Eco-Friendly Car Policy: Targeted and Spillover Effects

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Developments in the automobile industry can be either a boon or a bane. On one hand, they can spur economic growth and fuel employment (Miravete and Moral 2009). On the other hand, they can produce environmental pollution from greenhouse gas emissions (IEA 2011). This double-edged sword may be particularly sharp in developing countries such as China and India. In China, vehicular emission pollution is the main source of dust-haze (Vehicle Pollution Prevention Annual Report 2013).[1]

Thus, to bolster the automobile industry while stemming environmental side-effects, governments worldwide have developed various institutional policies. For instance, in 2009 the U.S. implemented the "cash for clunkers" program, formally known as the Cars Allowance Rebate System. The program offered a rebate of $3,500 - $4,500 for each old and low fuel-efficient vehicle that consumers traded in for a newer, more fuel-efficient one (Knittel 2009). While intended to reduce pollution and stimulate sales of more fuel-efficient cars, the policy garnered doubts about its effectiveness. Some researchers found that purchases stimulated by the policy were offset by a dip in auto sales further down the road (Mian and Sufi 2012), and others found the program to be too costly for tax payers (Knittel 2009). Thus, for institutional economies to effectively achieve intended goals is a challenge.

To overcome this challenge, the present study evaluates the impact of an alternative institutional policy launched in China. The Chinese automobile industry plays a critical role in the global economy as the world's largest automobile producer and consumption market. However, the pollution caused in China by automobiles is enormous. To help curb this pollution, in 2009 China launched the Tax-reduction for Low-emission Vehicles (TLV) policy, which reduced the purchase tax for cars with small engines for two years, from 2009 through 2010.[2] The implementation of TLV was intended to bloom the market of

[1] Source: http://www.vecc-mep.org.cn/news/e_home_gg/1390967956277.html; http://www.china-embassy.org/eng/xw/t650869.htm, last accessed on June 17, 2014.

[2] In China, three categories of automobile taxes, including the consumption tax, the value-added tax and the purchase tax, are charged by the government. Among these three taxes, the purchase tax is the only tax paid by consumers directly, while the consumption tax and value-added tax will be paid by manufacturers and retailers respectively. TLV reduced the purchase tax of

small-engine cars, of which the market share dramatically decreased from 2004 to 2007. The proposal of TLV policy was passed on January 14th, 2009 and implemented on January 20th, 2009.

TLV differed from "cash for clunkers" in two key ways: first, in the "cash for clunkers" program the federal government provided a direct incentive via monetary subsidy (up to 4,500 USD) for every qualified replacement of old vehicles, implying a high pay-out for the policy-maker. As Tyrell and Dernbach (2010 p. 491) note, "the hard reality about programs that depend on direct public subsidies [such as "cash for clunkers"] is that they are difficult to support over time." In contrast, the TLV operated by allowing consumers to pay a lower tax to the government if they purchased a small-engine car (i.e., 1.6-liter and below). Thus, a large initial fund allocation was not required for this program, which also means that it may be more financially feasible for developing countries. Second, TLV represented policy measures that attempted to influence consumers' choice and decision, i.e., on whether to buy a smaller-engine car to enjoy a tax reduction. This implies that all consumers who intended to buy a new car would be affected by the policy. In contrast, the "cash for clunkers" was only eligible for those who owned an old car that met the program criteria (Busse et al. 2012). Thus, in the context of a developing country in China, where most new car purchases are made by first-time buyers, TLV policy may have a larger impact.

Our identification hinges on the changes in car sales before, during, and after the TLV policy. In terms of environmental aspects, we assess the change in sales of more environmental-friendly cars with small-engines ($\leqslant$1.6-liter) vis-à-vis less environmental-friendly cars with big-engine (>1.6-liter). Our analyses reveal that the TLV produced three key results: 1) the policy indeed boosted sales of small-engine cars (a positive direct effect or targeted effect); interestingly, it also simultaneously dampened sales of big-engine cars (a negative spill-over effect or untargeted surprising effect). 2) Deeper analyses document that the positive direct effect of the TLV policy was driven by sales in smaller rural cities with slower economic and infrastructural developments. 3) The negative spillover effect of the TLV policy was attributed to sales in larger metropolitan cities with faster economic and infrastructural developments. The dip in sales occurred mostly for non-indigenous car brands, while indigenous car brands experienced increased sales.

Recently, research has addressed how car policies may curb pollution or "automobile externalities" (Parry et al. 2007; Porter 1999). A variety of car policies have been considered to limit automobile ownership,

small-engine cars (1.6 liter and below) from 10% to 5% in 2009. The policy continued implementing in 2010 with a little revision, the reduced tax rate changed to 7.5%, from January to December 2010. After the two-year TLV policy period, the purchase tax rate for small-engine cars turned back to 10% in 2011. The purchase tax for big-engine (>1.6-liter) cars is 10% all the time.

reduce automobile use, and promote more eco-friendly vehicles. Policies limiting ownership involve bidding and lottery mechanisms implemented in China (Chen and Zhao 2013; Hao et al. 2011).[3] Policies that reduce automobile use involve raising fuel taxes (Parry and Small 2005; Bento et al 2009) and prescribing the use of odd- or even-numbered car plates on the road in some cities such as Beijing (Cai and Xie 2011). Policies changing automobile use patterns involve charging higher toll fees during times and places when road systems are congested (to encourage people to travel during off-peak hours or via less congested areas). Such measures may reduce vehicular emissions because they help minimize trip durations and decrease speed variations (Daniel and Bekka 2000). Though effective to varying extents, these policies often achieve their environmental purposes at the expense of the automobile industry's development, i.e., by discouraging car purchases due to the high costs of purchase or usage. Some policies that promote eco-friendly vehicles specifically target automobile makers or consumers' cars. Examples include imposing requirements to meet vehicle manufacturing standards such as the Corporate Average Fuel Economy (CAFE) program in the U.S. and the system for controlling emissions of new vehicles in the E.U. Policies that target consumers include the "cash for clunkers" program to address environmental problems and stimulate the automobile industry (Mian and Sufi 2012).[4]

A series of studies have been conducted to assess the effectiveness of such programs with respect to either automobile manufacturers or consumers, with mixed results. For instance, such programs have been credited with "halo" sales of another quarter million cars (Maritz Research 2010).[5] In addition, an NHTSA's (National Highway Traffic Safety Administration) Report to Congress indicated that 49% of the cars sold under such a program were manufactured locally, thus creating over 60,000 jobs in automobile manufacturing and sales and related industries (Tyrell and Dernbach 2010). However, a more recent study by Mian and Sufi (2012) suggests programs simply shift purchases forward. Fewer autos were bought in the ten months after the U.S. program expired in counties with a higher number of clunkers, thereby offsetting most of the initial purchases made. They also found no evidence of the program's effect on employment in cities with higher exposure to the program. A study by Miravete and Moral (2009) on a comparable cash for clunkers program in Spain reached similar conclusions – that these programs may simply accelerate

[3] In the former (bidding-based mechanism), consumers who intend to purchase a car need to bid for a car license; in the latter (lottery-based mechanism), non-transferrable car licenses are allocated through random draws among registered participants.

[4] As stated by the U.S. Secretary of Transportation Ray LaHood on July 27, 2009, "with this program, we are giving the auto industry a shot in the arm, and struggling consumers can get rid of their gas-guzzlers and buy a more reliable, fuel-efficient vehicle. This is good news for our economy, the environment, and consumers' pocketbooks."

[5] Source: http://www.maritz.com/Press-Releases/2010/Maritz-Research-Findings-Cash-for-Clunkers-More-Successful-Than-Previously-Reported.aspx.

intentions to change cars. With respect to the program's intended environmental effects, most studies have provided affirmative evaluations (Huang 2010). For instance, the NHTSA's Report to Congress estimated that the program will lead to a reduction of greenhouse gas emissions by 9 million metric tons over 25 years. Also by replacing older vehicles with new ones, the program may reduce the emissions of other criteria pollutants. Yet, prior research points out that the costs of attaining these environmental benefits could be staggeringly high (Knittel 2009; Li et al. 2011).

