

The Implementation and Welfare Effect of Vehicle Quantity Regulation Policy: A Case Study of Beijing Vehicle Quota System

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Abstract

The quantity regulation of license plates for small passenger cars is a typical public policy of government intervention in transportation market. The goal of the policy is to control the number of vehicles in a region, with the main purpose of controlling the growth rate of small passenger cars and reduce traffic congestion. This paper takes Beijing as an example to analyze the implementation effect and welfare effect of the vehicle quantity regulation. The analysis results show that the policy implementation is different from Singapore. It can control the rapid growth of small passenger cars in a city from a macro perspective, but it cannot control the growth of vehicles on the road for a city, so it is limited to reduce traffic congestion. On the other hand, the policy of controlling the number of small passenger cars will bring a series of welfare losses. In this regard, this paper puts forward suggestions of improving policy design, increasing supporting policy measures, strengthening urban public transport construction and changing residents' travel mode to enhance the implementation effect of the policy.

Key words: Vehicle quota system; Regulation by quantities; Policy implementation effect; Welfare effects

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INTRODUCTION

As China's economy and society continues to develop rapidly, demand for passenger cars is vigorous, and small passenger car holdings continue to be a fast growing trend. In 2015, the total number of private small passenger cars exceeds 124 million, with 31 cars per hundred households. New car registration of up to 23.85 million, has a net gain of 17.81 million cars, which are the highest level in history. The traffic trip structure has changed radically. For example, the ratio of cars in motor vehicle has been increased rapidly, the ratio in recent five years has increased from 47.06% to 61.82%, and the mass motorized trip mode has undergone the transformation from motorcycle to car. There are 40 cities with more than one million cars per city in China. And 11 cities' car holdings are larger than 2 million. They are Beijing, Chengdu, Shenzhen, Shanghai, Chongqing, Tianjin, Suzhou, Zhengzhou, Hangzhou, Guangzhou and Xi'an. Urban road congestion has become one of the important issues in our city's urban development. In this regard, local government departments issued relevant control policies, such as lines of control policies, vehicle quantity regulation and so on. Among them, the vehicle quantity regulation policy is more controversial. The policy of "vehicle quantity regulation" is aimed at the control of small passenger cars with 9 persons or less. Through the control of the number of plates issued, the policy can limit the rapid growth of the annual vehicle population. At present, seven cities in China implement the vehicle quantity regulation policy for small passenger cars, namely Shanghai, Beijing, Guiyang, Guangzhou, Tianjin, Hangzhou and Shenzhen. These cities determine a certain amount of license plate issuance per year for small passenger cars, and distribute the license plate through a specific mechanism. There are mainly three issuance modes: lottery mode, auction mode and lottery-auction mixed mode.

Actually, China is not the first. In the early 1990s, some countries have adopted the quantity regulation

policy of small passenger cars to deal with the problem of road congestion, most typical of which is urban Singapore. This has also attracted some scholars who study public policy. Their research on the quantity regulation of small passenger cars mainly focuses on three aspects: policy effect, efficiency and welfare comparison. In terms of policy effects, there are mainly positive and negative effects. The positive effect on society is relatively simple. Anthony (1996) proved that the control regulation on the number of small passenger cars mitigated the growth rate of small passenger cars in the short term, and Seik(1998) showed that the number of small passenger cars was effectively arrested. But the policy has had a negative impact through other channels. Phang (1993) argues that Singapore's policy of controlling the number of small passenger cars promotes rent-seeking and speculation. Chu and Goh (1997) argued that the policy increased the license price of small passenger car, because the economic impact and limited supply of license as well as the intervention of automobile distributors would affect consumers' auction strategy and price. Koh (2003) studied the impact of the vehicle quantity regulation policy on the market structure of the auto distribution industry in Singapore, and found that the market concentration degree of distributors with high market share increased steadily, and the oligopoly monopolistic operation pattern of different goods appeared. Seik (1998) argued that Singapore's "vehicle quota" system raised the total price of buying cars and reduced residents' access to small passenger cars. At the same time, CHU s. (2015) further studies pointed out that the high cost of car purchase actually increases the frequency of people using passenger cars.

