# Car Ownership Choice Analysis under the Vehicle Quota Restriction Policy: A Case Study of Guangzhou

**Jun Li[1], Pinjie WU[1], Wenna ZHANG [1]**

[1]*School of Engineering, Sun Yat-sen University, Guangzhou, China*

**ABSTRACT**

Guangzhou is the fourth city in China to implement vehicle quota restriction policy and the first one adopting a new vehicle quota system. Guangzhou does not restrict the uses of non-local vehicles, so that the residents can use the private cars registered outsides of Guangzhou. This paper firstly presents the choices of residents to obtain licenses, and then a detailed analysis on the use of the non-local vehicles in Guangzhou is presented. The SP surveys are conducted to investigate residents' preferences when facing risks, such as the potential restriction policy to non-local vehicles, and the scenarios analysis basing on the multi-level nested logit model is presented to forecast the choice behaviours of car ownerships. It is found that Guangzhou residents have low perceptive value of a local license and prefer to the lottery, due to the current policy and the inherent pragmatic characteristics of Guangzhou residents; they also show risk aversion attitudes to the policy of restriction to non-local vehicles and are very sensitive to the policy. The new vehicle quota system demonstrates quite moderate impacts on traffic conditions of Guangzhou, and the policy is flexible to adjust the quota of three ways to obtain the licenses.

**Keywords:** Car ownership; Vehicle quota restriction, Choice analysis, Risk analysis, Metropolitan region

## INTRODUCTION

In past decades, many cities have experienced the unprecedented development of urbanization and motorization, which leads to traffic problems and environmental problems. It is generally accepted that the uncontrolled development of car ownership actually violates the principle of the sustainable transport development which implies finding a balance between (current and future) environmental, social and economic qualities ([1]). In such a situation, intervention policies are needed to ensure meeting needs of the present generation without compromising the needs of the next generation ([2]). A combination of policies also help to the development of sustainable transport and among that economic policy always play a significant role in it ([3]).

From the sustainable perspective, traffic demand management are required to address negative consequences that are internal to the transportation system ([4]). The traffic demand management can be classified into four categories: physical changes, economic policies, legal regulations and cognitive motivational approaches ([5]). The physical changes may refer to the improvement of the public transportation to make it more attractive and the technical improvement to make cars more energy-efficient. The economic policies are the most common seen in urban transportation management, including command-and-control policies and incentive-based policies ([6]). Command-and-control policies are easy to enforce by imposing some regulations and standards to driving activity. While incentive-based policies are more cost effectiveness measures which use financial measure as incentives to modify residents' behaviours. Legal regulations use forceful approaches to regulate driving activities. The cognitive motivational approaches aim to use communication and education to heighten residents' awareness and modify their behaviours.

To control the explosive increase and use of private cars in urban cities is an important step towards the sustainable transport development. Some cities have taken important steps towards limiting private cars registrations and their use in an effort to curb the worsening problem of the traffic congestion and air pollution. Among that, the most common used policies are incentive-based policies

which contain the price control and the quantity control. Congestion charge, parking charge and fuel tax are price control approaches. The vehicle quota restriction (VQR) policy is the best example of quantity control policy ([7]). It is a radical policy which aims to curb negative externalities of vehicles by limiting registrations of new vehicles. Singapore is the first city to institute the vehicle quota system to control the excess growth of automobile ownership. The policy sets a fixed number for vehicle registrations per year and residents have to bid for a license to buy a new car ([8]). This intervention policy on the growth of car ownership was also adopted by developing countries afterwards. The following section will give a detailed introduction of the VQR policy and its implementation by seven mega-cities in China.

Guangzhou is the fourth city to adopt the VQR policy while its policy designing is different from the former three cities. Being the third largest city in China, its bidding prices stay low for over two years comparing to other cities. This study aims to explore residents' reactions to the new VQR policy. Based on the statistics of the historical bid/lottery records and a stated preferences survey, this study would investigate residents' choice behaviours and their affecting factors. Specially, an analysis of non-local registered vehicles is made using traffic monitoring data gathered from multiple sources in Guangzhou. A license choice modelling is built to forecast residents' reactions facing risks. A comprehensive impact analysis of the VQR policy in Guangzhou is finally presented.

