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Analysis on Effects of Car Ownership Control Policy in China

Feng Suwei
(Shanghai University of Finance and Economics, Shanghai 200433, China)

Abstract: With the rapid development of urbanization and motorization in China, several cities have implemented a series of car ownership control policies. It is necessary to assess the effects for policies improvement. Based on the public regulation theories and a couple of econometric methods, this paper discusses the macro and micro effects of Shanghai quota auction policy on controlling the growth of car ownership. The results show that the policy has decreased annual car increment by 26%~35%. In addition, the paper analyzes the influence of external factors and the mechanism of internal correlation in the quotas, number of bidders, and average price using annual data of the auction. The monthly data of the auction market is discussed to reveal the mutual relationships of the major variables at micro level, and to verify several rules coherently at macro level.

Keywords: transportation policy; quota for private cars; econometric methods; ownership control; policy effects; Shanghai

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About the Author: Feng Suwei(1969—), Female, from Yangzhou Jiangsu, Associate Professor at School of Public Economics and Administration of Shanghai University of Finance and Economics, Director of Research Center for Transport Economics and Policy, Institute of Public Policy and Governance (think-tank). Research Focus Areas: Transport Economics and Policy.
E-mail: fsuwei@mail.shufe.edu.cn

0 Introduction

The government makes relevant rules to intervene the economic and social decisions, which is called public regulation (or governmental regulation)[1]. The car ownership control refers to the governmental restriction and intervention of residents' rights to own private cars, which is commonly known as car purchase restriction policy in China. The motorization developing pattern of private cars in Chinese cities is different from that in developed countries of North America and Europe. Most downtown of Chinese cities have highly-densed population, leaving scarce land for use of motor vehicles. In light of such national wide circumstance, the development of private cars has to accord with orderly and strictly-regulated policies. Shanghai, as the earliest city in China to enforce the purchase restriction policy, is famed for its smart administration and efficient allocation of public resources. By allocating quota of private car via auction, the cost for owning a car has been lifted, and the growth of private car has also been slowed down. Due to the developed transit and regular bus systems in Shanghai, residents are able to travel conveniently and effectively without degrading their travel utility.

Up till now, the car purchase restriction policy has been applied (or was applied) in eight cities, including Shanghai (1986), Beijing (2011), Guangzhou (2012), Wenzhou (1989- 2007), Guiyang (2011), Tianjin (2013), Hangzhou (2014) and Shenzhen (2014). The reason for purchase restriction varies in each city, either being boosted by major city events (e.g., to facilitate Olympic Games and or to reduce haze), or being the result of policy migration of surrounding cities (e.g., Beijing-Tianjin, Shanghai-Hangzhou, Guangzhou-Shenzhen, etc.). The quotas for private cars are allocated through auction, lottery or mixed mechanism. The enforcement of related policies in these cities has provided valuable experience for the demand management of private cars.

The world famous case about the car ownership control is the Vehicle Quota System (VQS) adopted in Singapore. Many scholars have made systematic analysis and evaluation on the policy performance from the perspectives including policy evolution[2-3], motor vehicle growth control [4], effects on environment, congestion and auto market[5-6], and relief of auction price fluctuation[7] and market fairness [8]. With respect to the practice of policies of car ownership control in China, some studies have focused on the macro-

scopic policy influence[9], the opportunity costs of policy participants[10] and the attitude and acceptance of the public [11], etc. As the principles of public policy and administrative management are gradually applied in the transportation domain, the academic and implementation authorities pay more attention to the evaluation on the performance of car ownership control policy.

Shanghai has enforced the quotas auction policy of private car for decades, thus can provide more open data for analysis. Taking Shanghai auction as an example, this paper has systematically summarized our relevant research findings in recent years. The micro and macro policy effects of the car ownership control have been studied via econometric methods like Difference- in- Difference (DID), Structural Vector Auto- Regression (SVAR) and Three- Stage Least Squares (3SLS). Besides, the effects of quota control policy on the slowdown of private car growth, and the external influencing factors on key variables of the auction market and the internal correlation mechanism of the key variables have also been explored.

1 Overview of Car Ownership Control Theory

Market failure may occur in case of multiple forms, such as natural monopoly, externalities, internalities, public products, information asymmetry and irrational preferences. The government intervenes the ownership of private cars primarily owing to the market failures related to motorization, which can be summarized into three main reasons: irrational individual decision- making (variance between personal cost and social cost), negative externalities (traffic congestion, emission and accident, etc.) and information asymmetry (variance between public information and private information).

