Research on Urban Low Carbon Intelligent Traffic Control Model

Yi Luxia 1, You Yucong*2
1Guangzhou College of Business and Technology, Guangzhou, China
2Guangzhou College of Business and Technology, Guangzhou, China
stoneyyc@163.com

Abstract. Intelligent transportation control is an important part of the entire transportation system, and low-carbon transportation is the ultimate goal of urban transportation development. Realizing the balance of supply and demand of intelligent transportation control in metropolis is one of the strategic means to build a low-carbon intelligent transportation in metropolis. The paper collects a time series related traffic data during the ten years of the metropolis, combined with the knowledge of systems engineering and economics, and constructs the supply and demand system model to the traffic volume of metropolitan intelligent control transportation; different vehicle costs and the marginal benefit of private transportation are both analysed accordingly. Modelling and systematic analysis of marginal cost, marginal revenue and marginal cost of public transportation are adopted to conduct optimal traffic volume of urban roads, with a view to constructing a low-carbon intelligent traffic model for metropolis from the perspective of supply and demand. Macro-control strategies for urban low-carbon intelligent traffic control are provided accordingly.

1. Introduction
Urban transportation is an important tool and carrier for social and economic development, and an important source of global greenhouse gas emissions. As the low-carbon economy sweeps across the globe, low-carbon intelligent transportation is increasingly attracting widespread attention. Low-carbon intelligent transportation is an important part of low-carbon economy. The basic connotation of low-carbon intelligent transportation is reflected in the following aspects: First, low-carbon intelligent transportation is a systematic development concept and project, aiming at realizing low-carbon development of the industrial chain in the transportation sector; second, adjusting urban supply and demand and optimizing transportation system. Urban low-carbon intelligent transportation includes three forms: low-carbon intelligent transportation, low-carbon water transportation and low-carbon air transportation. Intelligent transportation is the main form of urban transportation and is the key area for energy conservation and emission reduction. This paper analyzes the problems related to urban low-carbon intelligent transportation construction from the perspective of urban transportation supply and demand theory, mainly including transportation tools and urban roads.

2. Analysis of the status quo of intelligent traffic in metropolis
As a regional central city and a communication and communication hub, the transportation system plays an important role, and intelligent transportation is an important part of it. At present, the large-scale three-dimensional road traffic network composed of express roads, main roads and secondary roads in the metropolitan city has been established and improved. With the rapid development of the
metropolitan economy, the population is growing rapidly, the exchanges are frequent, the pace of life is accelerating, and the number and distance of urban residents' travels have increased significantly.

The great development of metropolitan intelligent transportation has also led to more and more sharp traffic contradictions and the problems are endless. Roads are crowded, inefficient, time consuming, accidents increase, high energy consumption and serious traffic pollution, and traffic disorder. Its pollutant emissions account for about 20% of the total vehicle emissions. These not only seriously endanger the traffic safety of residents, but also do not meet the development concept of urban low-carbon intelligent transportation, which seriously affects the sustainable development of metropolitan social economy. In addition, there are still serious supply and demand contradictions in metropolitan intelligent transportation. In general, the demand for smart transportation in metropolitan areas is far greater than the supply of roads. In a certain period of time, the capacity of road supply is fixed, and traffic during off-peak hours is relatively smooth; but during peak traffic hours, supply is often in short supply, resulting in traffic congestion. From the perspective of metropolitan intelligent transportation demand, it mainly includes residents' travel demand and transportation demand. From the perspective of supply of metropolitan roads, it mainly includes the following aspects: First, supply lags far behind demand. During the peak hours, almost all highways are saturated, the average running speed is less than 50 kilometers per hour, the traffic pressure of the main roads is further increased, the average running speed is only 24.4 kilometers per hour and the supply of expressways is insufficient. Second, the road structure design is unreasonable. Demand is growing rapidly, road construction is relatively slow and structural imbalances. The metropolitan urban road network is not systematic and the overall accessibility is low. The road lacks coherence, the vehicle is bypassed, the intersection is too dense, there are too many T-junctions and there is no bicycle lane. Third, the road is overused and poorly managed. The traffic volume of local sections and some intersections surges. The traffic capacity of the entire road network is subject to these local sections. The roads are completely closed. Pedestrians use the flyovers or ramps to cross the street. Some settings are unreasonable beyond the walking range.

