Using DID Model to Analyse the Impact of Vehicle Purchase Tax on the Sales of Alternative Fuel Vehicle

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Abstract. At present, countries in the world are paying more and more attention to the importance of green development and sustainable growth, and taxation plays a very good role in regulating it. In China, the role of taxation policy as a means of stimulating green consumption is becoming more and more significant. This paper starts with the vehicle purchase tax and uses the Difference in differences (DID) model to study its impact on the alternative fuel vehicle industry. The purpose of the research is to use the method of empirical research to test the impact of preferential vehicle purchase tax policies on the sales of alternative fuel vehicles using automobile production and sales data as samples. This research is helpful to enrich the research on preferential policies of vehicle purchase tax, and provides a good reference for empirical research on the impact of vehicle purchase tax on the sales of the automobile industry. Researched the impact of tax incentives for automobile purchase tax, and proposes constructive guidance with China's specific situation. It has an important impact on promoting China's further improvement of the tax system reform and the development of the alternative fuel vehicle industry, and also plays an active role in supporting macroeconomic transformation and development.

1. Introduction
For the last several years, under the guidance of the national macro-control policies, China's automobile industry has continuously expanded its production scale and market scale, and has become a major component of supporting China's economic growth. From 2013 to 2018, China's total auto product exports increased from 46 billion to 60.6 billion U.S. dollars, and the proportion of global auto product exports increased from 3.4% to 3.9%. As of the end of 2020, the number of motor vehicles has reached 372 million; a year-on-year increase of 6.9% [1]. With the continuous increase in the number of cars, the problem of energy waste and environmental pollution has become more and more serious. In order to coordinate the coordinated development of the automobile industry and environmental protection, China takes sustainable development as its guiding ideology, vigorously develops energy-saving and environmental protection industries, and supports the development of alternative fuel vehicles. The path that China must take to move from a major automobile country to a powerful automobile country is to develop alternative fuel vehicles, which is a strategic measure to tackle climate change and promote green development.

This paper takes the vehicle purchase tax as the research object, and studies the influence of preferential policies for vehicle purchase tax on the alternative fuel vehicle. Through sorting out the current situation of vehicle purchase tax and its preferential policies, using the production and sales of China's alternative fuel vehicles and traditional automobiles from 2011 to 2020 as sample data, using
the econometric DID model to analyse the effect of exemption of alternative fuel vehicle purchase tax on sales impact. Finally, combined with the status quo of vehicle purchase tax in China, it puts forward suggestions that are beneficial to the alternative fuel vehicle industry.

2. Theoretical analysis

The vehicle purchase tax is a tax levied on units and individuals that purchase prescribed vehicles in China; the tax rate is 10%. The taxable amount shall be levied by the method of ad valorem fixed rate and extra-price levy. The tax calculation basis is the price of taxable vehicles [2]. China began to levy a vehicle purchase tax on January 1, 2001 to replace the original vehicle purchase surcharge. This reform is conducive to the accumulation of national fiscal revenue, rationally raising construction funds, regulating government behaviour, adjusting income gaps, and cooperating with the fight against smuggling. And safeguard national rights and interests, to contribute to the development of the transportation industry, at the same time to reduce the burden on consumers. With the progress of China's economic development level and technological level, the vehicle purchase tax and tax system construction are constantly improving. On July 9, 2014, the executive meeting of the State Council decided that alternative fuel vehicles purchased in China from September 1, 2014 to December 31, 2017 were exempted from vehicle purchase tax, and central and local subsidy policies were successively introduced. On December 26, 2017, the Ministry of Industry and Information Technology, the Ministry of Finance, the State Administration of Taxation, and the Ministry of Science and Technology jointly issued the "Announcement on the Exemption of Alternative Fuel Vehicle Purchase Tax", which pointed out that from January 1, 2018 to December 2020 On the 31st, the purchase of alternative fuel vehicles was exempted from vehicle purchase tax. An announcement was issued again on April 16, 2020, extending the discount period to December 31, 2022.

The vehicle purchase tax has been adjusted many times in order to promote the development of the automobile industry and the implementation of the new energy strategy since the implementation. However, because of the different research directions and research methods, different experts and scholars also have different views on the actual effect of the preferential vehicle purchase tax policy. Mayburov proved that it is necessary to use financial means to promote the environmental behaviour of manufacturers and owners of vehicles and related products [3,4]. Zhang Xianglong studied the fluctuations in automobile sales and confirmed that taxes have an effect on the development of the industry [5]. Shiyu Yan and Gunnar S. Eskeland confirmed the tax significantly shifts consumers toward lower-emission vehicles through study Norway's vehicle registration tax linked to vehicle CO2 intensities [6]. ShiyuYan also analyzed European countries’ tax incentives for battery electric vehicles through cost-benefit analysis and ordinary least squares regression and found that the cost of reducing externalities through transportation electrification is high [7]. Stefan L. Mabit investigates the effects of a tax reform In Denmark, using a mixed logit model. It is concluded that the tax reform increases slightly the demand for more fuel efficient vehicles [8].