1) Irrational individual decision-making

In a market, if the personal cost is less than the social cost, excessive production and use of the goods will happen due to the market mechanism. When making car purchase decisions, the personal perceived costs (e.g., fuel cost, vehicle depreciation, toll, parking charge and travel time cost, etc.) vary from the actual social costs (e.g., road occupancy and parking, congestion, accident, pollution, energy dependence and global warming, etc.). Such irrationality in individual decision- making will lead to over- consumption of private cars and people tent to purchase more cars or use more. The external effects of over- consumption generally have the property as the cost function, which will grow progressively with the increase of the consumption level. Therefore, irrational individual decision-making in purchasing cars will lead to over-consumption, and finally result in a variety of negative externalities in the car use.

2) Negative externalities

The essence of the market lies in competition. Via the competitions by different market agents, the price is capable to reflect the full costs of manufacturing and distribution of commodities. But sometimes due to the lack of an effective transmission mechanism or without sufficient competition, the price is unable to reflect the external costs, or even during the production, manufacturing, circulation and consumption of the commodity, some positive or negative spillovers appear outside the market. As a result, externalities emerge. Negative externalities will come out when a person's action degrades the welfare of others while others are not totally compensated for such impact. The use and the purchase of private cars are two closely related decision- making behaviors. When a person decides to buy a car, he (or she) usually does not consider a series of external spillovers that may affect the environment and the society. At this point, his (or her) decision-making and the corresponding results will affect other people despite of the buyers and sellers in the market. The essence of externalities lies in that individuals (or enterprises) do not have to fully assume the costs stemming from their decision- making, or cannot totally gain the benefits of their decisions, that is, the corresponding costs or benefits cannot be completely absorbed by the market, giving rise to the market failure. Externalities will reduce the efficiency of the market. As a result, some people will suffer from the losses, and maximum social welfare will not be achieved.

3) Information asymmetry

Information failure can be widely found in the field of transportation, including information insufficiency and information asymmetry. For example, sometimes in a quota auction market, what the bidders could get is very little and inadequate information of the other bidders and even overall situation of the auction, and the insufficient information would obstacle their decision-making process. Take another example, sometimes the residents without a parking lot do not have the effective information of unoccupied parking space in community either, thus they will find it difficult to park their cars after purchasing them. Moreover, due to the lack of relevant information and knowledge, residents are unable to correctly estimate the costs of owning a car (including all personal and social costs), and then to make an irrational decision of purchasing cars. Additionally, the use or parking of cars may occupy on the public

roads and space while the supply and management of public space is traditionally in the charge of the government. Due to the lack of public participation process, the relevant information of urban planning, road construction and parking lot supply is not released openly to the public, which makes residents have to pay extra searching costs for such public information when using or parking cars. All lead to the asymmetry and insufficiency between personal information and public information in the process of owning and using cars. As a result, the allocation of resources cannot reach the Pareto Optimal State in the market.

Public regulation, as an institutional arrangement of the administrative agencies for supervision, management and standardization of market and social behaviors, has the typical property as a public good. On one hand, the market and the society run with their own laws, which do not need special intervention of the government if no deviation occurs. On the other hand, the market and the society may suffer more or less failures due to some reasons, which makes the governmental intervention a common routine to the market and the society under different institutional circumstance. Regulation has become an endogenous variable in the economic and social system, and the benefits from regulation are non-exclusive to all agents in the system. Just for the reasons of market failure, the government and management departments will intervene the decision-making process of the enterprises, individuals and other social entities through laws and decrees, rules and standards, for the purpose of maximize social welfare. The regulatory relationship reflects the correlation between the government, the market and the society. As to the governmental intervene in travel demand management, the regulations include market-based measures like price strategies, non-market-based measures relating to administrative intervention, and mixed mechanism which is the combination of the above two (see Figure 1). The first two can be further divided into two categories of car ownership control and usage control. Therefore, the existing three ways for car ownership control (i.e. quota auction, egalitarian ballot and mixed mechanism of auction and ballot) respectively belong to market-based measures, non-market-based measures and mixed mechanism.

Before evaluating the effectiveness of a regulatory policy, the mechanism of the policy shock should be figured out at first, that is, how public policy affects micro individual and organizational decisions and finally produces the effects in a macro aggregated level. Based on its objectives, the policy influences individuals and groups (which are subjects affected by the policy) through legislation, rules and standards, prompting them to change their decisions and behaviors. In this way, micro policy effects will be produced among the choices and decision-making of individuals and groups. For example, the purchase restriction will make some residents to quit the plan of car purchase because of the difficulty of gaining a quota, and the reduction of fuel tax will encourage more residents to use motor vehicles because of paying less. At the same time, regulatory policies will also involve different variety of stakeholders, such as the real estate owners whose housing prices rise (or fall) directly caused by a new road construction, and changes in the business layout by improved accessibility along the road. In this case, the related real estate industry, retail business and residents living along the road are all stakeholders. These stakeholders, with different preferences, attitudes, appeals and behaviors, will make different decisions and take different actions in light of the policy. When some interest conflicts occur, game relationships will be formed among each stakeholder, and finally the equilibrium among

