time window of 30 days before to 30 days after each policy change. The author tests the sensitivity of the results to alternative time windows by replicating the analyses using two different time windows, 60 days before and after, and 90 days before and after (see Table A 7 in Appendix C). The results are qualitatively similar to the main results.

6. Effect of Sales Tax on TV Networks and Advertisement Slots Chosen for TV Advertisements

This section further examines how vehicle sales tax policies affect firms' selection of TV networks and advertising slots for TV advertising, because these are critical decisions in media planning (Ghassemi Tari and Alaei 2013).

6.1. Types of TV Networks

In the sample data, there are three types of TV networks: central TV networks, provincial TV networks, and city TV networks. Provincial TV networks were associated with the highest spending during 2008–2017 (see Figure 6).

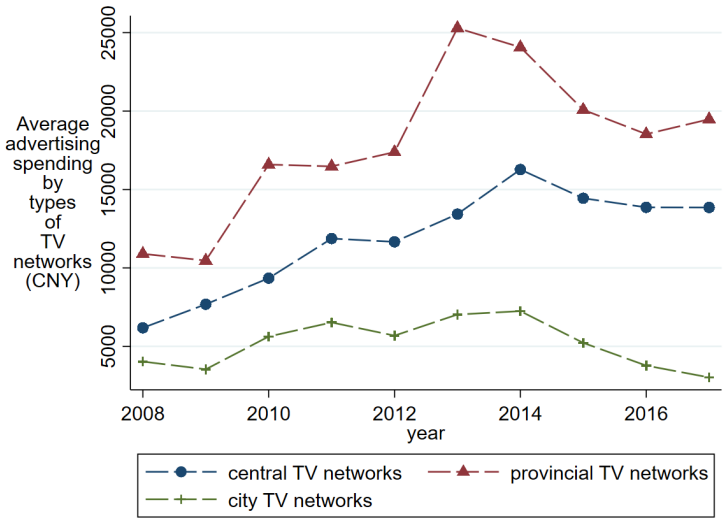

Figure 6. Average advertising spending by types of TV networks

To examine how the sales tax rate affects firms' selection of the TV network type, the author estimates a fractional multinomial logit model (Papke and Wooldridge, 1996). The model is specified as follows:

$$channel\_proportion_{it0} = \frac{1}{1+\sum_j e^{\alpha_j+\beta_{1j}\cdot Low\ emission_{it}+\beta_{2j}\cdot post_t+\beta_{3j}\cdot Low\ emission_{it}\cdot post_t+\beta_{4j}\cdot \#new\ types_{it}+\beta_{5j}\cdot \#new\ models_{it}+\varepsilon_{it}}}, \quad (3)$$

$$channel\_proportion_{itj} = \frac{e^{\alpha_j+\beta_{1j}\cdot Low\ emission_{it}+\beta_{2j}\cdot post_t+\beta_{3j}\cdot Low\ emission_{it}\cdot post_t+\beta_{4j}\cdot \#new\ types_{it}+\beta_{5j}\cdot \#new\ models_{it}+\varepsilon_{it}}}{1+\sum_j e^{\alpha_j+\beta_{1j}\cdot Low\ emission_{it}+\beta_{2j}\cdot post_t+\beta_{3j}\cdot Low\ emission_{it}\cdot post_t+\beta_{4j}\cdot \#new\ types_{it}+\beta_{5j}\cdot \#new\ models_{it}+\varepsilon_{it}}}, \quad (4)$$

where the dependent variable $channel\_proportion_{it0}$ denotes the fraction of product i's TV advertising spending that was spent on central TV networks on day t, and $channel\_proportion_{itj}$ is the fraction of product i's TV advertising spending spent on type $j\{1, 2\}$ (1=provincial, 2=city) TV networks on day t. The fraction of TV advertising spending for each type of TV network ranges from 0 to 1, and the fractions add up to 1. The independent variables are the same as those in Equation (1).