## HYBRID ALLOCATION POLICY IN GUANGZHOU

### The Implementation of the Restriction Policy

Considering the concentration of the population, residences and other functional areas, the private car is not suitable for being the predominant travel mode for the sustainable transportation development in China ([9]). Seven cities in China have launched the VQR policy to curb the explosive growth of vehicles. A similar auction system as Singapore's was implemented in Shanghai early in1994. And vehicles with non-local license plates were restricted from entering the elevated expressway in central areas during peak-hours. Unlike Shanghai, Beijing adopted a lottery system to allocate its licenses. Non-local vehicles are also restricted from entering road networks within 5th ring during peak-hours ([10]). However the lottery system might become an intensive to buy a car and then stimulate unnecessary car-purchasing demand ([11]). Given the efficiency of the auction mechanism and the equity of the lottery mechanism, it would make sense to combine these two mechanisms. Guangzhou is the first city to take a hybrid approach combining the auction and the lottery for licenses allocation. Following Guangzhou, Tianjin, Hangzhou and Shenzhen also adopted similar policy.

As the forth city to launch the VQR policy, there are two new features of the policy of Guangzhou. One is the combination of the auction mechanism and the lottery mechanism. The other is to group vehicles into three categories, namely new-energy vehicles, energy-efficient vehicles and normal vehicles. New-energy vehicles are free from the restriction policy. The allocation amount is 120,000 per year, among which 10% would be allocated to energy-efficient vehicles exclusively, 50% would be allocated to normal vehicles by the lottery and the remaining by the auction. The reserve price for bidders is RMB 10,000, but there is no limitation for the highest price. The eligible individuals would compete for the 88% of quotas and the rest are for organizations that satisfies the conditions. One year after the pilot run, the government announced that the policy becomes a formally long term regulation and would last for five years ([12]). Some adjustments were also made in this announcement to relax its conditions to applicants and vehicles.

It is to be observed that, different form policies implemented in other six cities, Guangzhou has no NLR policy, which raised much controversy on its obstruction to the policy. Because residents could choose to register non-local licenses for an alternative without waiting for a long time or spending much money.

### Observation on Residents' Bid or Lottery Behaviors

According to monthly allocation records on the website of Guangzhou passenger vehicle allocation management system, the lottery quota stably fluctuates between 5,000 and 6,000. But the amount of applicants to compete for the lottery keeps consistently increasing and has exceeded 0.2 million since January, 2014, which indicates a strong demand for local licenses. Figure 1 shows the amount of eligible applicants participating in the lottery and the success rate of each month during June, 2013 to

March, 2015. The success rate in this paper is defined as the proportion of eligible applicants who successfully got licenses. With the increasing amount of lottery applicants, the figures show a general decline in the success rate and it is about 2% in recent months. Moreover, less than one fifth of exclusive quotas for energy-efficient vehicles are applied each month.
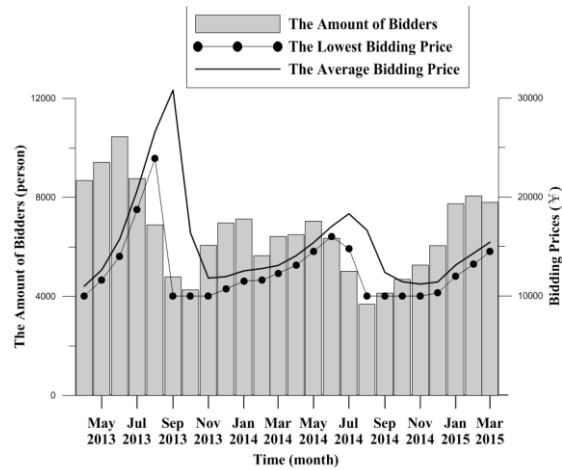


**Figure1.** *Amounts of Lottery Applicants and Success Rate*

Auction records of past two years imply that residents' bid behaviors are not so stable and show several meaningful features: The amount of bidders are far less than the amount of the lottery; Bidding prices stay in low level and show a high sensitivity to the NLR policy.
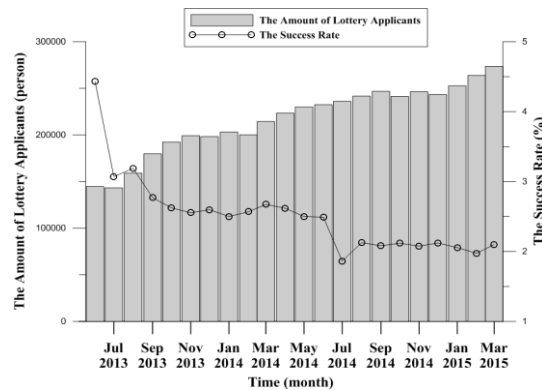