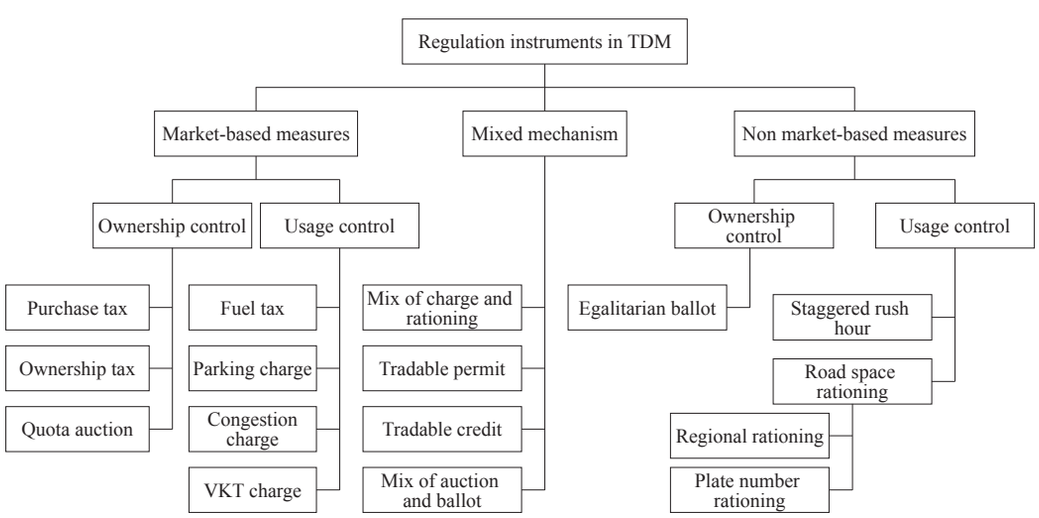

Fig.1 Strategies in travel demand management

different interests will be reached through negotiation and compromise. Under the influence of the policy, the macro policy effect will be formed by summing up the behavior decisions of different stakeholders and can be evaluated at the equilibrium. Generally speaking, the policy effect can be evaluated from both macro and micro levels, and the analytical methods applied at each level are quite different. Evaluation on the policy of car ownership control involves multiple aspects, such as the automobile industry, the performance of traffic system, the change of trip modal, and the environmental impact, and so on. Due to the limited space in this paper, only Shanghai's auction policy for private car quotas is observed, as the policy has been put in place long ago, with more annual and monthly data available for setting up econometric models. Through such information, the effect of quota restriction on private car growth control, and the internal correlation mechanism and external influencing factors among key variables of the auction market are analyzed, and the emphasis of this paper is laid on the consistency in the results from macro and micro analysis.

2 Analysis on Macro Effects of the Policy

"No man ever steps in the same river twice." Greek philosopher, Heraclitus' famous saying reflects the dilemma of policy evaluation. Apart from the policy shock, many other factors simultaneously cause changes to the system state. How to calibrate the causal relationship between policy shock and system state changes becomes the key link of policy evaluation. In addition, a city cannot stand in two states at the same time: with a policy or without the same policy. It is necessary to choose the appropriate reference system (comparison with other cities) or policy scenario (comparison with the referenced city itself) as a without-policy state and compare it with the state that has a policy put in place, so as to calibrate the policy effects. Considering that there are many factors that affect the development of urban motor vehicles, it is difficult to find a city which completely matches Shanghai for comparison, thus some appropriate groups of cities or provinces are used in this paper for comparison. By setting up multiple econometric models and comparing many times from different angles, the whole picture of policy effects is outlined, to avoid the low reliability and errors of using one model or by comparing only once. In this paper, three kinds of control groups are selected, which are respectively the cities and provinces of the Yangtze River Delta region, the developed coastal areas, and the areas with both high GDP and high car ownership rate. If the results are demonstrated as stable after multiple comparisons, then it shows that the comparison results are highly reliable and the conclusion is acceptable.