The results in Table 6, Column (1) indicate that in general, there is a decreasing trend on advertising budget allocated towards central TV networks (as indicated by the negative coefficient of *post*) and the decreasing trend is stronger for low-emission vehicles (as indicated by the negative coefficient of *Low emission · post*). The coefficient of the triple interaction term *Low emission · post · tax* indicates that tax rate changes affect low-emission vehicles and high-emission vehicles differently. When the sales tax rate increased by 2.5% (the 2nd, 3rd and 5th sales tax policy), TV advertising spending shifted away from central TV networks less for low-emission vehicles than for high-emission vehicles (the difference is 0.004*2.5=1%). When the sales tax rate decreased by 5% (the 4th sales tax policy), TV advertising spending shifted away from central TV networks more for low-emission vehicles than for high-emission vehicles (the difference is 0.004*5=2%). The author conjectures that this is because the cost of advertising slots on central TV networks is the highest, and its influence is also the largest (Wang 2011). When faced with policy changes, firms first adjusted their advertisements on central TV networks for low-emission vehicles that were affected by the policy changes.

Table 6. Policy Change Effects on TV Advertising Allocation Across TV Network Types

VARIABLES	(1) fraction of spending on central TV networks	(2) fraction of spending on provincial TV networks	(3) fraction of spending on city TV networks
Low emission	0.021***	-0.009**	-0.012***
	(0.003)	(0.004)	(0.004)
post	-0.006*	0.002	0.003
	(0.003)	(0.004)	(0.004)
tax	0.002*	0.002**	-0.004***
	(0.001)	(0.001)	(0.001)
Low emission · post	-0.026***	0.023***	0.002
	(0.005)	(0.006)	(0.007)
Low emission · tax	0.007***	-0.005***	-0.003
	(0.001)	(0.002)	(0.002)
*post · t*ax	-0.004**	-0.000	0.004*
	(0.001)	(0.002)	(0.002)
Low emission · post · tax	0.004**	0.000	-0.004
	(0.002)	(0.002)	(0.003)
#New Types	-0.000***	-0.001***	0.001***
	(0.000)	(0.000)	(0.000)
#New Models	0.011***	0.004***	-0.015***
	(0.001)	(0.001)	(0.001)
Observations	78,040	78,040	78,040

Notes. The dependent variable in each column is the fraction of advertising spending on the foal type of TV network. All columns are based on observations within the time window of 30 days before to 30 days after each policy change. Standard errors are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

6.2. Average Price Per Slot

Next, the author examines the effect of the sales tax rate on the average advertising price per slot. There is a decrease in the average price per slot for low-emission vehicles when the sales tax rate increased by 2.5%, and an increase in the average price per slot for low-emission vehicles when the sales tax rate decreased by 5% (see Table 7). These results imply that advertisers tend to reduce their efforts in promoting low-emission vehicles when facing unfavorable tax policy changes and increase their efforts in promoting low-emission vehicles when facing favorable tax policy changes.

Table 7. Policy Change Effect on Average Price Per Slot

VARIABLES	ln(Average Price Per lot)
post	-1.521***
	(0.146)
Low emission	-0.195
	(0.275)
Low emission · post	-0.215***
	(0.078)
tax	0.194***
	(0.029)
Low emission · tax	0.113***
	(0.032)
post· tax	-0.341***
	(0.032)
Low emission · post · tax	-0.057**
	(0.024)
#New Types	-0.000
	(0.002)
#New Models	-0.053
	(0.033)
Constant	2.890***
	(0.165)
Observations	376,860
R-squared	0.383
product_id FE	YES
day FE	YES
Number of products	1297

Notes. The dependent variable is the logarithm of the average price per slot. The model is estimated with observations within the time window of 30 days before to 30 days after each policy change. Robust standard errors clustered at the product level are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

7. Discussion and Conclusion

This study finds that advertisers tended to reduce their efforts in promoting low-emission vehicles in the face of unfavorable policy changes (i.e., increases in the tax rate) for these vehicles. This is possibly because most firms still perceive advertising as an expense versus an investment (Deleersnyder et al., 2009), and managers tend to exhibit procyclical advertising behavior when facing external policy changes. Our results add to previous research that demonstrates procyclical decision making in contexts such as R&D investment (Fabrizio and Tsolmon, 2014; Kim, 2021), alcohol consumption (Joo et al., 2021), public spending on health and education (del Granado, Gupta, and Hajdenberg, 2013), and rural public expenditure (Luo et al., 2020), etc.