**Figure2.** *Amounts of Bidders and Bidding prices*

As can be seen in the Figure 2, the amounts of applicants choosing to bid for licenses are less than 10,000 in most of months while more than 100,000 persons participated in the lottery at the same time period. The low amounts of bidders actually reflect the pragmatic attitudes of residents in Guangzhou ([13]). It is natural preference for them to cautiously evaluate choices before the decision to see whether they are worthy. The pragmatic attitude can also be represented in low bidding prices. Average bidding prices of Guangzhou fluctuates between RMB 10,000 and RMB 15,000, which is a low level comparing to Shanghai, Shenzhen and Hangzhou. These four cities are moderately developed cities and share similar levels of GDP, the population, and the motorization, so the comparison indeed makes sense. Bidding prices in Shanghai exceeded RMB 10,000 more than ten years ago and stably fluctuates between RMB 70,000 and RMB 80,000 in recent years. Two auctions have just been held in Shenzhen since the introduction of the policy. The average prices are RMB 22,173 and RMB 14,565 separately which are higher than the average level of Guangzhou. In Hangzhou, the average bidding prices are not so stable and fluctuate between RMB 15,000 and RMB 40,000 which are still higher than Guangzhou.

What's more, the erratic fluctuations of bidding prices in the past two years and the amount of bidders represent residents' sensitivity to the NLR policy. In April, 2013, the Guangzhou Commission of Transport published a draft of the NLR policy which rapidly pushed the average bidding prices up to RMB 30,802. The soaring tendency lasted until October, 2013 when the mayor declared that Guangzhou would not implement any restriction to non-local vehicles unless the traffic congestion

was serious. As a result, the prices dropped sharply in the next few months. In April, 2014, the Guangzhou Commission of Transport confirmed that the restriction to non-local vehicles in peak hours would be implemented step by step at an appropriate time during 2015 to 2017([14]). Correspondingly, the prices rose consistently in the next several months. The drop in July, 2014 may due to the policy launched in this month to raise parking fees. By the end of 2014, Shenzhen announced to implement the passenger VOR policy, which led to an increase of the amount of bidders and bidding prices. Because residents cannot register the Shenzhen licenses for an alternative.

As there are more and more residents participating in the lottery, the amount of bidders and bidding prices are still strangely at a low level and have erratic fluctuations corresponding to policies. It may be attributed to the pragmatic culture in southern China, which leads to the pragmatic attitudes of residents and therefore affect their choices. Actually, their cautious choosing behaviours are closely related to low perceptive value to local licenses and sensitive attitudes to risks bringing by non-local licenses. More discussion on their behaviours and their reactions when facing risks will be presented in section 3.

### Operating Characteristics of Non-local Registered Vehicles

Actually, without the NLR policy, residents would naturally choose to register a license outside of Guangzhou. In order to obtain the accurate number of residents who use non-local vehicles and their impact to traffic conditions in Guangzhou, a detailed analysis of the operation status of non-local vehicles was made, using the data collected on the OpenITS platform during April, 2014 to July, 2014 ([15]). The OpenITS platform uses sensors to gather operation data of traffic condition.

Non-local vehicles were defined into three categories: transit vehicles, migrant vehicles and local-used vehicles. Local-used vehicles refer to vehicles registered outside of Guangzhou but long-term used within the city area. Considering the amount and operation characteristics, non-local vehicles, especially local-used vehicles indeed have significant influences on urban traffic.