Tab.1 Evaluation of Shanghai vehicle quota auction policy by three control groups

Control Group	Yangtze River Delta Region		Developed Coastal Areas		Areas with both High GDP and Car Ownership Rate	
Model	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Time Dummy T_{it}	0.038 1	−0.054 6	−0.021 7	−0.114 4**	0.001 0	−0.061 6
Group Dummy G_i	0.257 8***	0.268 4***	0.226 3***	0.265 7***	0.259 2***	0.271 8***
Interaction Term $T_{it}G_i$	−0.320 4***	−0.353 9***	−0.260 6**	−0.305 8***	−0.283 2***	−0.299 6***
GDP Per Capita		−0.353 6		−0.339 9		−0.370 1
Residents with Hukou at the end of the year		0.801 5		0.193 5		−0.647 0
Disposable income Per Capita		2.820 4***		2.655 9***		2.370 0***
Road Area Per Capita		−0.003 2		−0.079 2		−0.045 3
Number of Buses Per Capita		−0.101 4		−0.041 7		−0.099 7
Road Length Per Capita		0.061 6		0.082 1		0.067 5
Real estate investment		0.173 6		0.296 3*		0.016 0
Constant	0.271 4***	0.042 6	0.302 9***	0.078 3	0.270 0***	0.119 3**
Number of Observations	84	84	98	98	112	112
R-Squared	0.094 6	0.301 1	0.106 3	0.321 5	0.127 5	0.285 1

Note: The dependent variable is change in logarithm of private vehicles. ***, **, and * denote significance level of 1%, 5%, and 10%, respectively.
Data source: reference [13].

Furthermore, with the Difference-in-difference method, the beginning year of the policy mature period, namely 2003 is selected as the time dummy variable[12] and the above-mentioned three control groups are introduced as group dummy variables. For each control group, regression models with (model 2,4,6) or without(model 1,3,5) control variables are employed for comparison. The data source comes from China Economic Information Network and China City Statistical Yearbook, and the time span is from 1996 to 2010. Analysis results show that the regression coefficient before the interaction term which represents the estimated policy impact varies from -0.2606 to -0.3539, with the significant level up to 1%~5% (see Table 1). This reveals that the annual growth rate of private cars in Shanghai is reduced by 26% ~35% compared with three control groups after the year of 2003 when the policy maturity period began, which indicates the policy has achieved remarkable results and reached its major objective to slow down the increasing rate of private cars.

Another important issue of the policy performance evaluation at macro level is: what kind of economic and social factors will affect the key variables in the auction market, e. g. quotas, number of bidders, and average price? Shanghai was the first city in China to issue the Shanghai Metropolitan Transport White Paper in 2002, which promises to restrict the car ownership and usage by several comprehensive methods, including license quota auction and congestion charge. And further the White Paper of 2013 version announces that the quotas would be determined by some factors including road capacity and its level of service, parking capacity and its level of service, and the quality of environment[14]. Then in practice what factors will actually affect the quotas' number? How do the key variables in the auction market affect each other? With the limited annual data ("Shanghai Statistical Yearbook", 2002 - 2014), Three-Stage Least Squares (3SLS) is applied in this section to establish five groups of regression models[15]. And by judging whether the regression coefficients of these models are sta-

Tab.2 Quotas, number of bidders, and annual mean winning bids with SVAR equations

Dependent Variable	Independent Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Annual Quota $\ln QT_T$	One-year Lagged Road Area Per Vehicle $\ln RoadV_{T-1}$	0.54	−0.22	−0.16	0.11	0.34
	One-year Lagged Change in Rail Length $D\ln RailL_{T-1}$	−0.29	−0.11	−0.14	0.40	0.75**
	One-year Lagged Change in SO_2 DSO_{2T-1}	−17.02***	−14.52***	−14.45***		
	One-year Lagged Change in NO_2 DNO_{2T-1}				17.90	
	One-year Lagged Change in PM10 DPM_{10T-1}					15.30
	Annual Average Price $\ln P_T$		0.35**	0.26	0.97**	1.31***
	One-year Lagged Average Price $\ln P_{T-1}$			0.07	−0.61	−1.11**
	R-Squared	0.66	0.70	0.72	0.36	0.12
Annual Number of Bidders $\ln QB_T$	One-year Lagged Rail Utilization $\ln RailU_{T-1}$	−2.89*	−3.27*	1.38	0.42	1.82
	One-year Lagged Bank Deposit Per Capita $\ln DEP_{T-1}$	1.88***	0.47	2.16***	1.97***	2.75***
	One-year Lagged Change in Population $D\ln POP_{T-1}$	−20.62	−0.95	−4.24	-2.15	0.64
	Annual Average Price $\ln P_T$		2.16	−3.23**	−2.27***	−4.11
	One-year Lagged Average Price $\ln P_{T-1}$			3.00***	2.46***	3.43***
	R-Squared	0.70	0.52	0.89	0.92	0.78
Annual Average Price $\ln P_T$	One-year Lagged Average Price $\ln P_{T-1}$	1.00***	0.90***	1.03***	1.03***	0.79***
	Annual Quota $\ln QT_T$	−0.37	−0.46	−0.48	−0.24	−0.67
	Annual Number of Bidders $\ln QB_T$	−0.42***	−0.34**	−0.43***	−0.43***	−0.28**
	One-year Lagged Bank Deposit Per Capita $\ln DEP_{T-1}$	1.12***	1.11***	1.19***	1.10***	1.20***
	R-Squared	0.93	0.93	0.93	0.93	0.92

Note: ***, **, and * denote significance level of 1%, 5%, and 10%, respectively.
Data source: reference [15].

ble, significant and within an acceptable and interpretable range, the external factors affecting the key variables of auction market can be determined and the internal correlation mechanism can also be calibrated (see Table 2).