Our results have managerial implications for managers of automobile firms and TV networks, and also lead to implications for policy makers.

Managers of automobile firms. A firm's advertising spending is usually decided by short-term-oriented senior managers, and nearly 60% of them use only heuristics (e.g., percentage of total sales) to determine advertising spending (Kim 2020; West, Ford, and Farris 2014), and most managers exhibit procyclical advertising behavior (Deleersnyder et al. 2009). Our results suggest that when faced with unfavorable policy changes, firms tend to reduce advertising spending, which will strengthen the negative effect of the unfavorable policy changes on consumers' demand because sales and advertising are positively correlated (see Table A 8 in Appendix D). However, this may not be the optimal advertising strategy from the firm's perspective. As competitors reduce their advertising efforts facing an unfavorable policy change, a firm might be able to gain competitive advantage by increasing its advertising effort. To examine whether this is the case, the author takes the fifth vehicle sales tax rate change (tax rate increase) as an example, and compute the monthly TV advertising spending for each brand during the time period of 3 months before

and 3 months after the change. Results indicate that after the vehicle sales tax rate increased, 61 brands decreased their TV advertising spending and fall into the procyclical group, 29 brands increased their TV advertising spending and fall into the countercyclical group. Estimating the effect of TV advertising on sales for these two groups of advertisers separately, the author finds that the countercyclical group seems to have benefited from the increased advertising (please see Table A 9 in Appendix D).[9]

TV networks. Advertising is a key source of revenue for companies in the broadcasting industry. Due to the rapid growth of online advertising and fierce competition in the advertising industry, traditional media have been forced to find innovative ways to win the attention of advertisers (Pandey, Dutta, and Joshi 2017). At the beginning of each season in the TV industry, broadcasters need to estimate demand to determine the rate card, which affects the size of the upfront market for advertisement slot sales (Pandey, Dutta, and Joshi 2017). Our results indicate that advertisers' demand for advertising slots changes in the face of external tax rate changes. Therefore, TV networks need to take such factors into account when predicting advertising demand, setting advertising prices, and reallocating advertising slots across industries.

Policy makers. In order to lower transport emissions to cope with the climate change, governments often provide tax incentives to discourage purchases of high-emission vehicles and/or encourage purchases of low-emission vehicles (Wappelhorst, Mock, and Yang 2018). Our results indicate that firms' procyclical advertising decisions can in fact reinforce the effectiveness of such tax policies in supporting the global effort of combating global warming, a significant and urgent task facing the international community. Therefore, although the procyclical advertising strategies may not be optimal for the firms, they can potentially help policy makers achieve desirable

[9] We note that this result may not be interpreted as causal because other factors that may potentially affect sales are not controlled for.

outcomes. However, the policy maker needs to consider firm reactions when considering making policy adjustments.

This study has several limitations, which also reflect opportunities for further research. First, this research focuses on TV advertising. As digital advertising becomes increasingly important, future research should explore how tax changes affect firms' digital advertising strategy as well as their budget allocations between traditional and digital advertising media. Second, this research does not analyze the sales implications of the changes in TV advertising strategies because of lack of data on automobile firms' spending on other advertising media. Finally, the context is the automobile market in China, and a comparison study across countries would be valuable.