In terms of efficiency and welfare comparison, some researches mainly compare the welfare and efficiency of price regulation and quantity regulation. According to Smith (1997), under imperfect information, the demand curve is uncertain. If the real demand is greater than the predicted demand, the welfare loss of price regulation is greater than the welfare loss of quantity regulation, that is, quantity regulation is more efficient. By constructing demand function for small passenger cars, Chu s. (2012) used the data under different quantity regulation modes in Singapore from 1991 to 1998 and from 2002 to 2011, and concluded that open auction and diversified license plate issuance are relatively efficient. Muthukrishnan (2010) analyzed from the perspective of welfare economics and concluded that compared with the quantity regulation policy of small passenger cars, the social welfare of imposing taxation (such as road charge, congestion charge) is much lower. So the existing quantity regulation policy was better. In the efficiency study mentioned above, when the welfare losses of quantity regulation and price regulation are compared and analyzed, there is no discussion on the different slope of the cost curve and the demand curve of small passenger cars, and data support is

also lacked, which will eventually lead to the difference of welfare loss comparison and lack of certain rigor.

There have been a lot of discussion on the issue of the quantity regulation of small passenger cars in some major cities in China. There are two types of opinions. Firstly, they support the quantity regulation policy. Rao xuyong (2011) argues that as far as the current situation of Beijing is concerned, the lottery is better than the congestion fee, road construction, traffic restriction and auction policies. This phenomenon also appeared in S.CHU (2015) 's analysis of Singapore brand control policy. That is to say, auction increases the cost of car purchase and encourages customers to use cars more than before, which makes congestion even worse. Xuan changyong (2013) believes that lottery and auction are not the mechanism to maximize social welfare, but lottery are preferable and sub-optimal than auction. The auction makes the road right more inclined to the rich and lacks fairness. However, there are two major problems of lottery: the low bid rate and the phenomenon of abandoning the mark. Second, some scholars hold negative attitude to quantity regulation policy. For example, from the perspective of law, Jie-jun Yang (2013), Liu Fangliang (2014), Chen Junfeng (2015) all agree that the vehicle quantity regulation policies and procedures are unfair. It violated the constitution, property law, other state laws, private property rights and deprived the rights of people to buy car, also restrict sellers' right of legitimate business. On the other hand, from the perspective of economic efficiency and fairness, Fan liangcong (2015) believed that the quantity regulation of small passenger cars would affect the decision-making of market subjects, distort the allocation of resources and reduce the allocation efficiency. He suggested that the right of way should be stripped from license plates and the right of way auction market should be constructed. Sun rong et al. (2014) pointed out that there is inequality in "lottery", and the existing policy will lead to invalid resource allocation, which will have a negative impact on the economy. In the welfare analysis, it is not clear which aspects are included in the welfare loss. In the effect analysis, the effect analysis of congestion control is not studied.

1. CASE: IMPLEMENTATION EFFECT OF VEHICLE QUANTITY REGULATION POLICY

1.1 The Vehicle Quota System in Beijing

In 2010, Beijing promulgated the "interim regulation of small passenger cars quantity", which made corresponding provisions on the vehicle purchase quota, regulation methods and regulation subjects. Details are as follow.

(a) the car registration for a total number is 240000 in 2011, 20000 a month on average. The individual quota

share was 88 percent. Operating small passenger car quota accounts for 2 percent; Institute and others quota account for 10 percent.

(b) the vehicle registration qualification needs to obtain through the lottery once a month. The process is to apply for lottery qualification code, and obtain the lottery opportunity after being qualified. The quota administration conducts a lottery on the 26th of every month. The individual or organization who obtain the registration qualification should complete the registration within 6 months.