**The amount of non-local vehicles increased sharply in these four months.** The total amount of three categories of non-local vehicles reached 3 million and increased 6.5% in four months which is higher than the increase rate of car ownership in Guangzhou. While the amount of local-used vehicles increased from 38,292 to 46,093 with an average monthly growth rate as 6.79%. Owing to the policy of Guang-Fo Unification which plans to form a Guangzhou-Foshan metropolitan region, a large number of residents commute between two cities every day, which makes Foshan be the biggest source of migrant vehicles. More than half of local-used vehicles were registered in Foshan and Shenzhen, because of their close relationship in geography, economics and politics.
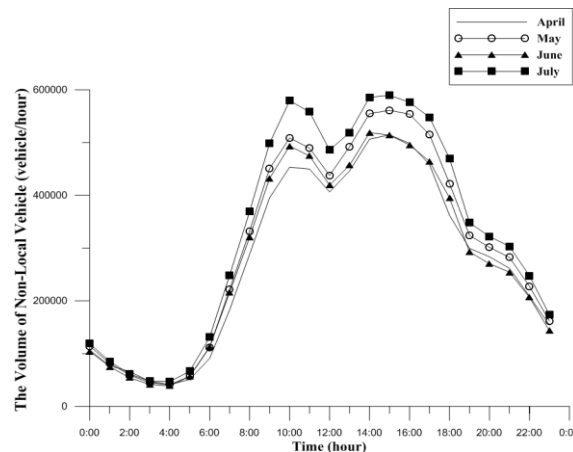


**Figure3.** *The Average Volume of Non-local Vehicles in Workdays*

**Local-used vehicles were mainly used in central city and had high operation frequency. Error! Reference source not found.** shows that the operation time of non-local vehicles was not limited in peak-hours and lasted from the morning peak to the evening peak. The total proportion of local-used vehicles and migrant vehicles to transit vehicles was 25%, but the operation frequency of local-used vehicles was more than ten times as transit vehicles. The operation frequency in this paper is defined as the catching frequency of vehicles by sensors. Spatially, local-used vehicles were mainly operated in central city area as being a contributor to traffic congestion in central city area.

Judging from the temporal and spatial travelling behaviours, non-local vehicles have great impacts on the traffic condition of Guangzhou. Without the NLR policy, some residents would naturally choose a non-local license. That's why all cities with the VQR policy have implemented the NLR policy, except Guangzhou. The NLR policy could play a role as the supporting policy to the VQR policy to ensure its effectiveness and the equity for residents choosing local licenses.

## STATED PREFERENCES SURVEY AND SCENARIO ANALYSIS

In this section, a quantitative analysis is performed to find out the affecting factors on residents' behaviour, and the relation of these exogenous variables and the endogenous outcome, the choice among bid, lottery, and non-local license. In particular, the analysis aims at residents' choosing behaviour under risks, which are: (1) R1 - waiting time exceeds desired limit; (2) R2 - auction price exceeds perceptive value; (3) R3 - restriction to non-local vehicles. A stated-preference (SP) survey was conducted to investigate how residents would make choices in hypothetical situations; a nested logit model was utilized to analyze the how residents would react when facing the risks due to the uncertainty of the policy.

### SP Survey

A total of 62 potential car buyers are sampled for the survey. The information collected includes: (1) demand urgency of using a new car; (2) desired waiting time for the lottery; (3) perceptive value of a local and a non-local license; and (4) the sequential choice when facing risks, e.g. a respondent who chose "bid", then she/he will be asked "what will you choose if the auction price exceeds your perceptive value?" then the respondent need to choose among "switch to lottery", "stay bid", and "switch to non-local license". It should be noted that this is a choice-based survey, where the number of respondents who choose bidding and non-local license was enlarged because their ratios are too small according to section 2. Some results of the survey are presented in the following tables and figures.