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APPENDIX

A. Data Details

Table A 1. Top 20 Brands for TV Advertisement Spending in China During 2008–2017

	Brand	N	Time (hours)	Spending (million CNY)	Spending (around ** million USD)	Share of all TV advertisement spending
1	FAW-Volkswagen	413,986	2,243.46	9,856.84	1,449.54	5.99%
2	SAIC-Volkswagen	274,181	1,913.64	7,134.00	1,049.12	4.34%
3	FAW-Volkswagen Audi	200,673	1,542.86	7,039.02	1,035.15	4.28%
4	SAIC-GM Buick	311,772	1,738.52	6,980.03	1,026.48	4.24%
5	Dongfeng-Nissan	363,345	1,897.88	6,574.47	966.83	4.00%
6	SAIC-Volkswagen Skoda	231,936	1,563.55	6,340.39	932.41	3.85%
7	Chang'an-Ford	211,054	1,110.86	6,322.99	929.85	3.84%
8	Beijing-Hyundai	306,387	1,456.45	6,054.03	890.30	3.68%
9	Dongfeng Yueda-Kia	281,920	1,471.61	4,853.66	713.77	2.95%
10	SAIC-GM Chevrole	216,725	1,240.97	4,750.61	698.62	2.89%
11	FAW-Toyota	313,082	1,518.82	4,500.00	661.76	2.74%
12	BMW	193,022	1,349.87	4,272.96	628.38	2.60%
13	Dongfeng-Peugeot	222,879	1,069.75	3,847.51	565.81	2.34%
14	Dongfeng-Citroen	222,654	1,111.06	3,188.05	468.83	1.94%
15	GAC-Toyota	155,185	728.23	2,948.00	433.53	1.79%
16	Mercedes-Benz	153,383	1,114.04	2,944.69	432.94	1.79%
17	Lexus	178,710	1,277.46	2,590.65	380.98	1.57%
18	Pentium	98,312	487.84	2,578.90	379.25	1.57%
19	Roewe	127,876	886.35	2,421.86	356.16	1.47%
20	BYD	162,273	779.99	2,315.91	340.58	1.41%

This author uses a case study to illustrate the relationship between the sales tax policy and advertising intensity. As shown in Table A 1, FAW-Volkswagen was the largest advertiser in terms of total advertising spending during 2008–2017. During this period, eight models of the FAW-Volkswagen were sold in the mainland China market (Table A 2). Among these, the emissions displacements of all body types of "CC" are higher than 1.6L, and the emissions displacements of all body types of "Bora," "Golf Sportsvan," and "C-TREK" are lower than or equal to 1.6L. The remaining four models—Golf, Magotan, Sagitar, and Jetta—include a mix of displacement sizes.

Table A 2. Models of FAW-Volkswagen During 2008–2017

	Models	Body Types		Fraction of body types with a displacement lower than or equal to 1.6L
		Number of body types with a displacement higher than 1.6L	Number of body types with a displacement lower than or equal to 1.6L	
1	Bora	0	37	1
2	CC	34	0	0
3	Golf	4	63	0.94
4	Golf Sportsvan	0	8	1
5	Magotan	63	14	0.18
6	Sagitar	11	79	0.88
7	C-TREK	0	7	1
8	Jetta	3	47	0.94
Total		115	255	0.69

During 2008–2017, FAW-Volkswagen advertised nine products on TV, including the eight models and the FAW-Volkswagen brand (see Table A 3). Table A 3 shows the advertising spending for each advertised product during the 30-day period before and the 30-day period after each sales tax policy change. When the sales tax rate increased (2nd, 3rd. and 5th policy changes), TV advertising spending for CC, C-TREK, and Magotan all decreased. When the sales tax rate decreased (4th policy change), TV advertising spending for Magotan, Sagita, Golf, and FAW-Volkswagen all increased. This implies a negative relationship between TV advertising spending and the sales tax rate for most models of FAW-Volkswagen.

Table A 3. TV Advertising Spending (Million CNY) for FAW-Volkswagen Models

	Advertised product	2nd policy change		3rd policy change		4th policy change		5th policy change	
		before	after	before	after	before	after	before	after
1	CC	0	0	11.30	2.53	0	0	0	0
2	Bora	23.50	31.74	6.96	9.67	7.55	1.80	0.11	0.01
3	Jetta	0	16.04	0	0.05	10.46	0.40	30.07	57.71
4	C-TREK	0	0	0	0	0	0	39.20	2.44
5	Magotan	46.04	18.32	40.47	1.76	1.65	21.16	69.48	8.61
6	Sagitar	0.29	30.34	0	0	1.22	42.66	4.53	0
7	Golf Sportsvan	0	0	0	0	0	0	0	0
8	Golf	37.72	10.89	0.01	0.02	23.44	25.06	0	0
9	FAW-Volkswagen	0.78	0	0.43	34.24	0.05	1.22	3.19	0