(c) there are three types of people could have the lottery qualification. local residents and the residents who hold the city's work and residence permit, as well as those who have paid tax in Beijing for more than 5 years and have the certificate of tax payment.

During the implementation of the policy, the number of residents participating in the lottery far exceeded the quota, and the rate of winning the lottery was getting lower and lower. In 2013, the Beijing Municipal Government revised the "interim regulation on the quantity control of small passenger cars". As of 2016, the major changes in the lottery mechanism mainly include the following three aspects: The first is to set the ladder winning rate, that is, the winning rate of the participants with different number of shaking numbers is different. Applicants who participated in the lottery 6 times were the first step, and the winning rate was the benchmark winning rate. Each time you participate in the 6th advanced level, the winning rate is the corresponding multiple of the benchmark winning rate. The second is to cancel the new indicators for the official vehicles of the organs and institutions. Third, in terms of quota allocation, the ratio of new energy vehicle indicators is close to the ordinary indicators, and the new energy vehicle indicators can be directly obtained.

1.2 Quantity Regulation Effect

Since the implementation of the quantity regulation policy in Beijing, it has been implemented for nearly 8 years. In order to analyze the effect of the quantity regulation of small passenger car licenses in Beijing, we use the counterfactual analysis method for analysis. We use the actual data before the implementation to predict the number of passenger cars under the assumption that the policy is not implemented. Specifically, this paper conducts a gradual multivariate linear regression of Beijing traffic data when the 1989-2009 policy is not implemented, and obtains a passenger car demand model. Then we use this model to predict the quantity of Beijing's passenger car in the six years of 2010-2016. The number of passenger cars is compared with the actual amount of car possession.

In the variable selection, we select the annual private

car ownership increment as the explanatory variable, indicated by G_NUM. Because of the policy setting of the number control of small passenger cars in Beijing, the main limitation is the number of private passenger cars, and the annual increments are controlled. Simultaneously selecting the increment of the quantity as the explanatory variable can avoid the autocorrelation problem of the interpreted variable. The explanatory variables are mainly factors affecting the increment of small passenger cars, respectively, disposable income (indicated by PICOM), population increment (indicated by G_POP), fuel price index (indicated by DI), road construction (using ROAD) and so on.

Table 1
Regression Results of the Incremental Demand Model of Private Small Car Ownership

	(1)	(2)
	G_NUM	G_NUM
PICOM	0.0016*** (0.000)	0.0018*** (0.000)
G_POP		-0.0398 (0.136)
DI		0.0191 (0.847)
ROAD		-0.0011 (0.508)
_cons	-3.7773* (0.015)	-2.8889 (0.815)
N	20	19
R ²	0.915	0.929
F	193.7409	45.5563

P-value in parentheses, $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Beijing Basic Database of Macroeconomic and Social Development <http://43.254.24.2/ww/MenuItemAction!queryMenu>

Then we use the regression model above to predict the number of private passenger car ownership under unlicensed conditions in 2010-2016. The final results are shown in Figure 1 below.

According to the forecast data, the actual and forecasted holdings of private passenger cars in Beijing from 2010 to 2016 are both on the rise. However the actual holdings are lower than the forecasted holdings, and the gap is gradually widening. As of 2016, the number of private passenger cars in Beijing remained below 5 million. In 2010, there was also a situation where the predicted number of private cars was less than the actual number. This was because the Policy was implemented on December 23, 2010, and the policy information was leaked in advance. In order to avoid the difficulties in registration, residents bring forward their consumption schedule. In the consumption plan of 2010, the sales volume in 2010 was affected by the upcoming policy, and the future consumption of the automobile market was overdrawn in 2010, so that the actual number is greater than the predicted number.