**Table1.** *Urgency of Using a New Car*

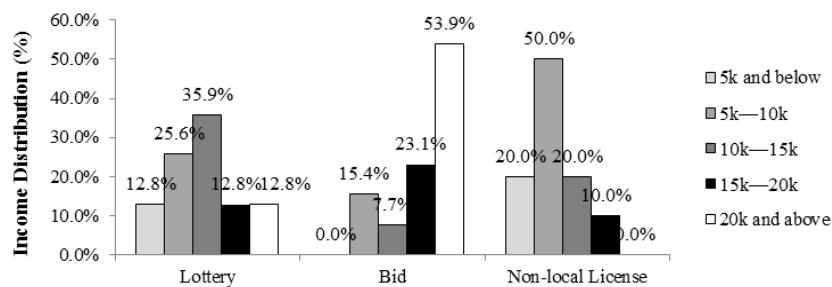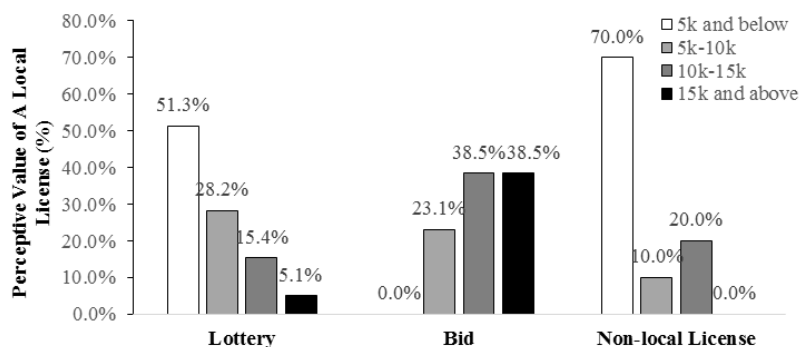| Urgency | Bid | Lottery | Non-local License |
|---------|-----|---------|-------------------|
| 1-2 | 0% | 5.2% | 10% |
| 3-4 | 0% | 7.7% | 40% |
| 5-6 | 15.4% | 33.3% | 10% |
| 7-8 | 61.5% | 35.9% | 20% |
| 9-10 | 23.1% | 17.9% | 20% |



**Figure5.** *Income Distribution*



**Figure6.** *Perceptive Value of A Local License*

**Table2.** *Sequential Choice when Facing Risks*

| Sequential Choices | Lottery | Bid | Non-local license |
|---|---|---|---|
| R1: waiting time exceeds desired limit, | 51.2% | 30.8% | 18.0% |
| R2: auction price exceeds perceptive value | 15.4% | 38.5% | 46.1% |
| R3: restriction to non-local vehicles | 10.0% | 80.0% | 10.0% |

Some interesting findings are as follow:

- Income and urgency are two most important factors: residents who chose bid and lottery have relatively higher urgency. And as analyzing income distribution, those who have relatively higher income chose bid, and those with lower income chose lottery.

- Urgency plays a more important role than income. When residents face risk R2, more proportion of them switched to non-local license than to lottery, which means they can use the car instantly. Similar for R3, 80% of them would switch to bid and only 10% to lottery, even though their incomes are relatively low, but the need of using a car prevails.

- Low perceptive value of a local license to residents: residents have low perceptive value of local license and they do not think the local license worth RMB 10,000. The reasons might be as follows: firstly the pragmatic characteristics of residents and they do not accept the bidding policy; secondly, the non-existence of the NLR policy, it seems unfair, and even foolish, for them to spend a fortune in bidding a local license.

- Lottery applicants seem to be the most patient and risk aversion. When face R1, more than half of them stay as the original optional, and they seem to be very patient when waiting for a free license. Another feature is the risk aversion, given that a non-local license could be a very risky option due to the highly potential of the implementation of the NLR policy. Only 18% switched to non-local license, it suggests that most of them seem to be risk aversion. From another point of view, their relatively low urgency explains their patience and risk aversion attitude.

- Non-local licenses choosers are the most sensitive to the NLR policy. 90% switch to other forms.