3. Methodology

Try to use the 5W2H analysis method to resolve this problem.

What: According to data from the National Bureau of Statistics, the sales of alternative fuel vehicles have increased significantly both year-on-year and month-on-month in the last ten years.

When: It is difficult to analyze the reasons for the overall rise. It is necessary to analyze the proportion of consumers who have risen in different periods, so as to analyze which period of time the rise is mainly concentrated.

Where: Starting from the literature, sort out the current situation of China's vehicle purchase tax system, and closely link the vehicle purchase tax exemption policy with the sales of alternative fuel vehicles. On the basis of drawing research, theoretically analyze the impact of China's current tax incentives on the sales.

Who: Analyze the attributes and behaviours of consumers, and analyze whether tax incentives can stimulate consumers' consumption. Taking the production and sales data of alternative fuel vehicles
and traditional cars from 2011 to 2020 as samples, using Stata software to calculate the average value, standard deviation and other variables of the above indicators perform descriptive statistics. Use the DID model to empirical research the impact of preferential vehicle purchase tax policies on the sales.

Why: Through analysis, the positive impact of preferential tax policies on the sales of alternative fuel vehicles was confirmed, and data and theory were combined at the same time.

How: Analyzing the reasons for the increase in sales of alternative fuel vehicles, it is necessary to adopt corresponding strategies to improve relevant policies.

How much: While providing perfect measures through data analysis, evaluate the corresponding costs to enhance the feasibility and value of the measures.

4. Empirical research

Difference in differences (DID) is a statistical technique used in econometrics and quantitative research in the social sciences [9]. For the last few years, it is widely used to evaluate the effect of policy implementation, and it can accurately and effectively evaluate the true effect of policy impact [10].

The paper studies the impact of vehicle purchase tax exemption on alternative fuel vehicles, and takes automobile sales as the research object, because it can directly reflect the supply and demand of the market. The background of the policy event selected in the paper is that in September 2014, China clearly proposed the vehicle purchase tax exemption policy for the alternative fuel vehicle industry for the first time, while the tax payment policy for traditional automobiles remained unchanged. The model sets alternative fuel vehicles and traditional vehicles as the treatment group and the control group.

The research data is selected from the 2011-2020 alternative fuel vehicle sales and traditional car sales in the National Bureau of Statistics, and China Automobile Manufacturers Association. First, perform a descriptive statistical analysis of the data (Table 1), where year represents the year of the study, type represents the type of car, sales represents the sales of the car, and produces represents the output of the car.

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|----------|-----|------|-----------|-----|-----|
| year     | 20  | 2015.5 | 2.946898 | 2011 | 2020 |
| type     | 0   | -     | -         | -   | -   |
| sales    | 20  | 1.22e+07 | 1.21e+07 | 8159 | 2.81e+07 |
| produces | 20  | 1.22e+07 | 1.22e+07 | 8368 | 2.82e+07 |

According to the DID model, 

\[ Y = \beta_0 + \beta_1 \cdot \text{treated} + \beta_2 \cdot \text{Time} + \beta_3 \cdot \text{treated} \cdot \text{Time} + \epsilon \]

\( \beta_0 \) is the current effect of the policy reform, \( \beta_1 \) is the time coefficient before and after the policy change, and \( \beta_2 \) is the coefficient of the alternative fuel vehicle and traditional cars. Set grouping dummy variables and time dummy variables: if it is an alternative fuel vehicle, set treated=1, otherwise treated=0; for time dummy variables, if it is after September 2014, Time=1, otherwise, Time=0. By taking the logarithm of the sales and bringing it into the DID model, the results are obtained (Table 2). The difference between the treatment group and the control group before policy implementation is Diff (TC)-7.391, and after policy implementation the difference is -3.794. Their difference, that is, the coefficient of difference in differences, is 3.597, which corresponds to P<0.01, which means that they have passed the test at a significance level of 1%. The interaction term of treated\( 1=\text{treated} \cdot \text{time} \) was constructed for OLS regression test, and the results were consistent (Table 3).
Table 2. DID estimation results of alternative fuel vehicle.

| Outcome var. | ln_sales | S. Err. | |t| | P>|t| |
|--------------|----------|---------|---|---|---|
| Before       |          |         |   |   |   |
| Control      | 16.805   |         |   |   |   |
| Treated      | 9.414    |         |   |   |   |
| Diff (T-C)   | -7.391   | 0.533   | -13.85 | 0.000*** |
| After        |          |         |   |   |   |
| Control      | 17.052   |         |   |   |   |
| Treated      | 13.258   |         |   |   |   |
| Diff (T-C)   | -3.794   | 0.349   | 10.86 | 0.000*** |
| Diff-in-Diff | 3.597    | 0.638   | 5.64  | 0.000*** |

R-square: 0.96
* Means and Standard Errors are estimated by linear regression
**Inference: *** p<0.01; ** p<0.05; * p<0.1

Table 3. DID result of alternative fuel vehicle (OLS regression results).

| VARIABLES | ln_sales |
|-----------|---------|
| treated   | -7.391*** |
|           | (0.533)  |
| time      | 0.247    |
|           | (0.451)  |
| treatedt1 | 3.597*** |
|           | (0.638)  |
| Constant  | 16.81*** |
|           | (0.377)  |

Observations 20
R-squared 0.956

Standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

Finally, do a balance test to see if there are differences between the treatment group and the control group for each variable (Table 4). It can be seen from the results that the explained variables are significantly different between the treatment group and the control group, while the average effects of the remaining control variables are not significantly different, which shows that the data is selected appropriately.

