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ORIGINAL PAPER

## ANALYSIS OF CHINA'S VEHICLE PURCHASE TAX POLICY RESEARCH METHODS: DID MODEL

L. Liu, Ural Federal University named after the first President of Russia B.N. Yeltsin, Yekaterinburg, Russia

I.A. Mayburov, Ural Federal University named after the first President of Russia B.N. Yeltsin, Yekaterinburg, Russia

**Abstract.** As the most common means of transportation in China, automobiles have brought considerable challenges to China's infrastructure due to the year-by-year increase in automobile exports in recent years. Therefore, China's policies towards the automotive industry have been different at different times, requiring the use of fiscal policies to guide and support the development of the automotive industry. Vehicle purchase tax (VPT), as an important tax in the automobile sales environment, plays a key role in the development of the automobile industry. This paper uses a difference-in-difference (DID) model to assess the implementation effect of China's third VPT incentives, taking the total monthly sales of vehicles enjoying China's VPT incentives as an explanatory variable, dividing them into a control group and an experimental group according to whether or not they enjoy the incentives, and adding the two influencing factors of the industrial value-added and the CPI as control variables. The results of the study show that China's third VPT incentive policy has had the desired effect, and that passenger automobile sales have continued to grow, boosting automobile consumption and, in turn, China's economic growth.

**Keywords:** automobile sales volume, COVID-19, DID model, Vehicle purchase tax

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ОРИГИНАЛЬНАЯ СТАТЬЯ

## АНАЛИЗ МЕТОДОВ ИССЛЕДОВАНИЯ НАЛОГОВОЙ ПОЛИТИКИ ПРИ ПОКУПКЕ ТРАНСПОРТНЫХ СРЕДСТВ В КИТАЕ: МОДЕЛЬ DID

Л. Лю, Уральский федеральный университет имени первого Президента России Б.Н. Ельцина, Екатеринбург, Россия

И.А. Майбуров, Уральский федеральный университет имени первого Президента России Б.Н. Ельцина, Екатеринбург, Россия

**Аннотация.** На протяжении последних лет наблюдается тенденция увеличения количества автомобилей, являющихся наиболее распространенным средством передвижения в Китае, что создает серьезные проблемы для инфраструктуры страны. В то же время нельзя не отметить, что политика Китая в отношении автомобильной промышленности в разное время отличалась, что требовало проработки и адаптации налогово-бюджетной политики для развития и поддержки отрасли автомобильной промышленности. Налог на покупку транспортных средств (VPT) как важный элемент в сфере продаж автомобилей играет ключевую роль в развитии сектора автомобильной промышленности. В данной статье используется модель «разница в разнице» (DID) для оценки эффекта реализации мер поддержки и стимулирования VPT в Китайской Народной Республике. Общий ежемесячный объем продаж транспортных средств, подпадающий под льготные условия VPT, рассматривается в качестве ключевой переменной и подразделяется на контрольную и экспериментальную группы в зависимости от того, используются ли меры поддержки или нет. При этом в качестве контрольных переменных рассматриваются два фактора, которые оказывают существенное влияние – добавленная стоимость в автомобильной промышленности и индекс потребительских цен. Результаты исследования показывают, что политика стимулирования VPT в Китае дала желаемый эффект и, как следствие, уровень продаж легковых автомобилей продолжает стабильно увеличиваться, что, в свою очередь, приводит к ощутимому вкладу в экономический рост Китая.