We contribute to the literature by showing that an institutional car policy may be effective in several ways. At its fundamental level, the policy could indeed orient consumer purchases toward small-engine cars as intended, while at the same inhibit the purchases of big-engine cars not targeted. In addition, automobile, which belongs to transportation or manufacturing industry, is indeed a large source of air pollution(Muller et al. 2011); our empirical evidence demonstrates the institutional policy could effectively reduce the air pollution by decreasing the purchase of large-engine cars in large metropolitan, which are the area with the most critical environment problems; on the other side, it could simultaneously increase the sales of small-engine cars in middles size and small size cities, where the environmental problem is gradually concerned, so as to pursue a long-term environmental improvement. Our results also show that environmental policies could garner local economic benefits by limiting the sales of big-engine cars of non-indigenous brands, while stimulating sales of indigenous car brands. In 2006, Djankov et al. claim that the role of political institutions in fostering or restricting entrepreneurship is very vital. Our study expand their study by improving the effectiveness of institutional policy, that TLV policy helped indigenous car brands, especially for local entrepreneurs, who usually play a crucial role in the success of country's economic growth and innovation, fend off competition.

The rest of the paper is organized as follows. Section I briefly overviews the automobile industry in China prior to the implementation of TLV. Section II reports the data and empirical results. Finally, Section III discusses the study's contributions and concludes with implications of the results.

I. Background

The automobile industry in China has undergone rapid developments since the 1978 reform and opening up policy. In 1980, the number of motor vehicles in China was only 1.8 million, but within 10 years the number grew to 5.1 million with an annual growth rate of 11.1%. The period from 1990 to 1999 witnessed a relatively stable growth of motor vehicles in the country, with the number reaching 14.5 million in 1999 (a

10.2% annual growth rate). More rapid growth subsequently followed from 2000 to 2009, with an annual growth rate of 14.5%; by 2009, the number of motor vehicles in China had reached 62.1 million. As a developing country, the automobile industry has played a key role in China's economic development, contributing to 28.6% of the nation's total GDP (based on reported statistics from 1978 to 2006) while also significantly supporting the developments of a wide range of other industrial segments, e.g., steel, manufacturing, and service.[6]

China has been actively cultivating the automobile industry during the past 30 years. In the early days, Chinese state-owned automobile manufacturers primarily focused on producing large commercial trucks, and only a limited number of passenger cars (Baker and Hyvonen 2011). Starting from the early 1980s, joint venture partnerships with major global automobile manufacturers were approved to develop China's domestic production capabilities through technology and knowledge transfer. The 1994 implementation of the Automobile Industry Policy took a significant step in this direction. The policy allowed large global manufacturers to operate in China under a joint venture with their ownership restricted to no more than half. Major local participants in these joint ventures included Beijing-based First Automobile Works (FAW), the Shanghai Automotive Industry Corporation (SAIC), and Hubei-based Dongfeng Motors, which collectively were the so-called "big three." Riding on the strong economic growth in China at the start of the 2000s, automobile production picked up significantly, with new state-owned and private manufacturers (e.g., Geely, Chery, and BYD) entering the market. In 2004 the Automobile Industry Policy was updated with a greater emphasis on domestic research and development, as a key objective was to develop a few famous indigenous brands and globally competitive automobile groups (top 500) by 2010 (Baker and Hyvonen 2011). Yet, given the extremely competitive automobile market in China, indigenous brands occupy only a small percentage of the market (Oliver et al. 2009).

It is important to recognize that due to the wide disparity in the economic development across the country, China constitutes a multi-tiered socio-economic landscape. First-tier metro cities are the most developed with the best infrastructures and typically host larger populations, e.g., Beijing and Shanghai. In contrast, lower-tiered rural cities lag in infrastructural development, and have smaller populations with lower average income levels. Traditionally the sales of private cars had been concentrated in higher-tiered cities, but this trend is changing as economic growth now drives personal income. According to a Nielsen report

[6] Source: http://www.cnautonews.com/pl/zl/201403/t20140321_298349.htm, last accessed on July 6, 2014.

(2013), more car purchases are increasingly coming from lower-tiered cities, with 56% of potential buyers first-time ones.[7] Coupled with the estimation that the penetration rate of the auto market is only 5% in China overall, there is still much potential for the automobile market.

Concomitantly, the negative implications of automobile development such as environmental pollution has also become increasingly striking. In 2009, vehicular emissions such as nitrogen oxide and hydrocarbon accounted for over 25% of national total emissions in China. In large cities such as Beijing, Shanghai, and Guangzhou, vehicular emissions have become a major source of air pollution (Wang and Hao 2012). It has also been noted that car emissions are the leading contributor of summer problems in Beijing (Wang et al., 2012). Against this backdrop, the TLV policy was initiated and evaluated in terms of its effectiveness.

II. Empirical Analyses

A. *Data*

Our dataset contains the entire record of passenger car registrations in China. To study the impact of TLV, we focus on the registration records from July 2008 through June 2011, covering the policy implementation period and six months prior and six months after the policy implementation. During this three-year observation window, 24,574,631 cars were purchased and registered in China. The registration records contain the following information: time of purchase (month), brand, car model, engine type, the city in which the car was purchased and car buyer's demographic data. There are 67,283 missing values of demographic variables (age and gender) in our data, which is about 1.13% of total 5,962,320 observations. We replace them by mean values of car buyer's age/gender proportion in specific month group, city-tier group and price-tier group respectively. We also collected a number of variables as controls from the China Statistical Yearbook[8], including GDP, average amount of savings, unemployment rate, and population. These variables have been considered in other studies investigating car policy stimuli (Mian and Sufi 2012; Miravete and Moral 2009), given that they may influence consumer decisions to purchase cars vis-à-vis the cost of car usage.

Figure 1 shows the sale changes of small- and big-engine cars in our study period. Table 1A presents the summary statistics of our dependent variables. Apart from the statistics of total car sales during the study period, we split the records into the sales of big-engine cars (>1.6-liter) and small-engine cars (≤1.6-liter),

[7] Source: http://www.nielsen.com/us/en/insights/news/2013/in-china_s-auto-market--smaller-cities-are-in-the-drivers-seat.html, last accessed on July 6, 2014.
[8] Source: http://www.stats.gov.cn/tjsj/ndsj/, last accessed on July 9, 2014.

and separated the statistics into three time periods (before, during, and after the policy period), and by different city tiers.

[Insert Figure 1 here.]

[Insert Table 1A here.]

Comparisons of monthly average sales six months prior to, during, and six months after the policy (TLV) show significant differences in terms of the sales of all cars, big-engine cars, and small-engine cars (see Table 1): sales were significantly higher during the policy implementation period, with a 124% increase in sales of small-engine cars, and only a 52.3% increase for big-engine cars. Comparing with the increase of total car sales (91.2%) from pre-policy period to policy period, it's reasonable to state that the sales of small-engine cars increased much more dramatically than those of big-engine cars in general. These provide initial model-free evidence for the impact of the TLV on car sales.

Besides, Table 1B and 1C present the summary of car related variables and demographic data of our study respectively.

[Insert Table 1B, Table 1C here.]

B. *Empirical Analyses*

We first examine the change in car sales with the following regression model:

$$Sales_{ijt} = \alpha_0 + \alpha_1 Policy_t + \alpha_2 Post_t + \boldsymbol{\Delta ControlVars_{it}} + \Omega i + \epsilon_{ijt} \quad (1)$$

where *i* indicates the city, *j* indicates the car type, and *t* indicates the month. The dependent variable, $Sales_{ijt}$, is the natural logarithm of sales volume. As the data cover three periods, i.e., pre-policy, during-policy, and post-policy, we use two dummies, $Policy_t$ and $Post_t$, to identify the periods respectively. $Policy_t$ is equal to 1 if month *t* is during the implementation of the TLV policy and 0 if otherwise. $Post_t$ is equal to 1 if month *t* is after the implementation of the TLV policy, and 0 if otherwise. Thus, when both $Policy_t$ and $Post_t$ are 0, month *t* should be before the policy implementation. As previously mentioned, we also control the macro-economic impacts, including time trend, regional GDP (100 billion in RMB), regional savings per household (1,000 in RMB), unemployment rate (%), and regional population (10 million), as well as other policies which were being implemented during the observation period of our dataset. Time trend is an important control because it helps rule out alternative explanation of consumers' ability to purchase cars in rural lower-tier cities over time, beyond the income effects controlled for by other covariates. We separated the analyses into the total car sales, the sales of big-engine cars, and the sales of small-engine cars, and

estimated the three models contemporarily by Seemingly Unrelated Regression (SUR) method. Table 2 presents the results.

[Insert Table 2 here.]