B. Parallel Trend

Figure A 1. Parallel Trend Test

C. Robustness Checks

Table A 4. Placebo Test

VARIABLES	(1) ln (Advertising spending + 1)	(2) ln(Number of advertisements+1)	(3) ln(Total time of advertisements+1)
post	-1.268***	-0.271***	-0.575***
	(0.133)	(0.029)	(0.059)
Low emission	-0.122	-0.017	-0.067
	(0.303)	(0.062)	(0.135)
Low emission · post	-0.018	-0.015	-0.019
	(0.057)	(0.013)	(0.025)
tax	0.118***	0.033***	0.066***
	(0.027)	(0.006)	(0.012)
Low emission · tax	0.092***	0.014**	0.034***
	(0.030)	(0.006)	(0.013)
post· tax	-0.256***	-0.060***	-0.125***
	(0.030)	(0.006)	(0.013)
Low emission · post · tax	0.006	0.004	0.007

	(0.022)	(0.005)	(0.009)
#New Types	0.003	0.000	0.001
	(0.003)	(0.001)	(0.001)
#New Models	-0.060	-0.010	-0.022
	(0.040)	(0.008)	(0.017)
Constant	2.433***	0.462***	1.067***
	(0.181)	(0.037)	(0.080)
Observations	389,400	389,400	389,400
R-squared	0.394	0.360	0.387
product_id FE	YES	YES	YES
day FE	YES	YES	YES
Number of products	1297	1297	1297

Notes. The dependent variables in columns (1) - (3) are respectively the logarithm of advertising spending, the logarithm of number of advertisements and the logarithm of total time of advertisements. All columns are based on observations within the time window of 30 days before to 30 days after each policy change. Robust standard errors clustered at the product level are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A 5. Redefining Low-emission Vehicles

	$fraction_i$>=0.4			$fraction_i$>=0.75		
VARIABLES	(1) ln (Advertising spending + 1)	(2) ln(Number of advertisements+1)	(3) ln(Total time of advertisements+1)	(4) ln (Advertising spending + 1)	(5) ln(Number of advertisements +1)	(6) ln(Total time of advertisements+1)
post	-1.513***	-0.312***	-0.702***	-1.515***	-0.312***	-0.703***
	(0.146)	(0.031)	(0.065)	(0.146)	(0.031)	(0.065)
Low emission	0.020	-0.025	0.000	-0.395	-0.110*	-0.201
	(0.267)	(0.057)	(0.120)	(0.270)	(0.065)	(0.127)
Low emission · post	-0.250***	-0.032*	-0.093***	-0.213**	-0.026	-0.076**
	(0.080)	(0.017)	(0.035)	(0.084)	(0.018)	(0.037)
tax	0.195***	0.041***	0.092***	0.193***	0.041***	0.091***
	(0.029)	(0.006)	(0.013)	(0.029)	(0.006)	(0.013)
Low emission · tax	0.113***	0.022***	0.047***	0.113***	0.022***	0.047***
	(0.032)	(0.007)	(0.014)	(0.032)	(0.007)	(0.014)
post· tax	-0.343***	-0.074***	-0.160***	-0.340***	-0.073***	-0.158***
	(0.032)	(0.007)	(0.015)	(0.032)	(0.007)	(0.015)
Low emission · post · tax	-0.057**	-0.009*	-0.022**	-0.057**	-0.009*	-0.022**
	(0.024)	(0.005)	(0.011)	(0.024)	(0.005)	(0.011)
#New Types	-0.000	-0.000	-0.001	-0.000	-0.000	-0.001
	(0.002)	(0.000)	(0.001)	(0.002)	(0.000)	(0.001)
#New Models	-0.053	-0.008	-0.023	-0.053	-0.008	-0.023
	(0.033)	(0.007)	(0.014)	(0.033)	(0.007)	(0.014)
Constant	2.805***	0.536***	1.230***	2.944***	0.562***	1.297***
	(0.162)	(0.035)	(0.073)	(0.153)	(0.035)	(0.070)
Observations	376,860	376,860	376,860	376,860	376,860	376,860
R-squared	0.383	0.354	0.378	0.383	0.354	0.379
product_id FE	YES	YES	YES	YES	YES	YES
day FE	YES	YES	YES	YES	YES	YES
Number of products	1297	1297	1297	1297	1297	1297

