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Original Paper

The Research on Traffic Congestion Problem in Beijing Based on Random Effect Model

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Abstract

With the advancement of urbanization and the rapid development of the economy, the number of motor vehicles has also increased sharply, which has led to the increasingly heavy traffic congestion problem, especially in the international metropolis like Beijing. It is more serious, bringing economic loss and seriously affecting its further development. Therefore, it is of great importance to solve the problem in Beijing. In response to the above issue, despite the introduction and implementation of a series of measures in Beijing, it is still unable to properly solve the traffic congestion problem. Today, traffic congestion in Beijing still exists. This paper will mainly start from the causes of traffic congestion, and analyze the problems and phenomena based on the random effects model to obtain the reasons. According to the goal of relieving the traffic congestion problem, we will use the traffic supply and demand theory combined with the actual traffic situation, establish the traffic light model, the travel optimization model and the automobile demand curve model. With the hypothesis, simulation and analysis, we drew the corresponding conclusions. At the same time, the corresponding policy recommendations were put forward to relieve the traffic congestion problem in Beijing.

Keywords

Beijing traffic congestion index, single and double number limit, traffic signal management, short-term travel mode, per capita motor vehicle ownership, supply demand curve

1. Introduction

The problem of traffic congestion is an inevitable stage in the process of social development and urban construction. From a global perspective, many international metropolises such as London, Paris, Singapore, etc. have experienced serious traffic congestion problems. Although they have all adopted relevant methods and measures to improve, the results are often unsatisfactory, The traffic congestion problem is still not relieved, but it is getting worse. This also means that using new models, principles

and technical methods to relieve traffic congestion is of great practical significance.

Traffic congestion affects the order of life in the entire society. Generally, it is mainly manifested in the following aspects. First, it affects the life of residents, mainly to increase their travel time and cost. The second is to affect the operation of the society. For public transportation, there are many potential safety hazards in large-scale traffic jams, which may lead to more serious traffic accidents. Third, the ability to influence the government's traffic management is mainly to increase the difficulty of government management. The government must invest more manpower and resources. The fourth is to affect the environment, leading to further deterioration of the urban environment, especially leading to smog.

With the development of China's economy, Beijing has become an internationally renowned metropolis and there is inevitably a traffic congestion problem. Despite the government's introduction of a series of policies and measures, the traffic congestion problem is still very serious, and further investigations are needed to propose more constructive countermeasures.

1.1 Research Purposes

Beijing is the capital of China, a political, economic and cultural center. However, regardless of the number of personnel and locomotives, the current situation of Beijing traffic is not optimistic. The number of personnel and locomotives is almost saturated, traffic roads are overloaded, and traffic congestion is very serious. This is an obvious problem for Beijing's urban construction and development, and it has also had a negative impact on Beijing.

Relieving Beijing's traffic congestion has become an important task for Beijing's development planning. Specifically, it is necessary to reduce the cost of residents' travel and vehicle transportation, improve the efficiency of urban operation, the quality of the environment, and the living standards of residents, meeting the goal of promoting economic and social development as well as quality development. At the same time, alleviating the traffic congestion problem in Beijing is also a very important demonstration role for the construction and development of other cities, which can be used for reference, thus promoting the development of other cities.

1.2 Research Status

Many scholars have studied the causes of traffic congestion. Wen Mengfei believes that motor vehicles are developing rapidly in the process of urbanization, and the amount of urban road traffic is increasing rapidly. The construction of road traffic infrastructure is slow, and the level of traffic management is relatively backward, causing traffic congestion problems. Zheng Changjiang believes that with the advancement of urbanization, the contradiction between urban transportation and urban development has become increasingly prominent. However, China's urban public transport itself has a low sharing rate and a low level of public transport services, lack of unified planning of public transport infrastructure and unreasonable public transport networks. Traffic congestion has not been alleviated.

Faced with the increasingly serious traffic congestion problem, many scholars have proposed some solutions based on their analysis. Chen Caijun believes that smart transportation is an effective way to

solve traffic congestion problems. It applies the new generation of information technology such as Internet of Things and cloud computing to the entire transportation system, improving the efficiency of traffic management services and people's travel experience. Smart transportation can improve the operational efficiency of the transportation system, reduce traffic accidents and improve the informationization, intelligence and humanization level of traffic management, and improve the systematization level of transportation services. It helps to improve the efficiency of the transportation system, thus alleviating traffic congestion. Shao Chunfu believes that to rationally layout the city from the perspective of urban land use and comprehensive transportation, traffic congestion can be avoided from the root cause.

2. The Current Situation and Analysis of Beijing Traffic

2.1 Status of Beijing's Traffic Development

With the rapid development of the national economy, the people's living level has increased steadily, and the number of motor vehicles in Beijing has continued to grow. This phenomenon affects the current transportation, mainly manifested in the following three characteristics.