## License Choice Modeling

In order to quantitatively analyze residents' responses to policies, a mathematical model is built to predict how their behaviours change when facing potential policies. A multi-level nested Logit (NL) model is chosen to model residents' stochastic choosing behaviours of car license ([16]). The NL model classifies similar choices into one nest and hence to represent their shared but unobserved errors. The choices each resident faces can be concluded as nine options and the sequential choice that resident made in hypothetical situations is modelled, as shown in Table 3. When a resident buys a new car, the resident has to make a local/non-local license choice in the 2nd level; and if the choice is local, then the resident would face a 3rd level question: bid or lottery? For instance bid is chosen, then the resident might face a risk that the auction price exceeds her/his perceptive value, so the resident needs to make a sequential choice that in the 4th level. The short terms of alternatives and nests are provided in Figure 7.
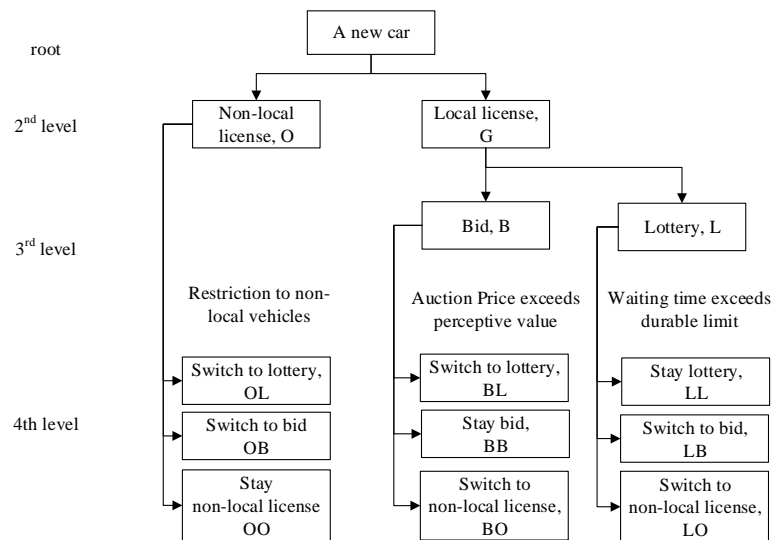


**Figure7.** *The Structure of a Multi-level Nested Logit Model*

Four types of attributes are included into the utility:

- Personal attributes: income, demand urgency to have a new car Ur;

- Cost: perceptive value of local license PL, perceptive value of non-local license PN, last month's bidding price PB;

- Time: desired limit of waiting time Td, the average waiting time Ta;

- Constant: inconvenience of not having a car C.

Combining the SP survey data, residents' behaviours considering risks are modelled in the 4th level. The risks are stated in Table 2, and their probabilities are stated as $P_1$, $P_2$, and $P_3$. These risks only affect the attributes of cost and time, and for the nine options they are shown in Table 3. There is a slight difference between PL and PN. Regarding PL, the hidden subtext is that "I do (not) consider the local license worth the auction price", it is the resident's willingness-to-pay price for the local license. As for the PN, it is the information they gather on "how much it costs me to have a non-local license", so it is close to the actual price. Once the risks become realized, residents have to accept the fact that they need to pay for the actual auction price or wait for the average waiting time.

The probabilities of risks are determined by the statistics on residents' auction and lottery choosing behaviours. As for the probability that the actual waiting time exceeds the desired limit,

$$P_1 = (Y - T_d) / Y \qquad (1)$$

where $Y = L/5000$, $L$ is the number of residents in the lottery pool, Y is the number of months to allocate licenses for all these residents.

As for the probability that the actual auction price exceeds the perceptive value of local license,

$$P_2 = N\{P_{Bj} \geq P_L\}/n, \ j = 1,...,n \qquad (2)$$

where $P_{Bj}$ is the average auction price of the $j$th month, n is the total number of months since the policy launched, $N\{P_{Bj} \geq P_L\}$ is the number of months that the actual auction price is not lower than $P_L$.

The probability that Guangzhou would launch restriction to non-local vehicles is set as 6/7, since it is the only one out of seven cities who launched license limitation policy without restriction to non-local vehicles.

**Table3.** *Alternative Options and Their Utilities*

| Nest | Alternative | Utility related to cost and time |
|------|-------------|----------------------------------|
| L | LL | $(1 - P_1) \cdot T_d + P_1 \cdot T_a$ |
| | LB | $(1 - P_1) \cdot T_d + P_1 \cdot P_B$ |
| | LO | $(1 - P_1) \cdot T_d + P_1 \cdot P_N$ |
| B | BL | $(1 - P_2) \cdot P_L + P_2 \cdot T_a$ |
| | BB | $(1 - P_2) \cdot P_L + P_2 \cdot P_B$ |
| | BO | $(1 - P_2) \cdot P_L + P_2 \cdot P_N$ |
| O | OL | $P_N + P_3 \cdot T_a$ |
| | OB | $P_N + P_3 \cdot P_B$ |
| | OO | $P_N + P_3 \cdot C$ |

## Scenarios Analysis

The choice-based SP survey results are used for estimation, and thus the weighted endogenous sampled maximum likelihood (WESML) is employed [17]. The actual number of population who chose non-local license is based on the findings of section **Error! Reference source not found.**.