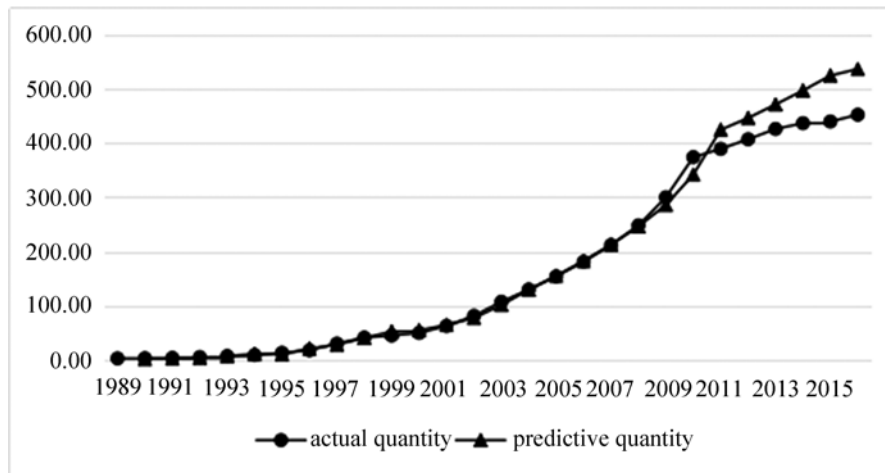


Figure 1
The Actual and Predict Number of Private Passenger Cars in Beijing 1989-2016.

From the above analysis, the vehicle quantity regulation can greatly control the growth of the number of passenger cars and reduce the pressure on road traffic. However, according to actual research, there are not only Beijing-brand vehicles but also out-of-town licensed vehicles on the roads in Beijing. This is also different from Singapore. That is to say, as a city-type island country, Singapore's regulated area is the whole country, and the overall domestic vehicle can be indirectly controlled by the quantity control. However, in China, taking Beijing as an example, after implementing the vehicle quantity regulation policy in Beijing, many Beijing citizens went to other provinces and cities, such as Tianjin and Hebei, to apply for other cities' licenses. This causes the vehicles on the road to not be reduced due to the control of the Beijing brand. At the same time, the relevant government has increased the cost of regulation, which requires additional policies to restrict the movement of out-of-town licensed vehicles in Beijing. Loss of efficiency in quantity regulation.

1.3 The Traffic Congestion Governance Effect

The mechanism of traffic congestion is very simple. When the road traffic density exceeds the road capacity in a certain period of time, the entry of the marginal vehicle occupies the road driving space, which reduces the driving speed of the vehicle on the original road, thereby increasing the time it takes for all vehicles to pass the section of the road. Considering time spending on road as cost, the increasing of time mentioned above can equal to the increase of private marginal cost and synchronously the marginal cost of society increasing. Of course, the social marginal cost is greater than the private marginal cost. We use the road supply and demand model shown in Figure 2 below to analyze the mechanism of the quantity

regulation policy. Here, the horizontal axis represents the traffic density, indicating the degree of traffic congestion, and the vertical axis represents the cost benefit. MSC is the social marginal cost under certain road traffic, MPC is the private marginal cost under certain road traffic, and the D curve represents the marginal benefit curve of residents under certain road traffic, that is, the demand curve for traffic density. The state of the area to the right of point A indicates the state of traffic congestion, and the more congestion to the right. As can be seen from the figure2, point A is the Pareto equilibrium point of the whole road, point B is the private marginal cost equal to the private marginal benefit curve, and the right side of point B indicates that if the marginal vehicle continues to enter the road, it will cause serious congestion, giving Private brings negative effects.

Now assume that the state of a congested section is point B. Except for the vehicle quantity regulation, no measures are taken. To reduce congestion, it is necessary to reduce the traffic density and move point B to the left. According to the above analysis, under the quantity control, our national vehicle licenses will increase at a steady rate, but actually road traffic density is not controlled by this policy. Because the road resources is limited, the number of vehicles carried on the entire road will only increase with the growing car quantity, and the points in the figure will not be moved to the left. However, on the other hand, they will also not move to the right quickly, because the total amount of vehicles is controlled. The number of vehicles on the road will just be less than the total number of vehicles. That is, the degree of congestion will not continue to increase. Therefore, in theory, civil vehicle control can keep traffic congestion steady without rapid deterioration, but the effect of reducing traffic congestion needs further study.