**Ключевые слова:** объем продаж автомобилей, COVID-19, модель DID, налог на покупку транспортных средств

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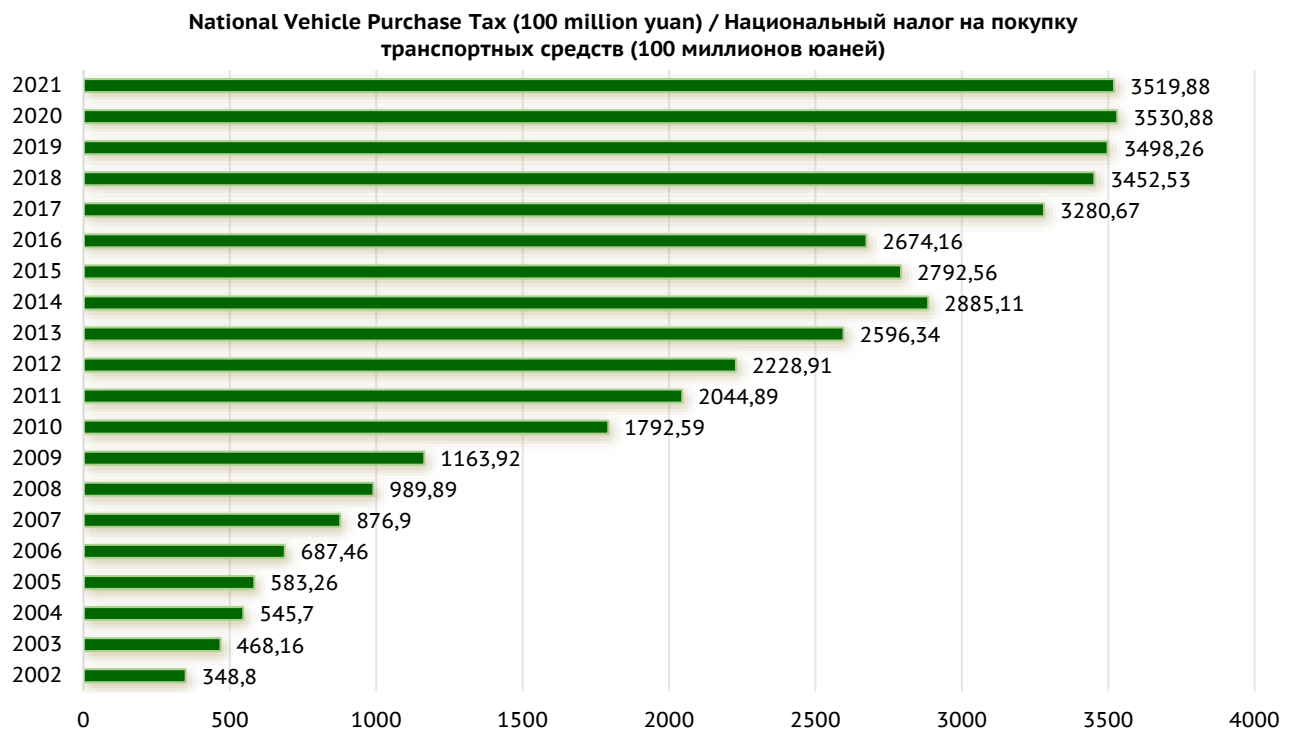
### Introduction

Vehicle purchase surcharge is extremely critical in China's transportation infrastructure. It is an extremely important source of funds for China's transportation infrastructure. It is also a mandatory tax in China. After the tax is collected, all of it will be invested in the construction of China's public transportation.

Since China resumed the policy of levying vehicle purchase tax at a rate of 10 per cent on vehicles with a displacement of 1.6L and below in 2001 [1], the tax has been growing steadily [2]. And the first time China implemented the preferential vehicle purchase tax policy was in 2009. In the same year there was a global subprime crisis and industries were slowly recovering their production. Since January 20, 2009, the new policy states that when purchasing passenger cars with an engine capacity of 1.6L and below in China, the vehicle purchase tax will be halved, that is, the vehicle purchase tax will be levied at a rate of 5%. The data in Figure 1 shows that in the year when the preferential policy was implemented, China's vehicle purchase tax revenue has increased significantly. China's first vehicle purchase tax incentive policy was stopped after less than 2 years of implementation.

Di Wu [3] argues that China's purchase tax has not yet been resolved in terms of methodology, collection management, institutions and other legacy issues; Baoyi Deng [4] proposes for the first time that the tax rate should be consistent with both the

principle of fairness and the concept of sustainable development, encouraging consumers to purchase energy-efficient vehicles; M. Ahman [5] argues that Japan, in response to the economic crisis, promotes the development of hybrid vehicles and introduces a purchase tax on energy-efficient vehicles to carry out preferential policies, and achieved significant results. M.A. Boyle [6] combed through the tax incentives for hybrid cars in each state of the U.S. in 2005, and A. Chandra et al [7] study showed that consumers in Canada purchased more energy-efficient cars due to the lower tax on hybrid and electric cars; Tuoyang [8] studied the relationship between tax breaks in the automobile market and the supply and demand of automobiles. His article takes vehicle purchase tax as a case study and adopts double-difference panel analysis method to prove the stimulating effect of vehicle purchase tax incentives on consumption as well as the radiation-driven effect of the automobile industry on the national economy. To summarize, we can say that there are many institutional research articles on the policy of preferential tax on vehicle purchases, but there is relatively little research on the impact of preferential purchase tax policies vehicles for car sales. This article analyzes the impact of the tax for the purchase of vehicles for car sales during Covid-19 based on DID model, which provides an analytical basis for tax reform after epidemic.