As the results show, the TLV policy had a positive effect on total car sales in general. However, when we refine the analysis by car types, we see that the policy indeed has a positive effect on the sales of small-engine cars (direct effects as intended by the policy). Interestingly, this policy also has a negative effect on the sales of big-engine cars (a negative spill-over effect). These effects are robust to controlling for the trends of growing car sales in China (denoted by the time trend variable), other policies that were implemented during the study period (both of them, denoted by Scrappage and Trucks), and other variables that may influence car sales: regional GDP, regional savings per household, unemployment rate, and regional population.

The positive targeted effect is straightforward: the TLV policy decreased price of small-engine cars and raised sales consequently. And about the negative spillover effect, it might be caused by the substitution effect, especially for big-engine cars with emission closer to 1.6 L, which is the cut point. Our additional study on more emission groups also provides an additional support to this explanation.

To gain deeper insights into these effects of the TLV policy, we segment the data analyses by city tiers in China (see the Appendix). As previously mentioned, China has different city-tiers with considerable variation in terms of development levels. First-tier cities consist of sixteen mega cities, including Beijing, Shanghai, and main provincial capital cities (e.g., Hangzhou, Nanjing, and Chengdu). These cities possess rich resources of economy, education, nature and have a relatively developed economy. The 154 cities in the second-tier are usually the capital cities of small provinces (e.g., Taiyuan, Fuzhou, and Guiyang) or important cities in medium-level provinces (e.g., Datong, Dalian, and Erdos). Most of the second-tier cities have their own pillar industries. Beyond the second-tier, China has cities that do not have well-developed economies. 194 cities belong to such third-tier in our dataset. To ensure the robustness of our study, we also checked the result of first-tier cities without Beijing and Shanghai, where have additional limitation for car plate application.[9] Table 3 presents the regression analysis across the three city-tiers.

[Insert Table 3 here.]

The results show that the intended positive effect of the TLV on the sales of small-engine cars actually

[9] Beijing has a lottery system for car plate application and Shanghai has an auction system for it.

occurred in the lower-tier cities (tiers 2 and 3), but not in the first-tier cities. In contrast, the negative spillover effect of the policy on the sales of big-engine cars occurred in higher-tier cities (tier 1), but not in the 2nd and 3rd tier cities at the bottom-end. As such, the direct, targeted positive main effects of promoting smaller engine cars are driven by sales in lower-tier cities, whereas the indirect, untargeted negative spill-over effects of limiting larger engine cars are driven by sales in higher-tier cities.

A possible explanation for the existence of positive targeted effect on smaller cities only is that citizens of smaller cities usually have a lower income and are more price-sensitive**.** By and large, the public transportation in smaller cities is comparatively inconvenient. Therefore, a lower price stimulates the sales of small-engine cars in smaller cities. In contrast, citizens of mega cities are of less price-sensitivity, which means the policy would not increase their willingness to buy small-engine cars to a great extent. And the public transportation in larger cities is more convenient, so citizens of larger cities might change the means of transportation to subway, bus and some other kinds of public transportation.

We next assess the policy effects across car brands. As show in Tables 4A, we find that the policy stimulated the sales of small-engine cars of both indigenous and non-indigenous brands but only reduced the sales of large-engine cars of non-indigenous brands. Specifically, we analyze twelve major brands, including five indigenous brands and seven non-indigenous brands respectively. As shown in Table 4B and 4C, most indigenous brands (FAW, BYD, Geely and JAC, except Chery) enjoyed a sales increase of small-engine cars while only three of seven non-indigenous brands (Honda, Peugeot, Suzuki) had the same increase. And about the large-engine cars, all indigenous brands enjoyed a sales increase; however, of the seven non-indigenous brands, two (Toyota and Peugeot) suffered in sales, three experienced no significant change (KIA, Kyundai, and Suzuki), and only two obtained a sales increase (Honda and Volkswagen). As such, this TLV policy actually favors the growth of indigenous car brands vis-à-vis non-indigenous counterparts, an interesting spillover effect not intended by the policy. The occurrence of negative spillover effect on non-indigenous brands is possibly caused by the fact that prices of non-indigenous brand automobiles are generally higher than indigenous brands. Consumers preferring to buy cars with non-indigenous brands might be influenced more by the TLV policy, and the substitution effect thereby occurs more on non-indigenous brands.

[Insert Table 4A, Table 4B and Table 4C here.]

C. Additional Studies

1. More Emission Groups

To further explore the effect of TLV policy, we replicate our basic model with six different emission groups.[10]

[Insert Table 5 here.]

The result shows that the effect of TLV policy on three emission groups of small-engine cars is consistently positive, and the negative spillover effect also occurs on all emission groups of large-engine cars. In addition, we find that the TLV policy has a comparatively larger positive targeted effect and negative spillover effect on emission groups around 1.6 Liter. This finding, to some extent, supports our explanation of substitution effect for the existence of negative spillover effect on big-engine cars.

2. Robustness Check

In order to ensure the reliability of our findings, we conduct a robustness check by adding individual control variables and car related variables in other study to measure consumer heterogeneity:

$$Sales_{ijt} = \alpha_0 + \alpha_1 Policy_t + \alpha_2 Post_t + \boldsymbol{\Gamma Individual_{ijt}} + \boldsymbol{\Theta Car_{ijt}} + \boldsymbol{\Delta ControlVars_{it}} + \Omega i + \epsilon_{ijt} \quad (2)$$

In model (2), $Individual_{ijt}$ includes age and gender. Following Chandra and Kaiser (2014), we use the Herfindahl Hirschman Indexes (HHIs) to measure the heterogeneity of car buyers' demographic characteristics. The value of a HHI closer to 0 indicates more diversity of characteristics, whereas it closer to 1 means greater homogeneity. $Cars_{ijt}$ cover the distributions of several major car features, including car model, ownership, usage, payment method of purchase, color, and fuel type. All these features are shown in percentage terms. For instance, $Black_{ijt}$ indicating the percentage of black cars sold in a specific car type per city per month. Other variables are the same as those in model (1).

We also do the robustness check in other two ways. As most Chinese retailers need to achieve the settled sale targets by the end of year, there are usually plenty of promotions provided by different 4S shops in the last quarter of each year. To eliminate the possible influence of those invisible promotions, we replicating the results of model (2) with data dropped the records of last three months of each year (October to December). Another robustness check of our study examines the model with the lag effect of sales. As

[10] The emission of automobiles is from 0.8 to 5.7 Liter. The divided six emission groups are: L≤1.0, 1.1≤L≤1.5, L=1.6, 1.7≤L≤2.5, 2.6≤L≤4.0, L> 4.0.

purchasing a car is, to some extent, a kind of conspicuous consumption, especially in China. The herding effect may possibly exist (McCormick 1983), which means sales of a certain car model in current month could be influenced by the previous sales. The results of the three robustness checks are shown in Table 5.

[Insert Table 6 here.]

We can see that the positive targeted effects on small-engine cars and the negative spillover effects on large-engine cars are revealed in all models, which are consistent with the results of our basic model (1).

3. Car Buyer Targeting Analysis

To study the effect of TLV policy on heterogeneous car buyer groups, interaction terms of policy with car buyer targeting variables (age, gender and car price) are added to the model as below:

$$Sales_{ijt} = \alpha_0 + \boldsymbol{BPolicy_t} * \boldsymbol{CT_{ijt}} + \alpha_1 Policy_t + \alpha_2 Post_t + \boldsymbol{\Gamma CT_{ijt}} + \boldsymbol{\Delta ControlVars_{it}} + \Omega i + \epsilon_{ijt} \quad (3)$$

[Insert Table 7 here.]

Car buyer targeting variables include age, gender of car buyers and the price of purchased car. Three age groups and gender, shown in percentage terms, are first used to study the effect of policy. We also use the constructed variables of age and group to study the interaction effect of TLV policy and consumer heterogeneity.

As shown in Table 6, the more heterogeneity of consumer in age, the more effective of TLV policy on both small-engine cars and large-engine cars. On the contrary, the interaction of policy and gender reveals an opposite phenomenon: the increasing gender heterogeneity of consumers reduces the positive targeted effect as well as the negative spillover effect of TLV.

We then concentrate on the direct distinction of policy effect on different age group and gender. As shown in Table 1C, the proportion of age group between 31 and 50 is the prime one of our data, which is averagely 16.79% for each car type per city per month. Interaction between the TLV policy and the other two non-prime age groups shows that comparing with the prime age group, the higher percentage of consumers of non-prime age groups, the more effective of TLV policy on large-engine cars. However, the positive targeting effect of TLV is different on these two age groups. The effect of TLV policy on small-engine cars is strengthened by the increasing proportion of consumers under 30, while it's eliminated by having more consumers over 50. The result also reveals asymmetrical impact of male proportion on positive targeted

effect and negative spillover effect: the increasing male proportion of consumers enhances the positive targeted effect, while reduces the negative spillover effect of TLV.