2.1 Influence factors of annual released quotas

From Table 2, the factors influencing the annual released quotas can be divided into two categories, namely macro external factors (including air quality and rail transit construction) and internal correlation factors of the auction market (annual average price):

1) The quotas are affected by the concentration of SO2 in the air with a significant regression, but not significantly affected by the concentration of NO2 and PM10.

2) Rail transit construction (rail length) has a negative impact on the quotas, that is, the construction of rail transit has restrained the increase of the quotas, but 4 from the 5 models do not have significant regression results. In addition, the impact of road area per vehicle is not significant either.

3) The quotas are affected by the annual average price, and the impact in the same period (year) is positive, while the impact in one-year lagged period is negative. It indicates the higher the auction price in the same period (year) is, the more quotas will be released.

2.2 Influencing factors of annual average bidders

1) The rail utilization (defined as the number of passengers served per mileage) is introduced, and the first two regression coefficients with -2.89 and -3.27 are negatively significant. This indicates that with the improvement of rail service and the number of passengers served per mileage, the number of bidders will be reduced.

2) There is a positive impact in the bank deposit per capita on the average annual bidders, which indicates that the improvement in the residents' income and financial status is conducive to increase the number of bidders.

3) The annual average price also has a complicated influence on the number of bidders, and with negative impact in the same period (year) and positive impact in one-year lagged period (previous year). It indicates that the high price of the same period (year) has a restraining effect on the number of bidders. Some people would prefer not participating in the auction when realizing the price is at a high level. But if the price would keep high last year, the auction still attracts more bidders this year. This reveals that the annual average price has a long-term impact on the number of bidders spanning more than one year, reflecting that the bidders prefer to join in the auction when the price is going up instead of going down.

2.3 Influencing factors of annual average price

1) The annual average price itself has a remarkable rising trend, and the market is bullish about its rise.

2) The number of bidders has a negative impact on the annual average price. If there are a large number of bidders, they can be roughly divided into two groups: those determined to win the bid and those just taking a chance. The two different groups of people will take opposite bidding strategies, the former offering a high price to ensure to obtain a quota, while the latter giving a lower price. Then the price can be diluted and inhibited if there are a huge number of bidders who belong to the second group.

3) The bank deposit per capita has a significant positive effect on the annual average price.

4) The increase in the quotas each year can restrain the price rise, but the regression result is not significant.

2.4 Summary

1) The economic status of residents (like the bank deposit per capita) has a positive effect on the number of bidders and the average price, thus the influence of economic factors on the auction market cannot be ignored. If Shanghai enjoys a stable economic development in the coming years, it is expected that the number of bidders and the annual average price will increase steadily.

2) The rail transit construction and the rail utilization (number of passengers served per mileage) have reduced the quotas (with no significant) and the number of bidders (partially significant), which indicates that continuous supply of rail transit construction and the improvement of its service can alleviate the residents' demand for motor vehicle quotas.

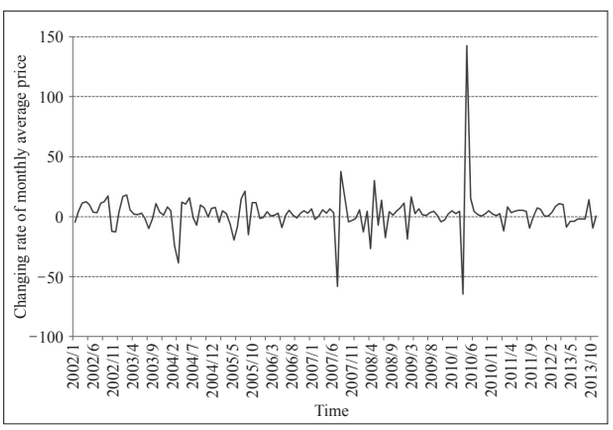

Fig.2 Changing rate of monthly winning bids

3) The air quality (SO2) will lead to a reduction in the quotas. As vehicle exhaust is one of the direct factors of air pollution, the air quality status will be considered as an increasingly important factor during the public decision-making process on the number of the quotas.

4) The increase in the annual average price will boost the quotas.