3. Model
The analysis of supply and demand of intelligent vehicles includes two aspects: one is the analysis of supply and demand of traffic volume; the other is the analysis of supply and demand of transportation modes.

3.1 Analysis of supply and demand of intelligent traffic in metropolis
The amount of demand for smart transport in a city is determined by many factors. The demand function can be expressed as

\[ Q = D(C, I, Pr, N) \]  
(1)

Where \( Q \) represents the quantity of vehicle demand, \( D \) represents a functional relationship, \( C \) represents the cost of transportation for residents, \( I \) represents the income level, \( Pr \) represents the relevant vehicle cost, and \( N \) represents the population. The relationship between traffic volume and them is:

\[ \frac{\partial D}{\partial C} < 0, \frac{\partial D}{\partial I} > 0, \frac{\partial D}{\partial Pr} < 0, \frac{\partial D}{\partial N} > 0 \]  
(2)

From the comparison of partial derivatives and 0, the demand has a reverse relationship with the travel cost; the demand has a positive relationship with the income level; the demand has a reverse relationship with the related vehicle cost; the demand is positive with the urban population. To change the relationship. When the income level, population size, and related vehicle costs are fixed, the demand curve can be obtained.
As can be seen from the figure, the travel cost and the demand for the vehicle are in a reverse relationship. When the travel cost increases, the demand for the vehicle decreases. When the travel cost decreases, the demand for the vehicle increases. In Figure 2, DB is the demand curve.

CS is the supply curve. When the travel cost is at point C, the demand for the vehicle is Q1. At this time, the demand is greater than the supply. The traveler is willing to pay a higher travel fee. The C point will move to the upper right, as the travel cost increases. When arriving at point B, the traffic volume is Q2, and the supply is greater than the demand, which means that residents are no longer willing to pay high driving expenses. At this time, point B will move to the upper left, and finally until the E point is balanced, demand is equal to supply, Q0 is the best traffic, and C0 is the best travel cost. However, this supply and demand balance only exists in an ideal state. In reality, if the cost of travel or the cost of travel is reduced, more units and individuals will buy cars, and more and more people will go out and drive. However, in the short term, the supply of traffic roads cannot be improved and improved, so new ones will be created. A round of traffic congestion, operating efficiency is even lower.

\[ AC = \frac{TC}{Q} \quad (3) \]

Among them, TC is the total cost and Q is the traffic volume. The average cost of a car is horizontal and straight, indicating that the average cost of a private car is constant, and there is no economies of
scale. It can be seen that controlling the number of private cars in the macro-control of the number of transportation vehicles is very important. At the same time, vigorously developing public transportation can reduce social costs and help control emissions, in line with the low-carbon concept. When determining the optimal amount of traffic for various modes of transportation, cars are private items, and buses and subways are public goods. Discussed in two cases. The first is the analysis of the optimal number of cars. Suppose there are only two consumers, A and B in the society. Their demand curve for cars is represented by Da and Db respectively, and the supply curve of the commodity market is S. Because the discussion is about private items, the Da and Db levels are added together to get the car market demand curve D. The intersection of D and S determines the equilibrium quantity and equilibrium price of the car. At this level, the marginal benefit of each consumer is equal to the marginal cost of the commodity. That is, CE=FG=KH. The second is the analysis of the optimal quantity of public goods such as public transportation and subway public. It is still assumed that each consumer's demand curve for public goods is known. For Da and Db, the public goods market supply curve is S, but the market demand curve of public goods is not the level of the individual demand curve, but the vertical phase. plus. As shown in Figure 3, the number of public goods is W, and the consumption of consumers A and B is then W. The prices they are willing to pay are L and N according to their respective demand curves. Therefore, when the consumption is W, the sum of the A and B payment prices is L+N=T.

Fig.3 The optimal number of supply and demand curves for cars

With the market supply and demand curve of public transportation, the equilibrium quantity W can be determined, which is also the optimal quantity. Because when the quantity is W and at the time of the supply curve, the marginal cost of public transportation is T. According to the demand curve, the marginal benefit of A and B is L. And N, so the total social marginal benefit is L+N=T. Furthermore, marginal social benefits equal marginal costs and the number of public goods is optimal. The optimal standards for cars and public transportation are not exactly the same. Cars are private goods, and the optimal quantity is determined by the marginal benefit of each consumer being equal to the marginal cost. Public transportation is a public good, and the optimal quantity is determined by the sum of the marginal interests of each consumer equal to the marginal cost. This is due to the competitive nature of public transportation.