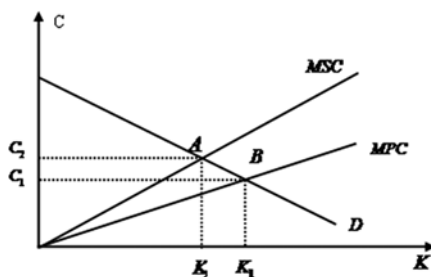


Figure 2
Road Resource Supply and Demand Curve

The above analysis can be verified from the traffic condition of Beijing where the quantity regulation policy has

implemented. This paper mainly uses the vehicles speed in road network to measure traffic congestion effect in Beijing.

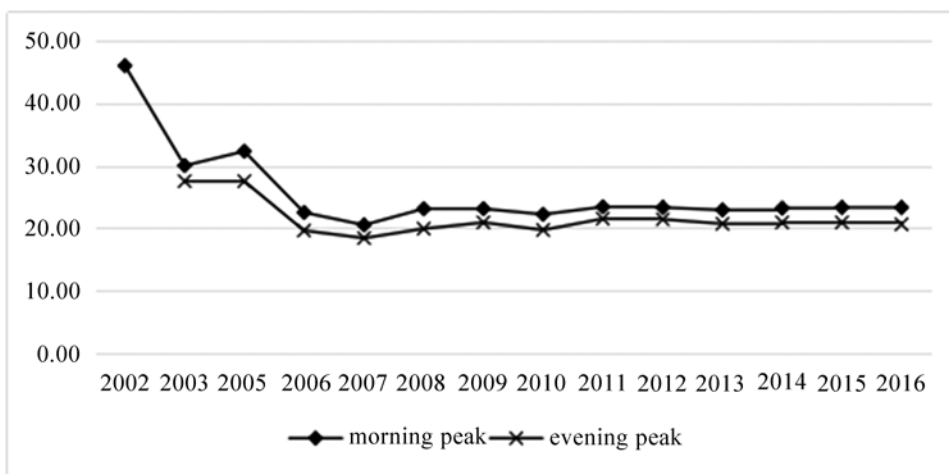


Figure 3
Average Speed of Morning and Evening Peaks of Beijing's Main Road From 2002 to 2016

Source: Beijing Transportation Development Research Center Traffic Development Annual Report

It can be seen from Figure 3 that the average allowable speed value of main road in Beijing urban area has been decreasing year by year from 46km/h in 2002, and it has been around 20km/h from 2006 to 2016. After the implementation of the vehicle quantity regulation in 2010, the speed has rebounded slightly, but it is still around 20km/h, indicating that the policy can stabilize the degree of traffic congestion and prevent traffic congestion from continuing to deteriorate, but it cannot reduce the congestion.

All of the above is an analysis of a certain section of one road. As far as the entire city is concerned, not all road sections will be congested. From the perspective of space, there are often traffic jams in the busy sections of the main city, commercial centers, etc., often showing the urban-rural dual structure. On the other hand, the peak hours of commuting are the most serious period of traffic congestion. The quantity regulation is only a macro-control of the total amount. It is impossible to control the number of vehicles passing through the congested road, nor can it regulate the distribution of vehicles during the peak hours of commuting.

2. ANALYSIS OF THE WELFARE EFFECT OF THE QUANTITY REGULATION OF PASSENGER CARS

Based on the above-mentioned road supply and demand model, this paper analyzes the welfare effect of the quantity regulation of small passenger cars, and theoretically analyzes the existence of welfare losses in existing policy and the actual situation of policy implementation to cause the loss of welfare. According to the analysis of the second part, the quantity regulation can not make the equilibrium point B move to the left. At this time, the welfare loss caused by the congestion cannot be reduced, that is, the area of the triangle DBE does not change. However, the implementation of the control of the number of passenger cars will increase the cost of the entire society, and the marginal social cost curve will move up. At this time, the social equilibrium point moves from E to D'. Then the social welfare loss increases, and the added portion is the area of D'D'E. The main causes of this additional social welfare loss include the following four aspects.