**Fig. 1. China's Vehicle Purchase Tax from 2002 to 2022/ Рис. 1. Налог на покупку транспортных средств в Китае с 2002 г. по 2022 г.**

*Source:* compiled by the authors based on public data from the State Administration of Taxation / *Источник:* составлено авторами на основе общедоступных данных Государственной налоговой службы

**Results and Discussion**

The double-difference DID model and the general equilibrium CGE model are two commonly used models that are highly practical for analyzing the effects of fiscal policy, have high quantification accuracy, and the results obtained are relatively accurate [9]. In previous studies, when using the DID model for empirical analysis, the model established only set policy dummy variables and explained variables [10], but changes in automobile sales in a certain country are not only affected by policy factors, but also by the superposition of macroeconomic environment, personal consumption preferences and other factors [11].

The double difference model has been widely used in recent years to assess the effect of policy implementation, which can accurately and effectively assess the real effect of policy impact. Combined with the research of Ye Fang [12], the basic idea of modeling using the double difference model in this paper is: car sales are divided into experimental and control groups according to the time series [13]. At the same point in time, the experimental and control groups are affected by different degrees of policies [14]. Data significance was tested by t test [15]. In the past,

China's purchase tax incentives only targeted cars with emissions below 1.6L, and vehicles with other emissions were still taxed at the original rate, while the current round of incentives targets cars with emissions below 2.0L, which provides a wider range of incentives.

As we all know, since 2019, due to the impact of the COVID-19 epidemic, global GDP has shrunk significantly, with most countries experiencing negative growth. China's GDP has also slowed down to varying degrees. Therefore, GDP has an indirect impact on people's purchasing power to some extent, and there is hysteresis. Therefore, based on previous research, this paper adopts some new control variables in order to estimate the model better, more quickly and intuitively, and to obtain more accurate research conclusions.

The implementation of vehicle purchase tax incentives is mainly to maintain the smooth and healthy operation of the automobile market economy and to boost GDP growth. When evaluating the effect of vehicle purchase tax incentives in this paper, how car sales change is the focus of this paper. According to the requirements for building the model, we set the following variables, as shown in *Table 1*.

*Table 1 / Таблица 1*

**Variable settings / Настройки переменных**

Notation / Обозначение	Name / Название	Note / Замечания
Y	Monthly total sales of passenger cars enjoying incentives	explanatory variable
T	Grouping Virtual Variables	-
A	Policy implementation dummy variables	-
T·A	Interaction terms between subgroup dummy variables and policy implementation dummy variables	Core explanatory variables
X <sub>1</sub>	value added by industry	control variable
X <sub>2</sub>	CPI	control variable

Source: compiled by the authors / Источник: составлено авторами

This paper explores the issue using monthly data on relevant variables for the years 2021-2022, which are collated from the National Bureau of Statistics of China, the National Taxation Bureau of China, the China Automobile Dealers Association, and the China Passenger Vehicle Federation. The data in this paper are processed and modelled using SPSSPRO software. In order to weaken the influence of heteroskedasticity of the data series, the relevant data are logarithmised.

According to the basic principle of double difference model, the following model is established as the double difference model of this paper:

$$Y_{it} = b_0 + b_1 \cdot T_t + b_2 \cdot A_t + b_3 \cdot T_t \cdot A_t + \beta_1 \cdot X_{1t} + \beta_2 \cdot X_{2t} + \varepsilon_{it} \quad (1)$$

Where, Y is automobile sales volume; i is different displacement specifications; t is month; b<sub>0</sub> is a constant term; T<sub>t</sub>A<sub>t</sub> is the interaction term between the grouping dummy variable and the policy implementation dummy variable; Y<sub>it</sub> is total monthly sales volume of automobile in different months; ε is the

disturbance term; T<sub>t</sub> is different months, 1 if in the policy preference period and 0 otherwise; A<sub>t</sub> is the while-stop variable, which is 1 if it is a passenger car enjoying the preferential policy and 0 otherwise.

b<sub>0</sub>, b<sub>1</sub>, b<sub>2</sub>, b<sub>3</sub>, β<sub>1</sub>, β<sub>2</sub> are the coefficients of each item, and b<sub>3</sub> is the important research object of this paper. Its size reflects the net effect of the vehicle purchase tax policy adjustment, that is, the greater the sales of cars enjoying preferential policies, the more significant the demand-pulling effect. With the help of analytical software, the results of the DID model were obtained as shown in *Table 2*.