The first is "more", specifically multi-vehicle; this is an inevitable trend of economic and social development. Beijing is the national capital, an international metropolis, resulting in a large population, a large flow of people, and multi-country activities. On the international stage, Beijing is an important venue for national events. In addition, there are many accidents and multiple engineering construction features.

The second is "less", mainly because there is less investment in mitigating traffic pressure, that is, less policies, manpower and material resources.

The third is "blocking", which is mainly reflected in both time and space. In terms of time, it is mainly concentrated in the peaks of commuting, holidays, and important state affairs. In terms of space, it is mainly concentrated in traffic control areas, accident areas, construction areas, and important areas of education and medical resources. In public transportation, congestion also occurs due to time (mainly commuting peaks) and space.

2.2 Characteristics and Causes of Traffic Congestion in Beijing

2.2.1 Characteristics of Traffic Congestion in Beijing

According to the current traffic congestion situation in Beijing, the following two basic characteristics can be derived.

(1) The traffic congestion index basically changes between moderate and mild.

The traffic congestion index is an important indicator to measure the severity of traffic congestion. Beijing divides the traffic congestion index into five levels according to the city's situation. They are: 0~2 is unobstructed; 2~4 is basically unobstructed; 4~6 is mildly congested; 6~8 is moderately congested; 8~10 is heavy congested. The functional curve was established by collecting the Beijing traffic congestion index in recent years. Analyze the increase and decrease trend of traffic congestion index in recent years and analyze the traffic situation in Beijing.

Table 1. Beijing Traffic Congestion Index from 2007 to 2017

Beijing-China Traffic Congestion Index 2007-2017	
years	Index value
2007	7.6
2008	5.84
2009	5.41
2010	6.1
2011	4.8
2012	4.7
2013	5
2014	5.5
2015	5.7
2016	5.6
2017	5.6

According to Table 1, using the Matlab curve fitting method, the relationship between the Beijing traffic congestion index and the year is obtained:

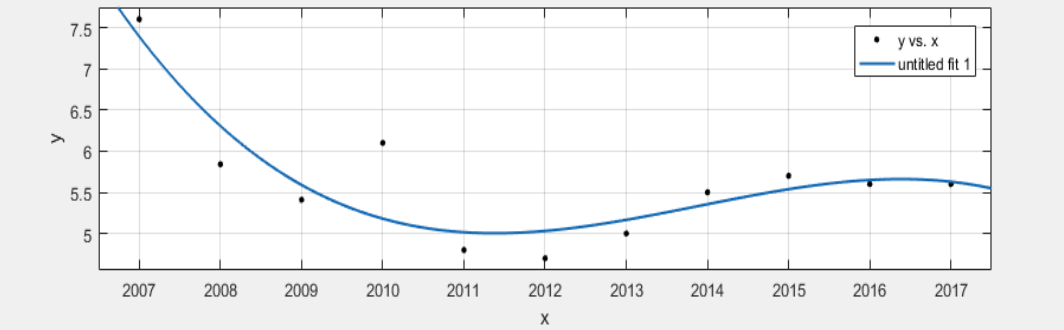

Figure 1. Relationship between Beijing Traffic Congestion Index and Year from 2007 to 2017

From the relationship between the traffic congestion index and the year of Beijing from 2007 to 2017, it can be seen that during this period, the Beijing traffic congestion index fluctuated between 5 and 7.5, indicating that Beijing traffic congestion is moderately congested and mild. During this period, 2011 was the minimum, and the overall trend showed a trend of decreasing first and then gradually increasing, indicating that the government's traffic management policies have a certain mitigation effect.

(2) Traffic congestion is time and regional

The traffic congestion in Beijing shows obvious temporal and regional characteristics at the peak of specific congestion. The main performance is:

a. Timeliness: Mainly concentrated in the peak hours of workdays. During this period, the traffic volume was highly concentrated, and the overall road network was saturated. The increase in congestion on holidays and weekends, as well as the number of vehicles and the number of people traveling, have become the main factors leading to more serious traffic congestion.

b. Regionality: First, on the main roads, such as Liangguang Road and Ping An Street. Secondly, the congestion in key areas is mainly due to comprehensive factors such as urban construction. Most of them are concentrated in culture, tourism, education, and medical care areas, such as commercial prosperous areas, wholesale market areas, and large venues. There are also factors such as unreasonable road construction, which leads to regional traffic congestion as well.

2.2.2 Analysis of the Causes of Traffic Jams in Beijing Based on Random Effects Model

According to the current traffic situation in Beijing, the characteristics of traffic congestion and the development of Beijing, the main causes of traffic congestion are the following three points:

(1) Beijing's various functions are too concentrated and lack reasonable partitions

Beijing has a diverse range of functions, including political, economic, and cultural centers. Coupled with the large number of visitors, it has challenged its ability to withstand. The central area is a prosperous social activity area. Several surrounding towns are concentrated areas for various professional employees. The running outside the city also increases the pressure of traffic congestion. The lack of reasonable zoning in various functional areas in Beijing has become a congenital factor contributing to traffic congestion.