The estimated model is used as a second step, which is based on the data collected in November (the month when the SP survey was implemented), to forecast the choosing probabilities of December for validation. The simulation method is used to generate synthetic population in order to forecast the future. Firstly the synthetic population is generated based on the empirical distributions (income, urgency, perceptive value, etc.) of the three different groups of residents, where these empirical distributions are based on surveys and historical statistics. Then for each simulated resident, his/her

probabilities of choosing the three options are calculated using the estimated model. At last all the residents' choosing probabilities are aggregated to calculate the whole population's choosing probabilities of the three choices.

At last, three scenarios with the estimated model and the synthetic population were tested. Three nests are built and a total of nine alternatives are analyzed. Results in **Error! Reference source not found.** suggest that the proposed method reproduces the desire results which approximate the reality. The forecasting data provides us quantitative information, especially how residents' behaviours change after launching the restriction to non-local vehicles. However from the scenario 1 the model suggests that residents switch from bid to lottery, which is different from the SP finding. Because the scenario tested here is not only "exceeds their perceptive value of local license", but twice of the initial auction price, then the "low perceptive value of local license" may prevail "urgency" and dominate residents' behaviours. It also indicates that residents are more monetary sensitive than risky sensitive facing too high bidding prices.

**Table4.** *Results of Three Scenarios*

| | Choosing Percentage (%, Lottery: Bid: Non-local license ) |
|---|---|
| Actual choosing percentage in December | 96.00 : 2.40 : 1.60 |
| Forecasting by the estimated model with the data collected in November | 95.69 : 2.75 : 1.56 |
| Scenario 1: auction price higher than 20,000 RMB | 97.81 : 0.59 : 1.60 |
| Scenario 2: #L increases by 50% | 92.70 : 5.17 : 2.13 |
| Scenario 3: restriction to non-local vehicles | 95.60 : 3.44 : 0.96 |

## DISCUSSIONS

Guangzhou implemented the VQR policy in 2013. After approximately two-year's implementation, there is a need to evaluate how the restriction policy actually affects traffic conditions of Guangzhou and how residents response to it. In order to answer these questions, a comprehensive discussion from perspectives of the traffic conditions, residents, policy makers and the sustainable transport development is made. In general, the VQR policy in Guangzhou demonstrates a moderate impact.

Technically speaking, the impact is not so significant on traffic conditions. The policy actually slows down the growth speed of car ownership of Guangzhou. The growth rate of passenger vehicles dropped from 17.8% in 2011 to 4.8% in 2013, with a monthly decrease of more than 10,000 new-car-registrations. On the other hand the traffic conditions have no significant improvement. Table 5 gives the average speed of arterials and minor arterials of whole day and evening peak separately during 2012-2013. There is no significant difference of average speed on arterials and minor arterials after the implementation of the policy. Moreover, without the NLR policy, the number of non-local vehicles used by local residents rises sharply in the observation period.

**Table5.** *Average Speed of Arterials and Minor Arterials in Guangzhou (km/h)*

| Time(year) | 2012 | 2013 | 2014 |
|---|---|---|---|
| Whole Day | 33.93 | 34.17 | 33.60 |
| Evening Peak | 30.78 | 31.41 | 30.96 |

Residents' reaction to the policy is also moderate comparing to other six cities. The two-year implementation of the policy actually represents some interesting issues of residents' reaction and behaviours:

**The Demand for New Cars is Still Strong:** the total amount of lottery applicants and auction applicants are stalely increasing, especially the lottery applicants. The increase of non-local vehicles in the city can also explain the strong demand for owning a new car.

**Residents Show Strong Patience to the Lottery and Low Enthusiasm to the Auction:** firstly, residents seem to be very patient with the lottery even though facing long waiting time. In section 3, the choosing percentage of the lottery is above 90% in all three scenarios and has low switch rate. Secondly, the amount of auction applicants was less than 10,000 in most of months. Last but not the least, residents have low perceptive value to local licenses and the bidding prices always stay in a low level comparing to other cities. In some months, the bids even dealt at the reserve price.