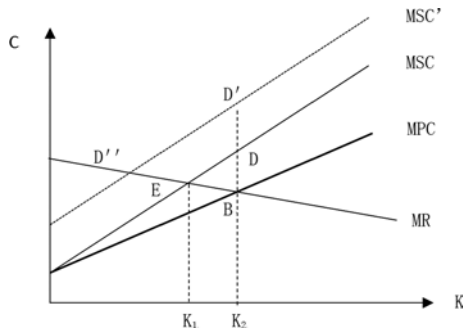


Figure 4
Road Supply and Demand Model

First, the policy generates additional car purchase costs. The quantity regulation policy encourages a large number of consumers to buy cars and register in some other countries, such as going to Hebei, which requires more, extra energy, time and capital costs. This also breeds the illegal trading market for license plates. In order to meet the demand for self-driving travel, many unqualified customers purchase or rent a license plate registration qualification under the name of others to achieve the purpose of purchasing a car. Not only does the purchase transaction cost increase, but vehicle ownership cannot be obtained. What is more serious is that if a traffic accident or other rights and responsibilities accident occurs, both the user and the vehicle registrant will face different degrees of risk. For example, the vehicle ownership registrant will have an economic dispute liability accident, the vehicle is likely to be seized and auctioned.

The second is to increase the cost of government regulation. The management cost of regulating cars from other provinces has increased. Beijing has a policy of restricting cars from other provinces in the city center. The quantity regulation in Beijing prompts residents to buy cars from other countries, this directly increase the number of out-of-town vehicles in Beijing. The traffic management department needs to invest more manpower and material resources to manage the vehicles from other provinces. In particular, some citizens also take risk in the restricted time period. Sometimes, in order to avoid management, traffic accidents are prone to occur. Then, there are a large number of illegal and counterfeit behaviors, which increases the difficulty and cost of monitoring by government.

The third is the loss of consumer surplus. Restricting consumer purchasing rights will cause social welfare losses. First of all, consumers always have the demand for car purchases, because the current punctuality rate, speed, frequency of departure, route coverage, and convenience of public transportation have not reached the level of replacing passenger cars. So the public transportation cannot meet consumers' travel requirement. There must be a demand for car purchase. Therefore, the small passenger car quantity regulation policy will bring about three aspects of social welfare losses: (a) The decline of

travel experience and quota allocation directly deprive consumers' right to purchase, which will inevitably result in loss of consumer surplus. (b) The loss of other life experience utility. Since the right to purchase is deprived, in the case of quota allocation, the quota is distributed randomly. In order to avoid the risk of no car in a long time, the car purchase plan is brought forward. Consumers need to spend a certain amount of energy, time, and money to participate in the lottery. And their investment in other life activities would be reduced. This increases consumer surplus losses. (c) The waste of social resources. In order to increase the probability of winning, usually all members of the entire family will participate in the lottery, which leads to a decline in the success rate and also caused resource losses.

The fourth is to generate rent-seeking costs and corruption. Many citizens have been unable to obtain registration qualification for a long time, or they are unwilling to spend time and effort on a small probability event. It is very likely that they will seek the internal staff of the policy introduction department in order to obtain license plates through internal operations. This will inevitably lead to government officials accepting bribes and conducting unfair violations. The time, money, manpower and material resources spent during this period must be a big cost behind the policy.