Notes. The dependent variables in columns (1) - (3) and (4) – (6) are respectively the logarithm of advertising spending, the logarithm of number of advertisements and the logarithm of total time of advertisements. All columns are based on

observations within the time window of 30 days before to 30 days after each policy change. Robust standard errors clustered at the product level are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A 6. Using Fraction of Low-Emission Vehicles as the Independent Variable

VARIABLES	(1) ln (Advertising spending + 1)	(2) ln(Number of advertisements+1)	(3) ln(Total time of advertisements+1)
post	-1.524***	-0.313***	-0.706***
	(0.145)	(0.031)	(0.065)
fraction	-0.229	-0.076	-0.132
	(0.271)	(0.061)	(0.124)
fraction · post	-0.213***	-0.028	-0.077**
	(0.081)	(0.017)	(0.036)
tax	0.197***	0.041***	0.092***
	(0.029)	(0.006)	(0.013)
fraction · tax	0.109***	0.022***	0.046***
	(0.033)	(0.007)	(0.015)
post· tax	-0.344***	-0.074***	-0.160***
	(0.032)	(0.007)	(0.014)
fraction · post · tax	-0.051**	-0.008	-0.020*
	(0.025)	(0.006)	(0.011)
#New Types	-0.000	-0.000	-0.001
	(0.002)	(0.000)	(0.001)
#New Models	-0.053	-0.008	-0.023
	(0.033)	(0.007)	(0.014)
Constant	2.904***	0.556***	1.283***
	(0.164)	(0.037)	(0.075)
Observations	376,860	376,860	376,860
R-squared	0.383	0.354	0.378
product_id FE	YES	YES	YES
day FE	YES	YES	YES
Number of products	1297	1297	1297

Notes. The dependent variables in columns (1) - (3) are respectively the logarithm of advertising spending, the logarithm of number of advertisements and the logarithm of total time of advertisements. All columns are based on observations within the time window of 30 days before to 30 days after each policy change. Robust standard errors clustered at the product level are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A 7. Different Time Windows

	60 days			90 days		
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	ln (Advertising spending + 1)	ln (Number of advertisements +1)	ln (Total time of advertisements +1)	ln (Advertising spending + 1)	ln (Number of advertisements +1)	ln (Total time of advertisements +1)
post	-1.309***	-0.263***	-0.584***	-1.420***	-0.268***	-0.643***
	(0.141)	(0.029)	(0.061)	(0.147)	(0.029)	(0.064)
Low emission	-0.032	-0.049	-0.058	0.011	-0.029	-0.026
	(0.248)	(0.055)	(0.114)	(0.232)	(0.050)	(0.105)
Low emission · post	-0.213***	-0.024	-0.074**	-0.203***	-0.032*	-0.082**
	(0.080)	(0.017)	(0.035)	(0.077)	(0.017)	(0.034)
tax	0.142***	0.028***	0.064***	0.169***	0.030***	0.076***

	(0.028)	(0.006)	(0.012)	(0.028)	(0.006)	(0.012)
Low emission · tax	0.121***	0.023***	0.050***	0.133***	0.025***	0.055***
	(0.030)	(0.006)	(0.013)	(0.029)	(0.006)	(0.013)
post· tax	-0.323***	-0.063***	-0.143***	-0.328***	-0.060***	-0.145***
	(0.032)	(0.007)	(0.014)	(0.033)	(0.007)	(0.014)
Low emission · post · tax	-0.053**	-0.008	-0.019*	-0.066**	-0.012**	-0.027**
	(0.026)	(0.006)	(0.011)	(0.027)	(0.006)	(0.012)
#New Types	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
	(0.002)	(0.000)	(0.001)	(0.002)	(0.000)	(0.001)
#New Models	-0.033	-0.005	-0.015	-0.044	-0.009	-0.021*
	(0.031)	(0.006)	(0.013)	(0.030)	(0.006)	(0.012)
Constant	2.574***	0.482***	1.122***	2.724***	0.492***	1.184***
	(0.155)	(0.033)	(0.070)	(0.162)	(0.034)	(0.072)
Observations	753,720	753,720	753,720	1,130,580	1,130,580	1,130,580
R-squared	0.370	0.339	0.366	0.356	0.325	0.353
product_id FE	YES	YES	YES	YES	YES	YES
day FE	YES	YES	YES	YES	YES	YES
Number of products	1297	1297	1297	1297	1297	1297