Besides, the interaction of policy and car price also reveals that the higher consumer paid for the automobile, the less effectiveness of TLV policy as purchasers of more expensive cars are less price sensitive.

III. Concluding Remarks

The automobile industry may buttress a country's economic development, but may also threaten the environment. We demonstrate that a policy measure designed to influence consumer purchase of more environmental-friendly cars with a tax-cut incentive could furnish both environmental and economical benefits. Environmentally, such a policy could encourage ownership of low-emission, small-engine cars and discourage ownership of high-emission, big-engine cars. Economically, the policy could favor the growth of indigenous brands, which is desired in a developing country such as China that hopes to cultivate its own brands to decrease dependence on non-indigenous companies.

Leveraging the uniquely huge and diverse markets of China, we also show that the policy is beneficial for encouraging purchases of small-engine cars in lower-tier cities, which range from fairly well developed to poorly developed areas. Furthermore, such a policy acted more to discourage the purchases of big-engine cars in higher-tier, mega cities, where air pollution due to vehicular emissions is particularly severe. [11]

The heterogeneous results across the different city-tiers highlights a caveat of the TLV policy – it turned out to be ineffective in inducing the purchases of small-engine cars in first-tier mega cities in China to pursue a long-term environmental improvement. While this does not negate the value of the policy given that it did reduce large-emission big-engine cars in the first-tier cities, it does mean that prudent policy-makers ought to ponder alternative policy designs if their objective is to promote a fleet of more environmentally-friendly cars in their forerunner cities.

This study is limited because it does not use any environment index to directly measure the impact of TLV on air pollution. However, environment is a long term goal, which is hard to quantify in couple of years, especially by focusing on only several years of data and limited influential factors. Based on the main finding of our paper, it's reasonable to claim that the TLV policy will consequently reduce environmental

[11] For instance, Beijing has become one of the cities with the most severe vehicular emission pollution. In Shanghai, although the amount of cars is only 1/12 of that in Tokyo, the air pollutants due to vehicular emissions are about equal to that of the latter. In Guangzhou, vehicular emissions constitute 22% of the pollution sources (the largest component), whereas the percentage even reaches 70% in Shenzhen (Source: http://www.ytepb.gov.cn/html/ztbd/wqzl/768.html, last accessed on June 12, 2014).

pollution, to some extent, as it limits car sales of big engine and lifts up sales of small engine in the same time period.

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Table 1, Panel A-Summary Statistics of Car Sales during the Study Period

(Thousand)	Pre-policy		Policy		Post-policy		P-Value
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**	
Monthly Sales of Automobiles	380.79	12.36	728.75	41	799.98	79.32	＜0.0001
Monthly Sales of Automobiles with Emission≤1.6L	204.97	8.36	406.9	30.4	493.21	45.85	＜0.0001
Monthly Sales of Automobiles with Emission＞1.6L	175.81	6.11	267.85	12.02	306.77	33.93	＜0.0001

Table 1, Panel B- Summary Statistics on Car Data

	Mean	SD	MIN	5%	95%	Max
Policy	0.667	0.471	0	0	1	1
Post	0.167	0.373	0	0	1	1
Time	18.5	10.39	1	2	35	36
Consumption Rate	0.944	0.229	0	0	1	1
Scrapped	0.528	0.499	0	0	1	1
Truck	0.611	0.487	0	0	1	1
GDP	15.39	12.17	0.395	1.654	42.43	53.21
Saving	10.20	8.329	0.185	1.058	31.41	40.41
Unemployment Rate	3.668	0.498	1.37	2.6	4.27	4.57
Population	5.228	2.785	0.292	0.633	10.13	10.50
Price (ten thousand)	14.85	13.22	3.58	4.48	39.66	96.2

Table 1, Panel C- Summary Statistics on Demographic Data

	Mean	SD	MIN	5%	95%	Max
Male(%)	18.45	34.93	0	0	100	100
Age						
Age<30(%)	4.75	14.56	0	0	33.33	100
31≤Age<50(%)	16.79	32.57	0	0	100	100
Age≥50(%)	3.07	11.42	0	0	20	100
Constructed HHIs						
HHIage	0.174	0.326	0	0	1	1
HHIgender	0.191	0.349	0	0	1	1

Table 2-Detecting the Effects of TLV

Dependent Variable Model	Total car sales	Sales of small-engine cars	Sales of big-engine cars
Policy	**0.0183*** **	**0.0216*** **	**-0.0037***
	(0.002)	**(0.002)**	**(0.001)**
Post	-0.1194***	-0.0811***	-0.0582***
	(0.003)	(0.003)	(0.002)
Time	0.0102***	0.0077***	0.0035***
	(0.000)	(0.000)	(0.000)
Consumption Tax	-0.0196***	-0.0096***	-0.0116***
	(0.002)	(0.002)	(0.001)
Scrapped	-0.0034[a]	-0.0078***	0.0001
	(0.002)	(0.002)	(0.001)
Truck	-0.0124***	-0.0069***	-0.0084***
	(0.002)	(0.002)	(0.002)
GDP	0.0178***	0.0100***	0.0095***
	(0.000)	(0.000)	(0.000)
Saving	-0.0068***	-0.0053***	-0.0017***
	(0.000)	(0.000)	(0.000)
Unemployment Rate	0.0189***	0.0116***	0.0089***
	(0.001)	(0.001)	(0.001)
Population	-0.0079***	0.0015***	-0.0122***
	(0.000)	(0.000)	(0.000)
Observations	5962320	5962320	5962320
R-Square	0.029	0.017	0.014

Note: Consumption tax indicates a change in the rate of consumption tax (in September 2008). Scrappage indicates a car scrappage policy (from June 2009 to December 2010); Trucks indicates a policy to promote light trucks and vans in villages (from March 2009 to December 2010).

[a] p<0.1, *p<0.05, ** p<0.01, ***p<0.001

Table 3-The Effects of TLV across City Tiers

	1st city tier	1st city tier (Without Beijing and Shanghai)	2nd city tier	3rd city tier
Panel A: Sales of small-engine cars ≤ 1.6 liter				
Policy	**-0.0085**	**-0.0103**	**0.0282*** **	**0.0244*** **
	(0.015)	**(0.016)**	**(0.003)**	**(0.002)**
Post	-0.2619***	-0.2231***	-0.1083***	-0.0330***
	(0.024)	(0.025)	(0.005)	(0.003)
Time	0.0210***	0.0203***	0.0107***	0.0056***
	(0.001)	(0.001)	(0.000)	(0.000)
Consumption Rate	-0.0340*	-0.0328*	-0.0153***	-0.0072***
	(0.015)	(0.016)	(0.003)	(0.002)
Scrapped	-0.0210	-0.0142	-0.0115***	-0.0066***
	(0.013)	(0.014)	(0.003)	(0.002)
Truck	-0.0171	-0.0179	-0.0113***	-0.0061**
	(0.016)	(0.017)	(0.003)	(0.002)
GDP	-0.0037***	0.0006	0.0094***	0.0040***
	(0.001)	(0.001)	(0.000)	(0.000)
Saving	-0.0003	-0.0026*	-0.0076***	-0.0051***
	(0.001)	(0.001)	(0.000)	(0.000)
Unemployment Rate	-0.0936***	0.0075	0.0188***	0.0069***
	(0.005)	(0.010)	(0.002)	(0.001)
Population	0.0144***	0.0186***	-0.0014***	0.0176***
	(0.002)	(0.002)	(0.000)	(0.000)
Observations	262080	229320	2522520	3177720
R-Squared	0.012	0.012	0.013	0.014
Panel B： Sales of big-engine cars＞ 1.6 liter				
Policy	**-0.0479*** **	**-0.0392** **	**0.0012**	**0.0021**
	(0.014)	**(0.015)**	**(0.003)**	**(0.001)**
Post	-0.1415***	-0.1098***	-0.0720***	-0.0289***
	(0.022)	(0.023)	(0.004)	(0.002)
Time	0.0098***	0.0098***	0.0052***	0.0030***
	(0.001)	(0.001)	(0.000)	(0.000)
Consumption Rate	-0.0126	-0.0081	-0.0179***	-0.0103***
	(0.014)	(0.015)	(0.003)	(0.001)
Scrapped	0.0087	0.0117	-0.0006	-0.0026*
	(0.013)	(0.013)	(0.002)	(0.001)
Truck	-0.0152	-0.0211	-0.0122***	-0.0081***
	(0.015)	(0.015)	(0.003)	(0.001)
GDP	-0.0043***	0.0000	0.0098***	0.0043***
	(0.001)	(0.001)	(0.000)	(0.000)
Saving	0.0118***	0.0049***	-0.0050***	-0.0034***
	(0.001)	(0.001)	(0.000)	(0.000)
Unemployment Rate	-0.0659***	-0.0179[a]	0.0063***	0.0104***
	(0.005)	(0.009)	(0.002)	(0.001)
Population	-0.0071***	0.0060**	-0.0170***	0.0066***
	(0.002)	(0.002)	(0.000)	(0.000)
Observations	262080	229320	2522520	3177720

R-Squared	0.008	0.007	0.009	0.010

Note: Consumption tax indicates a change in the rate of consumption tax (in September 2008). Scrappage indicates a car scrappage policy (from June 2009 to December 2010); Trucks indicates a policy to promote light trucks and vans in villages (from March 2009 to December 2010).