5) In the same period (year), the number of bidders and the annual average price mutually restrain each other, and the increasing number of bidders in the same period (year) can ease the price rise.

6) Due to the market expectation, the auction price will continue to rise based on its own inertia.

3 Analysis on Micro Effects of the Policy

The policy effects of at macro level should be analyzed from the scale of a longer period of time (on an annual data basis), while as for the effects at micro level, analysis should be made from a perspective of a shorter time (on a monthly data basis) to probe into the correlation among the key variables of the quota auction market, or on the behavior level to collect individual auction and trip data. Besides, the findings obtained from macro and micro analysis should be consistent, so as to test the reliability of the conclusions.

First of all, principal component analysis is used to set up a model for the monthly data (from Jan. 2002 to Dec. 2013). It is found that there is a significant and approximately linear relationship between the quotas, the number of bidders and the average price[16]. The partial derivatives of the bidders and the average price to the quotas are both positive. This means that the increase in the number of bidders and the average price will push the quotas rising, which partly verifies the policy analysis results at macro level, that is, being consistent with the conclusion 4) reached in Section 2.4. However, the partial derivative between the number of bidders and the average price is negative, which reflects that the two variables restrain each other and the result is consistent with conclusion 5) in Section 2.4.

Since the price cap was employed in April 2013 and the price ceiling has been under adjustment, the role of the price cap has not been fully exhibited during the research period, and the changing rate of auction prices still regresses to the median level (see Fig. 2). This feature can be found in many markets owing to the Cobweb effect caused by the information asymmetry between supply and demand sides. For example, the price of farm produce is high in

Tab.3 Variance decompositions from the SVARs %

Dependent Variable	Forecast Month	2002—2007				2008—2013			
		$\ln QT$	$\ln QB$	$\ln PR$	$\ln P$	$\ln QT$	$\ln QB$	$\ln PR$	$\ln P$
Quotas $\ln QT$	1	100	0	0	0	100	0	0	0
	3	59	35	5	1	95	2	2	1
	6	47	46	5	3	90	4	3	2
	12	41	41	4	14	86	7	3	3
Number of bidders $\ln QB$	1	9	91	0	0	5	95	0	0
	3	11	48	39	3	15	69	16	0
	6	11	38	37	13	17	63	20	0
	12	12	35	34	19	18	62	19	1
Price Range* $\ln PR$	1	12	29	59	0	2	22	76	0
	3	10	27	60	3	7	26	66	0
	6	11	27	59	3	8	26	64	1
	12	11	27	59	3	8	27	63	2
Price $\ln P$	1	22	7	0	71	4	41	18	37
	3	25	25	12	38	5	56	12	28
	6	24	26	10	40	10	56	9	25
	12	24	26	8	42	18	52	7	22

Note: *Price Range is defined as the difference between the average price and the minimum price.
Source: reference [15].

this period, while dropping in the next period, making it fluctuate around the median level. This shows that without price intervention, the internal law of the auction market will help to keep price change stable to some extent.

Secondly, SVAR method is adopted in this section to build econometric models in order to reveal the correlations among key variables[15], and the impacts of given policy shocks are tested. For example, suppose the quotas would be doubled as a policy shock, the impacts on quotas itself and other variables in the forecasting months could be tested.

The auction market was adjusted from single stage to two stages in 2008, which helped to resolve the information asymmetry and blind bid existing in the auction with one stage[14]. This section chooses the year of 2008 which separates the research time span into two, and the period between 2008 and 2013 will be emphasized on. In the first month of the predicted time span, a policy shock is given through simulation, for example, a certain variable increases by 100% in the first month, and the spreading of its impact in each subsequent month is followed up. Table 3 gives the status in the 3rd, the 6th and the 12th month. The following conclusions can be drawn:

1) The impacts of quotas and number of bidders are all within the range of their own variables, and have little influence on the other variables. For example, from 2008 to 2013, in the 12th months after the policy shock, 86% of impact to the quota itself remained, with the number of bidders increasing by 7% and the monthly average price rising by 3%; 62% of impact to the number of bidders itself remained, with the quotas increasing by 18% and the monthly average price rising by 1%.

2) The only different rule lies in the impact of monthly average price on the other variables. In the 12th month (the last row in Table 3) after the price shock, only 22% effect on monthly average price itself remained, but the number of bids has been increased by 52%, and the quotas by 18%. If the price is at a high level in a certain month in the year, then it will attract more people to enter the auction market in the same month of the next year, which has verified the mechanism for the phenomenon "buying when the prices are going up instead of going down" at the micro level.