Notes. The dependent variables in columns (1) - (3) and (4) – (6) are respectively the logarithm of advertising spending, the logarithm of number of advertisements and the logarithm of total time of advertisements. Column (1) - (3) are based on observations within the time window of 60 days before to 60 days after each policy change and column (4) - (6) are based on observations within the time window of 60 days before to 60 days after each policy change. Robust standard errors clustered at the product level are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

D. Relationship between TV Advertising and Sales

To study the relationship between TV advertising spending and vehicle sales, we collected monthly vehicle sales data from 2008 to 2017 in the Chinese market from the China Association of Automobile Manufactures (CAAM), and merged vehicle sales data with TV advertising data at the brand level. Because the car sales data do not include imported vehicle brands, the merged data include 130 brands. We use the following empirical model to explore the impact of TV advertising spending on sales:

$$ln\ Sales_{i.t} = \alpha_0 + \beta_1 \cdot ln\ Ad\ Spending_{i.t-1} + f_i + \delta_t + \varepsilon_{it}, \quad \text{(A1)}$$

where i and t represent the brand and the month, respectively. The dependent variable, $ln\ Sales_{i,t}$, is the logarithm of the total sales for brand i on month t and the independent variable $ln\ Ad\ Spending_{i,t-1}$, is the logarithm of the total TV advertising spending for brand i in month $t-1$. f_i represents brand fixed effect and δ_t represents month fixed effect. ε_{it} is the error term.

Results in Table A 8 show that there is a positive relationship between TV advertising spending and sales in the automobile industry. Note that because many factors that can potentially affect sales (e.g., Internet advertising, sponsorships) are not included, the result should be interpreted as a correlation instead of a causal relationship. In addition, we do not distinguish between different models within a brand, so the analysis is at a more coarse level compared with the analyses in the paper and is intended to provide some evidence on the relationship between TV advertising and sales at the brand level.

Table A 8. TV Advertising Effects on Sales

VARIABLES	$ln\ Sales_{i.t}$
$ln\ Ad\ Spending_{i.t-1}$	0.163***
	(0.018)
Constant	2.386***
	(0.188)
R-squared	0.746
Brand FE	YES
Observations	15,470
Number of brands	130

Notes. The dependent variable is the logarithm of sales of brand *i* in month *t*. Results are based on observations from February 2008 to December 2017. Robust standard errors clustered at the brand level are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

To further study the relationship between TV advertising spending and vehicle sales under different advertising strategies, we take the fifth vehicle sales tax rate change (tax rate increase) as an example, and compute the monthly TV advertising spending for each brand during the time period of 3 months before and 3 months after the change. We find that after the vehicle sales tax rate increased, 61 brands decrease their TV advertising spending and fall into the procyclical group, 29 brands increase their TV advertising spending and fall into the countercyclical group, the remaining 40 brands had zero TV advertising spending.

We further estimate model A1 to explore the impact of TV advertising spending on sales respectively for the procyclical group and for the countercyclical group. Results in Table A 9 show

that the effect of TV advertising spending on sales in the countercyclical group is more prominent than in the procyclical group.

Table A 9. TV Advertising Effects on Sales in Different Gourps

	$ln\ Sales_{i.t}$	
VARIABLES	Procyclical group	Countercyclical group
$ln\ Ad\ Spending_{i.t-1}$	0.004	0.070*
	(0.007)	(0.035)
Constant	8.213***	6.297***
	(0.148)	(0.503)
R-squared	0.958	0.951
Brand FE	YES	YES
Month FE	YES	YES
Observations	366	174
Number of brands	61	29

Notes. The dependent variable is the logarithm of sales of brand *i* in month *t*. Results are based on observations from October 2016 to March 2017. Robust standard errors clustered at the brand level are shown in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Note that because many factors that can potentially affect sales (e.g., Internet advertising, sponsorships) are not included, results in both Table A 8 and Table A 9 should be interpreted as a correlation instead of a causal relationship.