Table 4. DID result of alternative fuel vehicle (Balance test).

| VARIABLES | produces |
|-----------|----------|
| treated   | -1.991e+07*** |
|           | (1.115e+06) |
| Constant  | 1.992e+07*** |
|           | (788,694)   |

Observations 6
R-squared 0.988

Standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)
5. Scientific development

According to the above analysis, it can be known that under the 1% confidence level, the regression coefficient of the interaction term treated\(t1=treated*\text{time}\) is a positive. It shows that the sales are obviously affected by the policy of exemption from the purchase tax of alternative fuel vehicles. However, due to the lag of policy effects, for example, it takes time to understand the policy. At the same time, the tax exemption policy is a periodical short-term policy, and the exemption period is extended in the form of an announcement, which causes consumers to be unable to understand in time. As a result, consumers’ enthusiasm for preferential policies has gradually decreased, and the ability of policies to drive sales of alternative fuel vehicles has also gradually weakened. This has led to negative growth in sales of alternative fuel vehicles in 2019. In order to better promote the development of the alternative fuel vehicle industry and improve the vehicle purchase tax, the following suggestions are made:

The vehicle purchase tax can have a certain inhibitory effect on the consumption of automobiles, but with the development of the economy, automobiles have become more and more rigid demand for most people, which makes the role of taxation gradually weakened. The vehicle purchase tax law has been implemented on July 1, 2019, but the relevant provisions on alternative fuel vehicles have not been added to this law. The policy support for alternative fuel vehicles should be increased. Research and formulate policies to encourage purchases after the exit of existing preferential policies, and comprehensively apply tax exemptions and tax reductions and other preferential tax policies for alternative fuel vehicle manufacturers to reduce consumer purchase costs and guide people to purchase and use alternative fuel vehicles. The vehicle purchase tax is levied in stages. The current single-proportional tax rate is adjusted to a differential tax rate levied in stages according to differences in energy consumption and pollution levels. If the tax rate is set according to the displacement, the purpose of restricting the purchase and use of high-energy-consuming cars and controlling energy consumption can be directly achieved [11,12].

Actively guide the broad masses of consumers to establish a correct view of consumption, and strengthen the promotion of energy-saving, and environment-friendly. According to the concept of green, environmental protection, and sustainable development, the development of alternative fuel vehicles has become an important measure of China’s transportation energy strategic transformation, and it is also an important link in the practice of ecological civilization construction. The development of the alternative fuel vehicle industry is still in a critical period, so it needs continuous support from the government to ensure the sustainability of the policy. At the same time, it should actively guide and accelerate the promotion of technological innovation, promote the development and upgrade of alternative fuel vehicles, give preferential subsidies, and cultivate competitive domestically produced brand. Also pay attention to infrastructure construction, encourage alternative fuel vehicle companies to increase the construction of charging piles and charging stations, improve the upgrade and layout of charging outlets, and fully solve the worries of consumers.

6. Conclusion

Solving the problem of energy conservation and environmental protection is an important and urgent task for expanding domestic demand, stabilizing growth, adjusting structure, and building an upgraded version of China’s economy. Accelerating the development of energy conservation and environmental protection industries can promote investment and consumption, form new economic growth points, promote industrial upgrading and transformation of development methods, promote energy conservation, emission reduction and improve people's livelihood, and achieve sustainable economic development. The development of the alternative fuel vehicle industry is of long-term strategic importance. It is conducive to the implementation of the innovation-driven development strategy, to promote environmental protection, and to stimulate the domestic market to expand overseas markets. It unifies the development goals of economic development and environmental protection.

This paper takes vehicle purchase as the research object, uses quantitative analysis of econometrics, and uses the sales and production quantities of alternative fuel vehicles and traditional fuel vehicles in
China from 2011 to 2020 as sample data to establish a DID model. Analyse the impact of the policy of exempting the vehicle purchase tax on alternative fuel vehicles on sales. The conclusion shows that the policy can play a role in increasing the sales of alternative fuel vehicles. Since the policy is only a short-term promotion effect, the paper also proposes perfect suggestions in terms of taxation and related policies in response to the problems faced by the alternative fuel vehicle industry. The research helps to improve the improvement of China's taxation system and the sustainable development of the alternative fuel vehicle industry.

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