The double difference effect value (Diff-in-Diff) is 958548.686 > 0 and shows significance at 1% level, implying that the policy plays a positive role. For pre-experimental (base period), the Diff effect value is 1126032.600 > 0 and shows significance at 1% level, implying that the effect value of the experimental group is significantly higher than the effect value of the control group in the pre-experimental period. For

the pre-experimental (base period), the Diff effect value is 2084581.286 > 0 and shows significance at 1% level, implying that the pre-experimental

experimental group effect value is significantly higher than the control group effect value.

Table 2 / Таблица 2

Summary of DID Model Results / Сводка результатов модели DID

Time / Время	Items / Пункт	Effect Value Sales / Значение эффекта объема продаж	Standard Deviation / Стандартное отклонение	T / T	P / P
Before	Control	-77090.021			
	Treated	1048942.579			
	Diff(T-C)	1126032.600	181646.552	6.199	0.000**
After	Control	-123095.410			
	Treated	1961485.876			
	Diff(T-C)	2084581.286	153519.356	13.579	0.000**
Diff-in-Diff	958548.686	237831.164	4.030	0.001**	
<b>R2:0.930, Adjustment of R2:0.911</b>					
<b>* p&lt;0.05 ** p&lt;0.01</b>					

Source: calculated by authors using Spssau based on collected data / Источник: рассчитано авторами с использованием Spssau на основе собранных данных

The DID model usually needs to be tested for parallel trend, and there are various test methods, including t-test, graphical method, interaction term

regression method, etc. In this paper, we use t-test to test for parallel trend, and the test results are shown in Table 3 and Table 4.

Table 3 / Таблица 3

t-test (Before) / t-тест (до)

Projects / Проекты	Control (n=5) / Контроль (n=5)	Treated / Обработка	Diff / Дифф	T / T	P / P
Sales Volume	58598.200	1184630.800	1126032.600	3.992	0.016*
Control variable 1	0.286	0.286	0.000	0.000	1.000
Control variable 2	1.500	1.500	0.000	0.000	1.000
<b>* p&lt;0.05 ** p&lt;0.01</b>					

Source: calculated by authors using Spssau based on collected data / Источник: рассчитано авторами с использованием Spssau на основе собранных данных

The above table shows the t-test method of parallel trend test, that is, for the pre-experimental data, processing variables and explanatory variables t-test, sales show significance, indicating that to meet the "parallel trend" test; the other two control variables industrial value added and CPI did not show significance, indicating that does not meet the "parallel trend" test.

established in this article can be obtained, as shown in Table 5.

The table above demonstrates the results of the t-test between the treatment variables and the study variables after the experiment. If the data shows significance, it means that there is a significant difference between the control group and the experimental group at the time after the experiment.

In the regression results, the determination coefficient R2 and the adjusted determination coefficient R2 are 93.00% and 91.10% respectively, indicating that the goodness of fit of the sample equation is high. The p value of the F statistic is 0, indicating that the overall significance of the equation is high, indicating that the model has certain economic significance. After testing the significance of the variables, the net effect of the vehicle purchase tax preferential policy on car sales is the coefficient of the cross term 958548.686, indicating that the implementation of the policy increased the monthly sales of passenger cars with an engine displacement of less than 2.0 liters by 958548 units.