It can also be found that the average price and the number of bidders influence each other and their relationship is related to time scale and with asymmetry features: 1) in the same month, the number of bidders and the average price constrain each other, that it, the increase in the number of bidders will dilute the average price, and the price will not rise quickly, and vice versa, the high price level will lead to declined number of bidders; 2) as to the longer period of year (the 12th month after the shock is generated), the rising price will attract more bidders after a year, as people believe in that the price will continue to rise and are willingness to enter into the auction market. Or it could be said that the large number of bidders of a certain period is the result of high price a year earlier. It seems two kinds of forces with different time scales in the auction market which affect the price changes. The positive force takes effect for a longer time, so the current high price will attract more people to enter the auction market after 12 months later, reflecting that people will rush to buy when the price is going up. The negative force takes effect for a shorter period, so if there are a large number of bidders and some of them would like to take a chance, the price will be diluted, showing the law of "low price in case of a lot of buyers". The positive force in the long term and the negative force in the short term are able to explain well the internal mechanism of regression of price changing rate to the median level (see Fig. 2).

It is worth noting that the above conclusion is drawn by analyzing data before the launch of price ceiling strategy in 2013. After price ceiling strategy was rolled out in April 2013, the auction prices converged and the price range between the average price and the lowest price shortened. In some extreme auction case, the average price is only one yuan (RMB) different from the lowest price. The mechanism that the price changing rate returns to median level

is broken, resulting in the effect of administrative intervention of price ceiling in replace of price competition and market self-adjustment.

In summary, the following laws can be found in this section by analyzing the monthly data of the auction market:

1) There is a complex correlation relationship between the number of bidders and the average price, which is mutually restrictive in the current period (at a shorter time scale). But in the long term (at a longer time scale), the high price will boost the number of bidders.

2) Before the price ceiling strategy was implemented in 2013, the price changing rate returned to the median level, and the auction price was able to be restored and could be self-adjusted.

3) The rise of the number of bidders and average price will increase the quotas, which is characterized by the rising of both quotas and price with a positive incentive on the quotas.

4 Research Summaries and Policy Meaning

In this paper, the private car quota auction policy of Shanghai is fully evaluated, and multiple econometric methods have been applied to explore the macro and micro effects brought out by this policy. The effects of regulatory policy on motor vehicle growth and the law of correlation between external influencing factors and internal variables in the auction market have been explored. In summary, the following research conclusions are drawn:

First, Shanghai is the earliest city enforcing the car ownership control policy. A DID method is applied to make comparative analysis on multiple control groups. It demonstrates that this policy is conducive to restricting the growth of the number of private cars in general, reducing the car number by one third since the policy became mature in 2003.

Second, multiple econometric methods including SVAR and principal component analysis have been used to set up models, which have revealed the external influencing factors in the car quota auction market and the correlation mechanism of internal variables (see Fig. 3). The external factors that influence the auction market include: the higher income of residents has driven up the number of bidders and the average price, while the rail transit construction and air quality have reduced the number of bidders and the released quotas. Inside the auction market, the quotas, the number of bidders and the average price form a more complicated correlation:

1) The auction price reflects the market scarcity of license plate quotas, while the rising price of land and the limited space regeneration in megacities have decided that the quota price has a sustained growth trend, indicating that the auction price has an initial growth if the local economy continuously increases. Meanwhile, before the price ceiling was implemented in April 2013, the number of bidders and the average price in the auction market inhibited each other in the same period and reinforced each other in the long run, resulting in returning of price changing rate to the median level, which is conducive to market stability.

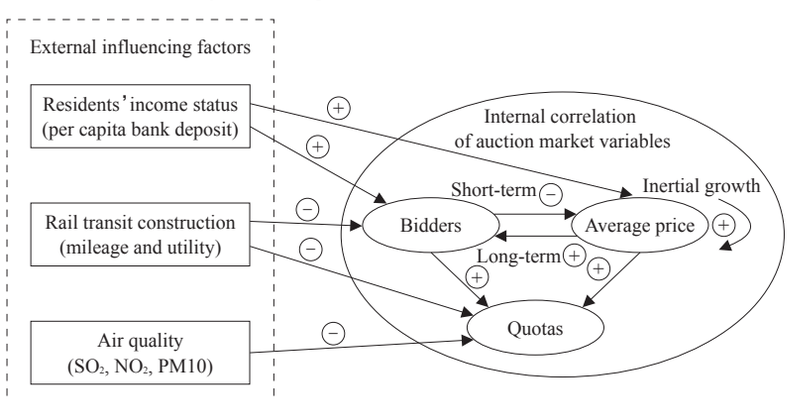

Fig.3 The influence of external factors and the mechanism of internal correlation of private car auction market

2) The relationship between quotas, number of bidders and average price is characterized by increase in both volume and price and with positive incentive. Both the growth in the number of bidders and the average price will help to boost the increase of quotas. This trend will easily lead the quotas to exceed the planned upper limit, making the expected objectives of motor vehicle control hard to achieve.