CONCLUSION

From the above analysis, the implementation of the vehicle quantity regulation can indeed alleviate the deterioration of traffic congestion, and can promote the upgrading of the automobile industry, change the concept of people's travel, and stimulate the rapid construction of public transportation, but it still cannot be ignored that there are series of negative effects and additional social welfare losses. But why do most cities still choose the vehicle quantity regulation policy? We have found that the selection of small passenger car volume regulation policies in some cities in China has its specific subjective and objective conditions. Subjectively, the government departments hope to control the number of small passenger cars quickly and accurately, so as to avoid a significant increase in the difficulty of future traffic management. Objectively speaking, it is the current urban planning and development. The government still lacks new traffic management plan with high innovation and high intelligence, and the cost is too high, including much the manpower and material resources. If we consider the effect of price regulation, we will find that there will be more welfare losses in price regulation. Under the existing resource endowments in Beijing, price regulation will also bring welfare losses, which needs to combine the economic status of Beijing and China. Further in-depth comparative analysis.

From the perspective of public choice theory, the government will take into account the interests of the government, individuals and related interest groups in the process of intervening in the growth of the number of passenger cars in Beijing. Relatively speaking, the vehicle quantity regulation is currently a sub-optimal choices. What is most needed at present is to optimize the rule “interim regulation of small passenger cars quantity”, and to shift the simple restrictions to deregulation. The government should adjust policies according to economic, political, cultural and other dynamic variation of society and then introduce corresponding supporting policies. Based on international experience, actual conditions and our research, this paper proposes the following policy recommendations.

(a) Optimize the application conditions for consumers. In order to balance the car consumers and car-free consumers, and to improve the existing congestion situation, the qualification requirements should change. For families with more than two cars, one of them can directly obtain the update index, and the rest which need to be updated should obtained by lottery. Or the government can set duration for all license plates like Singapore and consumers will need to application again at the end of qualification.

(b) The tradable mechanism of license plate or passage right. As a policy to control traffic congestion, it should be able to solve the problem at present and foresee the problems then governance those problems advance. What needs to be managed now is to reduce congestion on the road in the center of the city and avoid the “tragedy of the commons”. Therefore, it is feasible to separate the right of passage from the license plate for regulation. For example, the limit line itself is also a kind management of the right of passage. The right of passage can be divided into different types, combined with the traffic capacity of each area, and distributed according to a certain amount for the travellers of different needs. Under the premise of one person one car or one household one car, the government could allow legal trade of the original stock license and the new license of the lottery. Then eliminate distortion of registration allocation.

(c) Alleviate the city’s pressure and establish a multi-core integrated commercial body. At present, the Beijing Municipal Government has gradually moved the administrative center to the east, but correspondingly, it is necessary to develop a multi-core commercial center to evacuate the commercial functions of the city instead of transferring congestion from one place to another.

(d) Improve intercity traffic, urban public transportation and sharing economy. Public transportation is a shared transportation resource provided by the government. It needs to be combined with urban planning to achieve seamless conversion between various public transportation (intra-city rail transit, inter-city rail

transit, buses, public bicycles). It also need to provide vehicle parking lot around transportation junction in the commercial center to facilitate self-driving travellers to change travel modes. Another solution is to open a special bus-only passage on the main road; increase the number of bus trips in the central business district; and reduce the transit time between the central business districts through planning. It is important to make public transportation gradually become the best choice for commuters. So it is necessary to accelerate the construction of inter-city public transportation, and reduce the pressure from the out-of-town cars. In order to improve the utilization rate of each passenger car, it is efficient to advocate sharing travel. At the same time, we should strengthen the supervision of network car service system to enhance the safety of the network car, and then promote the consumption of shared vehicles by consumers.

(e) Gradually establish the intelligent transportation system. In order to manage the right of passage in the future, such as collecting road congestion fees, parking fees, etc which need to be supported by high intelligence systems. Labor is not only costly but inefficient. And the intelligent transportation system can provide real-time traffic information for the travellers, which is convenient for drivers to adapt to local conditions and flexibly adapt to changes in traffic conditions. Therefore, the development of intelligent transportation is not only the trend, but also the key point of city development.

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