[a] p<0.1, *p<0.05, ** p<0.01, ***p<0.001

Table 4, Panel A - The Effects of TLV on Indigenous Brands and Non-indigenous Brands

	Indigenous Brands	Non-indigenous Brands
Panel A: Sales of small-engine cars ≤ 1.6 liter		
Policy	**0.0134*** **	**0.0325*** **
	(0.002)	**(0.003)**
Post	-0.0633***	-0.1029***
	(0.003)	(0.005)
Time	0.0075***	0.0080***
	(0.000)	(0.000)
Consumption Rate	-0.0024	-0.0186***
	(0.002)	(0.003)
Scrapped	0.0007	-0.0184***
	(0.002)	(0.003)
Truck	-0.0032	-0.0116***
	(0.002)	(0.003)
GDP	0.0077***	0.0129***
	(0.000)	(0.000)
Saving	-0.0057***	-0.0048***
	(0.000)	(0.000)
Unemployment Rate	0.0125***	0.0105***
	(0.001)	(0.001)
Population	0.0045***	-0.0022***
	(0.000)	(0.000)
Observations	3313128	2649192
R-Squared	0.015	0.020
Panel B： Sales of big-engine cars＞ 1.6 liter		
Policy	**-0.0002**	**-0.0072***
	(0.001)	**(0.003)**
Post	-0.0174***	-0.1085***
	(0.002)	(0.004)
Time	0.0010***	0.0067***
	(0.000)	(0.000)
Consumption Rate	0.0020	-0.0285***
	(0.001)	(0.003)
Scrapped	0.0053***	-0.0063*
	(0.001)	(0.002)
Truck	-0.0035*	-0.0146***
	(0.001)	(0.003)
GDP	0.0047***	0.0154***
	(0.000)	(0.000)
Saving	-0.0020***	-0.0013***
	(0.000)	(0.000)
Unemployment Rate	0.0011[a]	0.0188***
	(0.001)	(0.001)
Population	-0.0035***	-0.0232***
	(0.000)	(0.000)
Observations	3313128	2649192
R-Squared	0.006	0.025

Note: Consumption tax indicates a change in the rate of consumption tax (in September 2008). Scrappage indicates a car scrappage policy (from June 2009 to December 2010); Trucks indicates a policy to promote light trucks and vans in villages (from March 2009 to December 2010).

[a] p<0.1, *p<0.05, ** p<0.01, ***p<0.001

Table 4, Panel B - The Effects of TLV across Non-indigenous Brands

Non-indigenous brands:	Honda	Toyota	Volkswagen	KIA	Hyundai	Peugeot	Suzuki
Panel A: Sales of small-engine cars ≤ 1.6 liter							
Policy	**0.0620*****	**0.0121**	**-0.0008**	**0.0167**	**0.0132**	**0.1496*****	**0.0566****
	(0.015)	**(0.010)**	**(0.016)**	**(0.011)**	**(0.015)**	**(0.025)**	**(0.018)**
Post	-0.0679**	-0.1155***	-0.3655***	-0.0718***	-0.2839***	-0.3928***	-0.4980***
	(0.023)	(0.015)	(0.025)	(0.017)	(0.023)	(0.039)	(0.027)
Time	-0.0015*	0.0016***	0.0240***	0.0085***	0.0171***	0.0192***	0.0189***
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Consumption Rate	-0.0021	0.0081	-0.0238	-0.0350**	-0.0266^{a}	-0.0587*	-0.0660***
	(0.015)	(0.010)	(0.016)	(0.011)	(0.015)	(0.025)	(0.018)
Scrapped	0.0220^{a}	0.0002	-0.1266***	0.0539***	-0.0385**	-0.2454***	-0.1471***
	(0.013)	(0.009)	(0.014)	(0.010)	(0.013)	(0.022)	(0.015)
Truck	-0.0159	-0.0183^{a}	-0.0146	-0.0104	-0.0372*	0.0397	-0.1119***
	(0.016)	(0.010)	(0.017)	(0.011)	(0.016)	(0.026)	(0.018)
GDP	0.0042***	0.0064***	0.0342***	0.0135***	0.0155***	0.0456***	0.0257***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Saving	0.0065***	0.0108***	-0.0144***	-0.0072***	-0.0110***	-0.0335***	-0.0093***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Unemployment Rate	-0.0561***	-0.0407***	0.1213***	-0.0060	0.0316***	0.0815***	0.0395***
	(0.007)	(0.005)	(0.008)	(0.005)	(0.007)	(0.012)	(0.009)
Population	0.0099***	-0.0127***	-0.0210***	-0.0006	0.0006	-0.0009	0.0025
	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.003)	(0.002)
Observations	117936	222768	196560	196560	170352	52416	117936
R-Squared	0.021	0.028	0.045	0.026	0.018	0.081	0.049
Panel B: Sales of big-engine cars > 1.6 liter							
Policy	**0.0491***	**-0.0747*****	**0.0302***	**-0.0029**	**-0.0150**	**-0.0755*****	**0.0007**
	(0.021)	**(0.013)**	**(0.014)**	**(0.007)**	**(0.011)**	**(0.014)**	**(0.003)**
Post	-0.2557***	-0.0220	-0.3938***	0.0515***	-0.2697***	-0.3491***	0.0557***
	(0.032)	(0.019)	(0.022)	(0.011)	(0.017)	(0.021)	(0.005)
Time	0.0077***	0.0059***	0.0152***	0.0039***	0.0184***	0.0188***	-0.0015***
	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)
Consumption Rate	-0.0250	-0.0401**	-0.0017	-0.0200**	-0.0858***	-0.0702***	0.0044

	(0.021)	(0.013)	(0.014)	(0.007)	(0.011)	(0.014)	(0.003)
Scrapped	-0.0225	0.1057***	-0.1257***	-0.0144*	-0.0630***	-0.1331***	0.0128***
	(0.018)	(0.011)	(0.012)	(0.006)	(0.010)	(0.012)	(0.003)
Truck	-0.0218	0.0087	-0.0550***	-0.0079	-0.0401***	-0.0686***	0.0508***
	(0.022)	(0.013)	(0.015)	(0.007)	(0.012)	(0.015)	(0.003)
GDP	0.0274***	0.0143***	0.0379***	0.0093***	0.0257***	0.0141***	-0.0002
	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)
Saving	0.0099***	0.0176***	-0.0201***	-0.0050***	-0.0225***	-0.0026*	0.0027***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
Unemployment Rate	0.0095	0.0268***	0.0540***	0.0166***	0.0128*	0.0310***	0.0011
	(0.010)	(0.006)	(0.007)	(0.003)	(0.006)	(0.007)	(0.002)
Population	-0.0307***	-0.0415***	-0.0339***	-0.0106***	-0.0116***	-0.0211***	-0.0041***
	(0.003)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.000)
Observations	117936	222768	196560	196560	170352	52416	117936
R-Squared	0.063	0.044	0.040	0.019	0.038	0.055	0.012

Note: Consumption tax indicates a change in the rate of consumption tax (in September 2008). Scrappage indicates a car scrappage policy (from June 2009 to December 2010); Trucks indicates a policy to promote light trucks and vans in villages (from March 2009 to December 2010).