**Residents are Sensitive to the NLR Policy and Show Risk Aversion Attitudes:** the fluctuations of bidding prices and the amount of auction applicants are significantly corresponding to the attitude of administrations to the NLR policy. As there was a tendency to launch the NLR policy, the bidding prices and the amount of auction applicants increased. Otherwise they dropped. If the NLR policy was launched, 90% of residents who initially chose non-local licenses would switch to other two options. Their sensitive reactions are owing to their risk aversion attitudes.

Residents' reactions are closely related to the pragmatic culture in Guangzhou. It is inherent characteristic for Guangzhou residents to carefully weight options before the decision. The existence of almost free licenses leads to their low perceptive value of local licenses. Most of them prefer to count on the luck instead of making an unworthy deal in the auction. Nevertheless, residents show risk aversion attitudes when facing risks. They are very sensitive to the restriction policy to non-local vehicles. As mentioned before in scenarios analysis, the launch of the NLR policy would push most of them who initially chose non-local license to switch to the auction.

From the perspective of policy makers, it is a cost-effective policy in policy designing. Firstly, it takes account of the efficiency and the equity at the same time. Guangzhou is the first city to take the hybrid approach which divides residents into two groups: one is for residents who have urgent demand to get a license as soon as possible and could choose to bid for a plate; while the other is for those who are not so in a hurry and could wait for the lottery. Residents could make choices according to their demand urgency and income level when registering a new car. But the quota ratio needs deep consideration so as to achieve the best effectiveness in the allocation. Secondly, the policy slows down the growth speed of car ownership and gains time for the development of public transportation system. Thirdly, the policy earns funds for the improvement of public transportation system. By June 2013, the auction income of Guangzhou was more than 1.3 billion and all of them were used in the public transportation development of the city.

There is a growing controversy over no restriction to non-local vehicles in Guangzhou. Considering the increasing amount of local-used vehicles which were registered outside of Guangzhou, the supporters of restriction policy argue that it would make the VQR policy inefficient and violates the principle of fairness. Considering residents' choice behaviours to non-local vehicles, there is no doubt to implement restriction to non-local vehicles would support the current policy technically, but the administrations' attitudes to the NLR policy has changed several times since 2013, which led to the fluctuations of bidding prices and the amount of auction applicants. Actually, the decision to limit non-local vehicles is not only related to the traffic system but also the development of the whole region. As Guangzhou is the capital city of the province, it has promoted to form a Guangzhou-Foshan metropolitan region and the integration of Pearl River Delta for many years. So the decision should be under consideration before its launch in case of setting the traffic barriers for nearby cities.

## CONCLUSIONS

The new vehicle quota restriction policy of Guangzhou has demonstrated the diverse impacts on the traffic condition and car ownership. Considering the distinctive culture of the city Guangzhou, China, there are some interesting issues needed to be investigated. This paper focuses the new VQR policy from the perspective of residents' responses and behaviours in Guangzhou, which is the first time to investigate the traffic demand management from the perspective of individuals. Several sources of data, including the traffic monitoring system, statistics of the historical data, SP surveys are analyzed. A discrete model that captures residents' behaviours when facing risks is used to forecast and analyze resident's responses under three potential risky scenarios. There are some interesting findings of residents' attitudes and behaviours in response to the policy:

- The pragmatic characteristics of Guangzhou residents play important roles in their license choosing decisions.

- Residents prefer to the lottery and have strong patience to it.

- Low perceptual value of local licenses lead to few auction applicants and low bidding prices in Guangzhou.

- Without the restriction to non-local registered vehicles, many residents choose to register outside of Guangzhou. Auction applicants and bidding prices are very sensitive to the implementation of the NLR policy.

Basing on data in a macro level and a micro level, a comprehensive discussion is presented from the perspectives of residents, the policy makers and the sustainable transport development. In summary, the policy in Guangzhou is flexible to launch the restriction policy to non-local vehicles and to adjust the quota of three ways to allocate licenses. Because the sole policy to restriction car ownership is not sufficient, considering the non-local car restriction is not carried out and current impact is moderate. Further research work will improve the license choice model to involve the test of the effective quota ratios of three ways. The dynamic interaction of the policy, residents' behaviours, car ownership and traffic conditions would also be the subject of a future study.

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## AUTHOR'S BIOGRAPHY



**Jun Li,** He received his Doctor's degree (2001) in transportation planning and management of Nagoya University. And still today he is employed as a associate professor in Sun Yat-sen University in China.