Fig.4 Best supply and demand curve of public transportation
4. Discussion
The demand for metropolitan traffic roads is far greater than the road supply. With the intensification of the contradiction between supply and demand of intelligent vehicles, the contradiction between supply and demand of traffic roads is becoming increasingly prominent. For motor vehicle growth, road growth is “slow growth”. According to statistics, the annual growth rate of urban roads in China has remained at a level of 3% to 5%, which cannot meet the rapidly growing traffic demand. In fact, relying solely on the increase and transformation of urban roads and the expansion of road supply cannot solve the problem of urban traffic congestion. Moreover, urban roads cannot expand indefinitely. Urban roads are public resources and are likely to be overused, with disastrous consequences. This means that adjusting traffic demand and controlling traffic volume are crucial. It is necessary to determine the optimal number of traffic trips on public roads depending on the marginal social benefits and marginal social costs of the entire city. For the entire city, the optimal amount of traffic should be such that the marginal social benefits are exactly equal to the marginal social costs.

Suppose \( x \) is used to indicate the amount of traffic on the road. For the sake of simplicity, the total number of vehicles is generally considered as a whole. Here is an abstract analysis. Assuming that the amount of traffic per unit can bring 1 unit of social income per day, then the number of traffic in \( x \) units is \( x \) gains per day, then the demand function of traffic volume is:

\[
P = a - bx\quad (4)
\]

\( P \) is the market price corresponding to the \( x \) unit social income, \( a \) and \( b \) are constants greater than 0, and the total social benefit of the \( x \) unit of traffic is:

\[
TR = Px = ax - bx^2,
\]

the marginal social benefit is:

\[
MR = TR' = a - 2bx.
\]

The cost of setting up a unit of traffic is \( c \), \( c \) is a non-zero constant, then the total social cost of traffic in \( x \) units is:

\[
TC = cx,
\]

the marginal social cost is:

\[
MC = TC' = c,
\]

that is, \( MR = MC = a - 2bx = c \), which solves the most traffic roads. Excellent traffic. However, in order to achieve this optimal quantity, one condition must be met: the government stipulates the quantity of all means of transportation and no unit or individual may exceed the number of vehicles required. In this case, as long as the specified amount of traffic is equal to \( x^* \) and a strong policy is adopted to ensure execution, the result is optimal.

5. Conclusion
Based on the above mode of intelligent control transportation, the development of public transportation is conducive to saving social costs, while the average cost of cars is unchanged. Therefore, we must optimize the urban low-carbon intelligent transportation structure. First, prioritize the development of urban public transport and limit the number of cars used. Establish relevant laws and regulations to ensure land, funds, and road rights for public transport development, and improve bus price and tax support policies, and incorporate public transport development levels into the performance appraisal of urban government. Specific evaluation indicators may include: share of public transport, non-motorized traffic, share of travel, the energy consumption of transportation fossils, and the emission factors of carbon dioxide and other pollutants. The relevant government departments should adopt preferential fare policies and convenience measures to encourage the public to use public transport. From the analysis of supply and demand of public goods, this measure has increased social marginal benefits and total social benefits. Second, improve the travel environment and encourage walking or cycling. Due to the acceleration of urbanization and the rapid development of motorization, the current walking and cycling environment in metropolitan areas has been deteriorating, and the proportion of travel has been declining year by year. It is necessary to vigorously develop the bicycle leasing business, increase capital investment, improve the layout of rental facilities and supporting infrastructure, and strive to improve the transfer of walking and bicycles with other urban transportation modes, and solve the problem of “last mile” for residents to travel.
Third, improve the construction of metro metros. At present, metropolitan public transport has a big problem in the transfer of stations along the subway and between subway stations. Many stations have long walking distances. The problem of connecting conventional bus and rail transit needs to be solved urgently, and underground space should be planned reasonably. The metropolitan area is formed with a subway as the skeleton, a commercial underground city as a node, a city underground plaza as a region, and an underground entertainment network, which is complemented by underground entertainment, leisure, and cultural and educational facilities. In short, to diversify the traffic structure, more use of low-energy, low-emission, low-pollution vehicles is encouraged.

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