[a] p<0.1, *p<0.05, ** p<0.01, ***p<0.001

Table 4, Panel C-The Effects of TLV across Indigenous Brands

Indigenous brands	FAW	BYD	Chery	Geely	JAC
Panel A: Sales of small-engine cars ≤ 1.6 liter					
Policy	**0.0162[a]**	**0.0605[**]**	**0.0116**	**0.0919[***]**	**0.1340[***]**
	(0.009)	**(0.020)**	**(0.008)**	**(0.012)**	**(0.015)**
Post	0.0043	-0.1987[***]	-0.1024[***]	-0.0887[***]	-0.1558[***]
	(0.013)	(0.031)	(0.012)	(0.019)	(0.023)
Time	0.0032[***]	0.0200[***]	0.0079[***]	0.0059[***]	0.0179[***]
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Consumption Rate	-0.0025	0.0619[**]	0.0104	0.0184	-0.0344[*]
	(0.009)	(0.020)	(0.008)	(0.012)	(0.015)
Scrapped	0.0690[***]	-0.0422[*]	0.0404[***]	0.0520[***]	-0.0667[***]
	(0.008)	(0.017)	(0.007)	(0.011)	(0.013)
Truck	-0.0068	-0.0166	0.0007	0.0160	0.0251
	(0.009)	(0.021)	(0.008)	(0.013)	(0.016)
GDP	0.0094[***]	0.0135[***]	0.0106[***]	0.0122[***]	0.0195[***]
	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
Saving	-0.0077[***]	-0.0046[**]	-0.0105[***]	-0.0112[***]	-0.0262[***]
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Unemployment Rate	-0.0117[**]	0.0442[***]	0.0153[***]	0.0169[**]	-0.0200[**]
	(0.004)	(0.010)	(0.004)	(0.006)	(0.007)
Population	0.0017	0.0103[***]	0.0174[***]	0.0100[***]	0.0185[***]
	(0.001)	(0.003)	(0.001)	(0.002)	(0.002)
Observations	183456	117936	353808	183456	78624
R-Squared	0.015	0.034	0.019	0.018	0.065
Panel B： Sales of big-engine cars ＞ 1.6 liter					
Policy	**0.0108[a]**	**0.0565[***]**	**0.0136[***]**	**0.0254[***]**	**0.0272[a]**
	(0.006)	**(0.010)**	**(0.002)**	**(0.003)**	**(0.016)**
Post	-0.0220[*]	0.0225	-0.0300[***]	-0.0383[***]	-0.1291[***]
	(0.009)	(0.015)	(0.004)	(0.005)	(0.025)
Time	-0.0009[**]	0.0021[***]	0.0002[a]	-0.0020[***]	0.0088[***]
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Consumption Rate	0.0544[***]	-0.0064	-0.0064[*]	0.0088[**]	-0.0344[*]

	(0.006)	(0.010)	(0.002)	(0.003)	(0.016)
Scrapped	-0.0066	0.0130	0.0092***	-0.0334***	0.0064
	(0.005)	(0.008)	(0.002)	(0.003)	(0.014)
Truck	-0.0023	0.0176[a]	-0.0134***	-0.0174***	-0.0064
	(0.006)	(0.010)	(0.003)	(0.003)	(0.017)
GDP	0.0079***	0.0047***	0.0015***	0.0016***	0.0353***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Saving	-0.0079***	-0.0004	-0.0001	-0.0018***	-0.0308***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)
Unemployment Rate	0.0022	0.0079[a]	-0.0163***	-0.0035*	-0.0242**
	(0.003)	(0.005)	(0.001)	(0.001)	(0.008)
Population	-0.0026**	0.0009	-0.0004	0.0015***	-0.0055*
	(0.001)	(0.001)	(0.000)	(0.000)	(0.002)
Observations	183456	117936	353808	183456	78624
R-Squared	0.005	0.015	0.007	0.017	0.059

Note: Consumption tax indicates a change in the rate of consumption tax (in September 2008). Scrappage indicates a car scrappage policy (from June 2009 to December 2010); Trucks indicates a policy to promote light trucks and vans in villages (from March 2009 to December 2010).

[a] p<0.1, *p<0.05, ** p<0.01, ***p<0.001

Table 5-Detecting the Effects of TLV on Different Emission Groups

Dependent Variable Model	L≤1.0	1.1≤L≤1.5	L=1.6	1.7≤L≤2.5	2.6≤L≤4.0	L> 4.0
Policy	**0.0324***	**0.1493*****	**0.1551*****	**-0.1166*****	**-0.0331*****	**-0.0009****
	(0.013)	**(0.021)**	**(0.032)**	**(0.030)**	**(0.005)**	**(0.000)**
Post	-0.2075***	-0.5749***	-0.4493***	-0.4318***	-0.0360***	-0.0017***
	(0.021)	(0.033)	(0.050)	(0.046)	(0.007)	(0.000)
Time	0.0119***	0.0378***	0.0135***	0.0055***	0.0012***	0.0001***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.000)	(0.000)
Consumption Rate	0.0002	-0.0715***	0.0353	-0.0005	-0.0147**	-0.0030***
	(0.013)	(0.021)	(0.032)	(0.030)	(0.005)	(0.000)
Scrapped	-0.0380**	-0.0634***	0.0424	0.1802***	0.0270***	-0.0003
	(0.012)	(0.019)	(0.028)	(0.026)	(0.004)	(0.000)
Truck	-0.0369**	-0.0678**	0.0188	0.0049	-0.0027	-0.0003
	(0.014)	(0.022)	(0.034)	(0.031)	(0.005)	(0.000)
GDP	0.0072***	0.0447***	0.0599***	0.0544***	-0.0004	-0.0000
	(0.001)	(0.001)	(0.002)	(0.002)	(0.000)	(0.000)
Saving	-0.0001	-0.0058***	0.0356***	0.1143***	0.0113***	0.0001***
	(0.001)	(0.002)	(0.003)	(0.002)	(0.000)	(0.000)
Unemployment Rate	0.0129[a]	-0.2610***	-0.4732***	-0.5331***	-0.0313***	-0.0002[a]
	(0.007)	(0.010)	(0.016)	(0.015)	(0.002)	(0.000)
Population	-0.0135***	-0.0532***	-0.1937***	-0.3722***	-0.0222***	-0.0005***
	(0.002)	(0.003)	(0.004)	(0.004)	(0.001)	(0.000)
Observations	5962320	1.0871***	5962320	5962320	5962320	5962320
R-Squared	0.0003	0.0036	0.0032	0.0066	0.0010	0.0001

Note: Consumption tax indicates a change in the rate of consumption tax (in September 2008). Scrappage indicates a car scrappage policy (from June 2009 to December 2010); Trucks indicates a policy to promote light trucks and vans in villages (from March 2009 to December 2010).

[a] p<0.1, *p<0.05, ** p<0.01, ***p<0.001

Table 6- The Robustness Checks

Model	Basic	Without Last Three Months	Without Last Three Months With Lag Effect
Panel A: Sales of small-engine cars ≤ 1.6 liter			
Policy	**0.0056*** **	**0.0120*** **	**0.0197*** **
	(0.001)	**(0.002)**	**(0.001)**
Post	0.0436***	0.0712***	-0.0234***
	(0.002)	(0.003)	(0.002)
Time	-0.0017***	-0.0025***	-0.0003***
	(0.000)	(0.000)	(0.000)
Consumption Rate	0.0199***	0.0185***	0.0188***
	(0.001)	(0.002)	(0.001)
Scrapped	0.0116***	0.0120***	-0.0023***
	(0.001)	(0.001)	(0.001)
Truck	0.0094***	0.0114***	-0.0266***
	(0.001)	(0.001)	(0.001)
HHIage	-1.7712***	-1.7260***	-0.5958***
	(0.002)	(0.002)	(0.001)
HHIgender	-0.4723***	-0.4628***	-0.1357***
	(0.003)	(0.003)	(0.002)
NB	0.1287***	0.1206***	0.0124***
	(0.001)	(0.001)	(0.001)
MPV	-0.3535***	-0.3430***	-0.0948***
	(0.002)	(0.002)	(0.001)
Private	1.0532***	1.0675***	0.3811***
	(0.002)	(0.002)	(0.001)
Non-operation	-0.2183***	-0.2592***	-0.1471***
	(0.004)	(0.005)	(0.003)
Fullpaid	0.6351***	0.6223***	0.2414***
	(0.003)	(0.003)	(0.002)
Black	-0.4681***	-0.4272***	-0.1529***
	(0.002)	(0.002)	(0.001)
Gray	0.0497***	0.0495***	0.0008
	(0.002)	(0.002)	(0.001)
White	-0.0636***	-0.0499***	-0.0324***
	(0.003)	(0.003)	(0.002)
Petrol	1.3676***	1.3531***	0.5249***
	(0.004)	(0.004)	(0.003)
Price	-0.0076***	-0.0076***	-0.0021***
	(0.000)	(0.000)	(0.000)
GDP	0.0025***	0.0024***	-0.0001
	(0.000)	(0.000)	(0.000)
Saving	-0.0020***	-0.0018***	-0.0001[a]
	(0.000)	(0.000)	(0.000)
Unemployment Rate	-0.0095***	-0.0096***	-0.0039***
	(0.001)	(0.001)	(0.000)
Population	-0.0011***	-0.0013***	-0.0001
	(0.000)	(0.000)	(0.000)
Lagged (Sales)			0.7122***
			(0.000)
Observations	5962320	4471740	4306120
R-Squared	0.567	0.562	0.854