5 Conclusion

Since more cities in China join in the line to make car purchase restriction in practice recent years, some theoretical guidance and systematic evaluation are urgently needed for implementing such a policy. This paper has analyzed the reasons for the implementation of private car ownership control and its positioning in the travel demand management. Due to the limited data, it has attempted to analyze the effects of private car ownership control policy in Shanghai through establishing a variety of models by some econometric methods, and with a number of control groups. It emphasizes the consistency of conclusions at both macro and micro levels, to ensure credibility and stability of the research outcomes. Besides Shanghai, such policy has been launched in other cities for a rather short time, with more limited open data, thus the application of the methods used herein to other cities is restricted, but this does not prevent the use of the traditional qualitative method for analysis and evaluation of the effects of policies, in order to obtain information about the effectiveness of policy implementation and some improvement direction.

Moreover, from the macro perspective, although the direct effect of the private car ownership control policy is to limit the growth of motor vehicles, its impact on other issues such as the automobile and related industries (including new energy vehicles), traffic congestion and environment, vehicle management with non-local license, and social justice still need detailed analysis; and its correlation with other transportation policies in terms of motor vehicle use needs further clarification. At the micro level, many issues related to consumer behaviors, such as consumer preference of motor vehicles, selection of local or non-local plate license, travel mode and family transportation expenditures, still need to acquire micro behavior data through elaborate research design and carry out delicacy analysis, which eventually forms a closed loop of policy evaluation covering the whole process from micro to macro effects.

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References:

[1] Liu X B. Public Regulation[M], The Press of Shanghai University of Finance and Economics, 2009.

[2] Phang S Y, Asher M G. Recent Developments in Singapore's Motor Vehicle Policies[J]. Journal of Transport Economics and Policy, 1997, 31(2): 211−220.

[3] Koh W T H, Lee D K C. The Vehicle Quota System in Singapore: An Assessment[J]. Transportation Research Part A: Policy & Practice, 1994, 28(1): 31−47.

[4] Chin A. Containing Air Pollution and Traffic Congestion: Transport Policy and the Environment in Singapore[J]. Atmospheric Environment, 1996, 30(5): 787−801.

[5] Chin A, Smith P. Automobile Ownership and Government Policy: The Economics of Singapore's Vehicle Quota Scheme[J].Transportation Research Part A: Policy & Practice, 1997, 31(2): 129−140.

[6] Koh W T H. Control of Vehicle Ownership and Market Competition: Theory and Singapore's Experience with the Vehicle Quota System[J], Transportation Research Part A: Policy & Practice, 2003, 37(9): 749−770.

[7] Chu S. Allocation Flexibility and Price Efficiency Within Singapore's Vehicle Quota System[J]. Transportation Research Part A: Policy & Practice, 2012, 46(10): 1541−1550.

[8] Tan L H. Rationing Rules and Outcomes: The Experience of Singapore's Vehicle Quota System[J]. IMF Economic Review, 2003, 50(3): 436-457.

[9] Feng SW, Ma ZQ, Yu K. Policy Effects Analysis on Private Vehicle Plate Auction in Shanghai[J], Comprehensive Transportation, 2011, 353(1): 36-41.(in Chinese)

[10] Hou X, Peng S P，Ma Y. Cost Analysis of and Comparison Between Beijing's Car Plate Lottery and Shanghai's License Auction[J]. China Soft Science, 2013(11):58-65.

[11] Chen X J, Zhao J H. Bidding to Drive: Car License Auction Policy in Shanghai and its Public Acceptance[J]. Transport Policy, 2013, 27(2): 39-52.

[12] Feng S W. Performance Evaluation of the Private Car License Auction in Shanghai from the Historic Events[J]. Mechanics in Engineering, 2015, 37(3): 452-456.(in Chinese)

[13] Feng S W, Li Q, Xu D. The Private Car License Plate Auction in Shanghai: Macro-Effectiveness and Micro- Mechanisms[C]// American Society of Civil Engineers. CICTP 2012: Multimodal Transportation Systems. Reston: American Society of Civil Engineers, 2012:118-129.

[14] Shanghai Municipal Government (SMG). Shanghai Metropolitan Transport White Paper[M], Shanghai People's Publishing House, 2002 and 2013. (in Chinese)

[15] Feng S W, Li Q. Evaluating the Car Ownership Control Policy in Shanghai: A Structural Vector Auto-Regression Approach[J/OL]. Transportation, 2016.

[16] Lin C, Feng S W. Behavior Analysis on Shanghai Private Car License Auction Market with Statistical Learning Methods[J]. Journal of Transportation Systems Engineering and Information Technology, 2014, 14 (3):221-226. (in Chinese).