The principle of the DID model is to use OLS regression to perform effect size testing. Through analysis, the OLS regression results of the model

Table 4 / Таблица 4

t-test (After) / t-тест (после)

Projects / Проекты	Control (n=7) / Контроль (n=7)	Treated (n=7) / Обработка(n=7)	Diff / Дифф	T / T	P / P
Sales volume	59423.286	2144004.571	2084581.286	63.662	0.000**
Control variable 1	0.297	0.297	0.000	0.000	1.000
Control variable 2	2.286	2.286	0.000	0.000	1.000
<b>* p&lt;0.05 ** p&lt;0.01</b>					

Source: calculated by authors using Spssau based on collected data / Источник: рассчитано авторами с использованием Spssau на основе собранных данных

In summary, the demand-pulling effect brought about by the implementation of China's preferential vehicle purchase tax policy is significant. As can be seen from the mechanism of the tax policy, the preferential policy indirectly lowers the relative price of small-displacement vehicles by lowering the

purchase tax rate for small-displacement vehicles, and at the same time makes the real income of consumers relatively higher, thus guiding consumers to increase their consumption of automobiles, and thus achieving the purpose of stimulating the growth of the domestic economy.

Table 5 / Таблица 5

### OLS Regression Analysis Results (n=24) / Результаты регрессионного анализа OLS (n=24)

	Regression coefficients / Коэффициенты регрессии	95%CI / 95% ДИ
Constant	-77090.021 (-0.340)	-553690.801~399510.760
Industrial Added Value	174838.757 (1.031)	-181520.447~531197.960
CPI	57122.891 (0.429)	-222616.857~336862.639
Whether the experimental group	1126032.600** (6.199)	744407.355~1507657.845
Time	-46005.389 (-0.233)	-461339.640~369328.862
Whether the experimental group*TIME	958548.686** (4.030)	458883.951~1458213.420
Sample Size	24	
R <sup>2</sup>	0.930	
Adjustment of R <sup>2</sup>	0.911	
F/Ф	F(5,18)=48.189, p=0.000	
<b>Explained variable: Total Monthly Sales of Passenger Cars Enjoying Preferential Policies</b>		
* p<0.05 ** p<0.01		

Source: calculated by authors using Spssau based on collected data / Источник: рассчитано авторами с использованием Spssau на основе собранных данных

### Conclusion

This paper studies the stimulating effect of the adjustment of China's vehicle purchase tax incentives on automobile sales by establishing a double-difference model, and the results of the study show that both incentives have significantly increased automobile consumption in the short term.

1) In 2009-2010, the Chinese government implemented the preferential policy on automobiles for the first time, and the sales of automobiles increased substantially in the second year, and the growth decreased after the preferential policy ended; in 2019, against the background of economic globalization encountering a countercurrent and the New Crown Epidemic being difficult to end in the short term, the Chinese government implements the preferential policy once again in 2022, and appropriately reduces the purchase tax rate which is conducive to stimulating the potential automobile consumption or pull forward consumption, which in turn can promote the stable development of the automobile industry and the national economy to a certain extent in the short term.

2) According to the implementation of the two preferential policies, the development of the automobile industry is not only affected by policy factors, but also by macroeconomic factors, and China's tax incentives for small-displacement vehicles last

for a maximum period of no more than two years, which is not only detrimental to stabilizing the overall sales volume of small-displacement and new-energy vehicles, but also detrimental to the stability of the country's tax revenues. It is recommended that the number of tax incentives be reduced and that the tax incentives for vehicle purchase tax be implemented on a long-term basis.

### Authors' Contribution

L.L. developed the methodologies and designed the experiments; L.L. and M.I.A. analyzed and validated the results; L.L. wrote the paper; L.L. and M.I.A. improved it. All authors have read and agreed to the published version of the manuscript.

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#### About the Authors / Информация об авторах

**Лили Лю** – старший преподаватель, Уральский федеральный университет имени первого Президента России Б.Н. Ельцина, Екатеринбург, Россия / **Lili Liu** – Senior lecturer, Ural Federal University named after the first President of Russia B.N. Yeltsin, Yekaterinburg, Russia

E-mail: liulili@mail.ru

SPINРИНЦ 4050-5823

ORCID 0000-0001-8791-665X

**Игорь Анатольевич Майбуров** – д-р экон. наук, профессор; заведующий кафедрой, Уральский федеральный университет имени первого Президента России Б.Н. Ельцина, Екатеринбург, Россия / **Igor A. Mayburov** – Dr. Sci. (Economics), Professor; Head of the Department, Ural Federal University named after the first President of Russia B.N. Yeltsin, Yekaterinburg, Russia

E-mail: i.a.mayburov@urfu.ru

SPINРИНЦ 3904-2810

ORCID 0000-0001-8791-665X

ResearcherID AAQ-4302-2020

Scopus Author ID 56584757200

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