Panel B: Sales of big-engine cars > 1.6 liter			
Policy	**-0.0096*** **	**-0.0168*** **	**-0.0043*** **
	(0.001)	**(0.002)**	**(0.001)**
Post	-0.0398***	-0.0597***	-0.0282***
	(0.002)	(0.003)	(0.002)
Time	-0.0002**	0.0004***	-0.0000
	(0.000)	(0.000)	(0.000)
Consumption Rate	-0.0205***	-0.0166***	-0.0048***
	(0.001)	(0.002)	(0.001)
Scrapped	0.0010	-0.0021[a]	0.0012[a]
	(0.001)	(0.001)	(0.001)
Truck	-0.0053***	-0.0066***	-0.0054***
	(0.001)	(0.001)	(0.001)
HHIage	-0.9697***	-0.9840***	-0.3048***
	(0.002)	(0.002)	(0.001)
HHIgender	-0.1160***	-0.1217***	-0.0046*
	(0.003)	(0.003)	(0.002)
NB	0.1803***	0.1801***	0.0548***
	(0.001)	(0.001)	(0.001)
MPV	0.3240***	0.3129***	0.1487***
	(0.002)	(0.002)	(0.001)
Private	-0.6646***	-0.6857***	-0.3563***
	(0.002)	(0.002)	(0.001)
Non-operation	1.4447***	1.4631***	0.6285***
	(0.004)	(0.004)	(0.003)
Fullpaid	-0.0545***	0.0003	0.0333***
	(0.002)	(0.003)	(0.002)
Black	0.5703***	0.5516***	0.2013***
	(0.002)	(0.002)	(0.001)
Gray	0.0622***	0.0750***	0.0302***
	(0.002)	(0.002)	(0.001)
White	0.1957***	0.1981***	0.0749***
	(0.003)	(0.003)	(0.002)
Petrol	0.3827***	0.3505***	0.0693***
	(0.004)	(0.004)	(0.002)
Price	0.0075***	0.0076***	0.0021***
	(0.000)	(0.000)	(0.000)
GDP	0.0042***	0.0041***	0.0008***
	(0.000)	(0.000)	(0.000)
Saving	0.0012***	0.0012***	0.0006***
	(0.000)	(0.000)	(0.000)
Unemployment Rate	0.0004	0.0013*	0.0006
	(0.001)	(0.001)	(0.000)
Population	-0.0148***	-0.0148***	-0.0046***
	(0.000)	(0.000)	(0.000)
Lagged (Sales)			0.7128***
			(0.000)
Observations	5962320	4471740	4306120
R-Squared	0.405	0.406	0.800

Note: Consumption tax indicates a change in the rate of consumption tax (in September 2008). Scrappage indicates a car scrappage policy (from June 2009 to December 2010); Trucks indicates a policy to promote light trucks and vans in villages (from March 2009 to December 2010). [a] p<0.1, *p<0.05, ** p<0.01, ***p<0.001

Table 7-Car Buyer Group Targeting

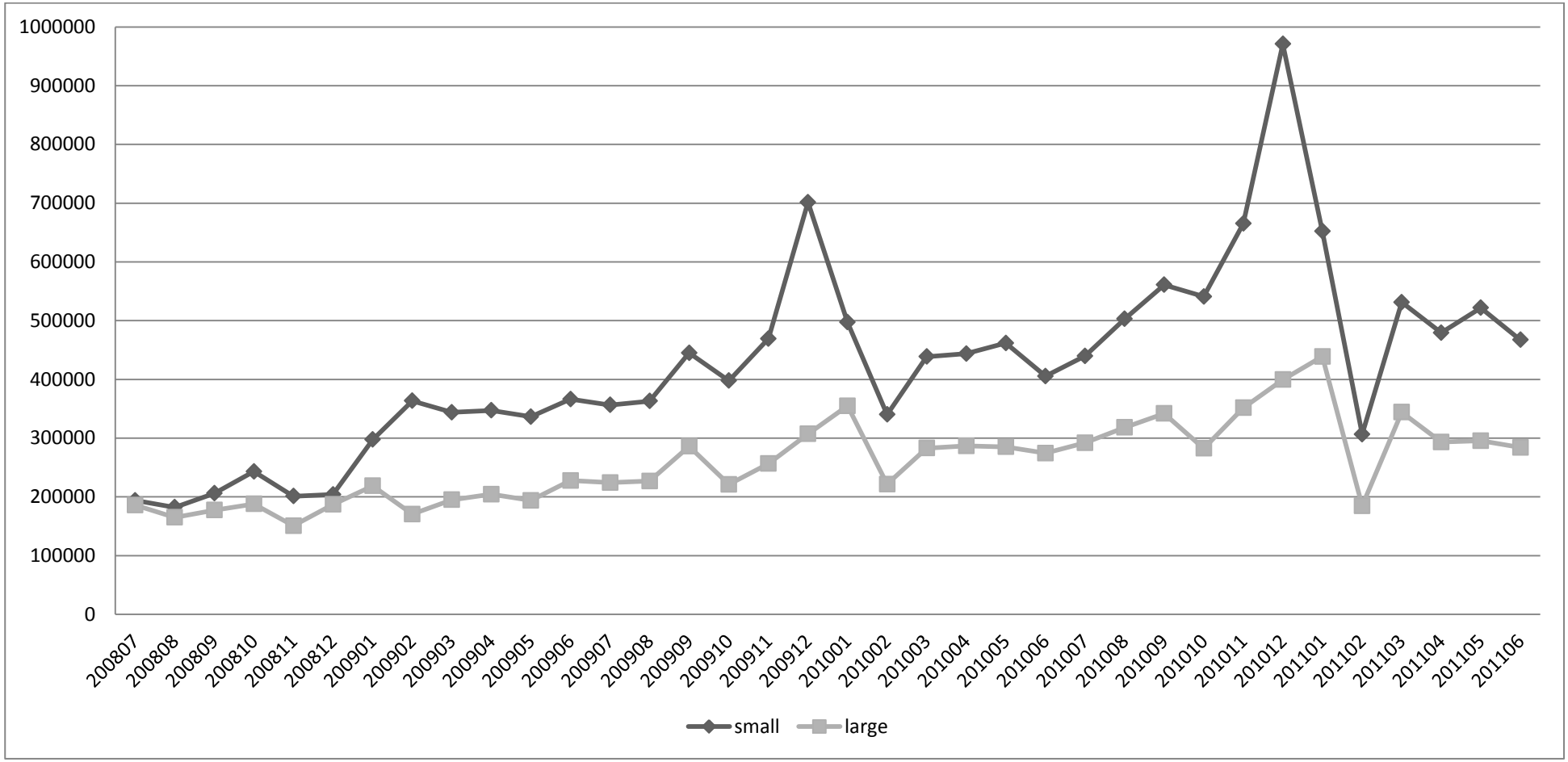
	HHI	Share
Panel A: Sales of small-engine cars ≤ 1.6 liter		
Policy	**0.0790*** **	**0.0801*** **
	(0.002)	**(0.002)**
Post	0.0692***	0.0806***
	(0.003)	(0.002)
Time	0.0024***	0.0017***
	(0.000)	(0.000)
Consumption Rate	0.0069***	0.0032*
	(0.002)	(0.001)
Scrapped	-0.0008	-0.0021
	(0.001)	(0.001)
Truck	0.0031*	0.0040**
	(0.002)	(0.002)
Price	-0.0053***	-0.0051***
	(0.000)	(0.000)
HHIage	-0.4541***	
	(0.005)	
HHIgender	1.5575***	
	(0.005)	
Policy*HHIage	-0.1245***	
	(0.006)	
Policy*HHIgender	0.2261***	
	(0.006)	
Policy*Price	-0.0048***	-0.0048***
	(0.000)	(0.000)
GDP	0.0075***	0.0062***
	(0.000)	(0.000)
Saving	-0.0037***	-0.0031***
	(0.000)	(0.000)
Unemployment Rate	0.0038***	0.0030***
	(0.001)	(0.001)
Population	-0.0044***	-0.0039***
	(0.000)	(0.000)
Age≤30		0.0074***
		(0.000)
Age＞50		0.0045***
		(0.000)
Male		0.0105***
		(0.000)
Policy*Age≤30		0.0018***
		(0.000)
Policy*Age＞50		-0.0003***
		(0.000)
Policy*Male		0.0007***
		(0.000)
Observations	5962320	5962320
R-Square	0.298	0.359
Panel B：Sales of big-engine cars＞ 1.6 liter		
Policy	**-0.0675*** **	**-0.0666*** **

	(0.001)	(0.001)
Post	-0.0854***	-0.0685***
	(0.002)	(0.002)
Time	0.0002***	-0.0006***
	(0.000)	(0.000)
Consumption Rate	0.0002	0.0002
	(0.001)	(0.001)
Scrapped	0.0027*	0.0060***
	(0.001)	(0.001)
Truck	-0.0030*	0.0004
	(0.001)	(0.001)
Price	0.0049***	0.0050***
	(0.000)	(0.000)
HHIage	-0.0355***	
	(0.004)	
HHIgender	0.9682***	
	(0.004)	
Policy*HHIage	0.0442***	
	(0.005)	
Policy*HHIgender	-0.0422***	
	(0.005)	
Policy*Price	0.0043***	0.0043***
	(0.000)	(0.000)
GDP	0.0077***	0.0067***
	(0.000)	(0.000)
Saving	-0.0005***	-0.0001
	(0.000)	(0.000)
Unemployment Rate	0.0022***	0.0017**
	(0.001)	(0.001)
Population	-0.0170***	-0.0163***
	(0.000)	(0.000)
Age≤30		0.0031***
		(0.000)
Age＞50		0.0024***
		(0.000)
Male		0.0090***
		(0.000)
Policy*Age≤30		-0.0007***
		(0.000)
Policy*Age＞50		-0.0001**
		(0.000)
Policy*Male		0.0001***
		(0.000)
Observations	5962320	5962320
R-Square	0.263	0.296

Note: Consumption tax indicates a change in the rate of consumption tax (in September 2008). Scrappage indicates a car scrappage policy (from June 2009 to December 2010); Trucks indicates a policy to promote light trucks and vans in villages (from March 2009 to December 2010).

[a] p<0.1, *p<0.05, ** p<0.01, ***p<0.001

Figure 1: Monthly Sales of Small- and Large-engine Cars



Appendix: Cities in Different Tiers in China

City Tier	Names of the Cities
1st City Tier (Large metropolitan, 16 in Total)	Shanghai, Beijing, Guangzhou, Shenzhen, Tianjin, Hangzhou, Nanjing, Chengdu, Wuhan, Xi'an, Chongqing, Shenyang, Harbin, Urumqi, Zhengzhou, Suzhou.
2nd City Tier (Middle size, 154 in Total)	Kunming, Changsha, Dalian, Jinan, Lanzhou, Qingdao, Wuxi, Taiyuan, Hefei, Changchun, Fuzhou, Xiamen, Nanning, Nanchang, Baotou, Haikou, Ningbo, Foshan, Xining, Dongguan, Shijiazhuang, Hohhot, Yinchuan, Wenzhou, Guiyang, Luoyang, Changzhou, Xuzhou, Tangshan, Jilin, Liuzhou, Zhuzhou, Weifang, Huizhou, Yantai, Nantong, Daqing, Erdos, Datong, Zhanjiang, Guilin, Qiqihar, Mianyang, Zhongshan, Zibo, Hengyang, Changde, Anqing, Anyang, Anshan, Bengbu, Baoji, Baoding, Beihai, Benxi, Binzhou, Cangzhou, Chaozhou, Binzhou, Chifeng, Chuzhou, Deyang, Dezhou, Dongying, Fushun, Ganzhou, Handan, Hulunbeier, Huzhou, Huaian, Huainan, Huanggang, Huangshi, Jixi, Jining, Jiyuan, Jiamusi, Jiaxing, Jiayuguan, Jiangmen, Jiaozuo, Jinhua, Jingmen, Jingzhou, Jiujiang, Kaifeng, Kelamayi, Lasa, Langfang, Leshan, Lianyungang, Liangshan, Liaocheng, Linfen, Linyi, Longyan, Loudi, Luzhou, Lvliang, Maanshan, Maoming, Nanchong, Nanyang, Panjin, Pingdingshan, Putian, Qinhuangdao, Qingyuan, Quanzhou, Rizhao, Sanya, Shantou, Shangrao, Shaoxing, Shihezi, Siping, Songyuan, Taizhou, Taian, Tongliao, Tongling, Weihai, Weinan, Wuhai, Wuhu, Wuzhou, Xianyang, Xiangtan, Xiaogan, Xinxiang, Xinyu, Xingtai, Xuchang, Yanan, Yancheng, Yangzhou, Yangquan, Yibin, Yichang, Yichun, Yingkou, Yulin, Yuulin, Yueyang, Yuncheng.
3rd City Tier (Small size, 194 in Total)	Akesu, Ankang, Anshun, Bayanzhuoer, Bayinguole, Baicheng, Baishan, Baiyin, Baise, Baoshan, Bijie, Haozhou, Changji, Chaohu, Chaoyang, Chengde, Chizhou, Chuxiong, Dazhou, Dali, Dandong, Ezhou, Fangchenggang, Fuzhou, Fuxin, Fuyang, Guangan, Guangyuan, Guigang, Hami, Hanzhong, Hetian, Heyuan, Heze, Hezhou, Hebi, Hegang, Heihe, Hengshui, Huludao, Huaihua, Huaibei, Huangshan, Jian, Jieyang, Jinchang, Jinzhou, Jincheng, Jinzhong, Jingdezhen, Jiuquan, Kashi, Laibin, Laiwu, Lijiang, Lishui, Liaoyang, Liaoyuan, Lincang, Liuan, Liupanshui, Luohe, Meishan, Meizhou, Mudanjiang, Nanping, Neijiang, Ningde, Panzhihua, Pingliang, Pingxiang, Puyang, Puer, Qitaihe, Qinzhou, Qingyang, Qujing, Sanmenxia, Sanming, Shanwei, Shangluo, Shangqiu, Shaoguan, Shaoyang, Shiyan, Shuangyashan, Suzhou, Suihua, Suizhou, Suining, Tianmen, Tieling, Tonghua, Tongchuan, Tulufan, Wulanchabu, Wuzhong, Wuwei, Xiantao, Zhangjiakou, Zhangzhou, Changzhi, Zhaoqing, Zhenjiang, Zhoushan, Zhuhai, Zigong, Xianning, Qizhou, Xinyang, Xinganmeng, Suqian, Suzhou, Xuancheng, Yaan, Yangjiang, Yichun, Yiyang, Yingtan, Yongzhou, Yuxi, Yunfu, Zaozhuang, Zhangjiajie, Zhangye, Zhongwei, Zhoukou, Zhumadian, Ziyang, Zunyi, Aba,Alaer, Alashan, Aletai, Ali, Bazhong, Boertala, Changdu, Chongzuo, Daxinganling, Danzhou, Dehong, Diqing, Dingxi, Dongfang, Enshi, Gannan, Ganzi, Guyuan, Guoluo, Haibei, Haidong, Hainan, Haixi, Hechi, Kenqu, Hengyang, Honghe, Huaiyin, Huangnan, Juzhou, Kezilesu, Kuitun, Linzhi, Linxia, Longnan, Naqu, Nanhai, Nujiang, Qianjiang, Qiandongnan, Qiannan, Qianxinan, Qiongbei, Qionghai, Qiongnan, Quzhou, Rikeze, Shannan, Shennongjia, Shizuishan, Shunde, Simao, Tacheng, Tianshui, Tongren, Wanning, Wenchang, Wenshan, Wuzhishan, Xishuangbanna, Xilinguole, Xiangxi, Xiangfan, Suxian, Yanbian, Yangling, Yangpu, Yikezhao, Yilihasake, Yushu, Zhaotong, Zhuzhou.