(2) Serious imbalance between traffic supply and demand

The supply and demand situation of Beijing's transportation shows a serious imbalance. The contradiction between the two has become the root cause of the traffic congestion problem in Beijing. The transportation supply mainly includes road traffic mileage, road grade and public transportation service level, while transportation demand mainly includes the purpose of motor vehicle transportation and travel time.

From the perspective of demand: With the rapid development of the economy and society, the population of Beijing continues to increase, and the total demand for travel continues to grow. According to the analysis of the number of motor vehicles, the total number of motor vehicles accounts for the vast majority of road traffic, which can directly reflect the traffic demand in Beijing. The following table is obtained by counting the total number of motor vehicles in Beijing from 2007 to 2017.

Table 2. 2007-2017 Beijing City Vehicle Ownership

2007-2017 Beijing city vehicle ownership	
years	Number of vehicles (unit: 10,000 units)
2007	312.8
2008	350.4
2009	391.8
2010	480.9
2011	498.3
2012	520.0
2013	543.7
2014	559.1
2015	561.9
2016	571.8
2017	590.9

The total number of motor vehicles in Beijing is linearly regression to construct a functional relationship, as shown in the following figure.

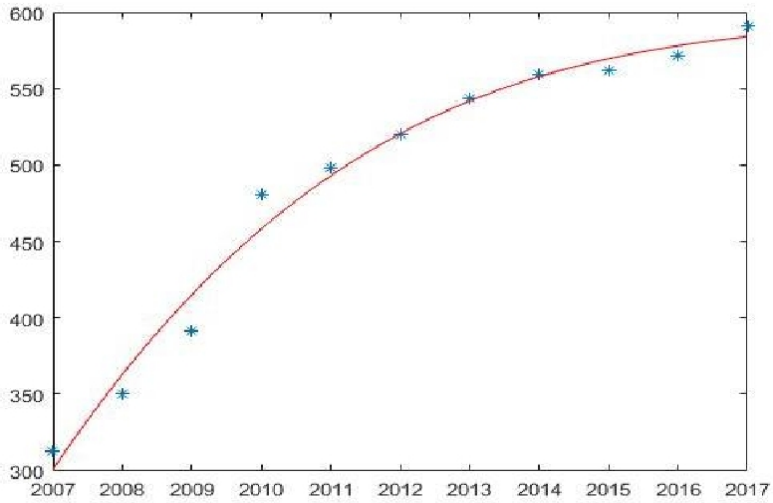

Figure 3. Vehicle Ownership in Beijing, 2007-2017 (unit: 10,000 units)

It can be concluded that the total number of motor vehicles in Beijing is a function of time:

$Y2 = 0.1628x^3 - 6.056x^2 + 79.38x + 227.2$

According to the image and function relationship of the data, the growth rate of vehicle ownership in Beijing from 2007 to 2017 is gradually decreasing. Despite being in a low level, Beijing's motor vehicle ownership base is quite large. Therefore, the traffic demand caused by the number of motor

vehicles continues to increase. Moreover, the number of people carrying small cars is limited, the transportation efficiency is not high, and the traffic demand cannot be alleviated. These have led to an increasing demand for traffic in Beijing.

From the perspective of supply, Beijing's traffic is relatively insufficient, and it is completely unable to meet the growing traffic demand in 2000. In terms of the level of road mileage and public transport services, the Beijing subway has entered an accelerated construction period since the 21st century,. As of August 2018, the Beijing subway operation line has 22 subway lines covering 11 municipal districts in Beijing. By 2020, the Beijing Subway will form a rail network with 30 lines and a total length of 1,177 kilometers. Despite this, the subway is still very crowded during the morning and evening peak hours. The efficiency of public transportation and trams in Beijing is not satisfactory due to traffic congestion. There are also problems such as a single service form, insufficient depth of delivery routes, and repeated lines. Public services such as public bicycles have been ineffective due to inefficiency. In addition, due to the lack of better parking lots or excessive charges, the phenomenon of random parking of motor vehicles continues to occur, which has become an insufficiency aspect of Beijing's transportation supply. Therefore, the overall growth of Beijing's transportation supply is very slow.

From the perspective of the relationship between supply and demand of traffic in Beijing, the contradiction is very prominent. On the one hand, it is the rapidly growing traffic demand, on the other hand, it is a slowly increasing supply capacity, and there is a serious imbalance between supply and demand. This is the most fundamental reason for urban traffic congestion.

(3) The structure of Beijing road network is unreasonable

Beijing road network is congenitally insufficient, the road network is in the shape of a ring line plus radiation, the north-south main road is lacking, and the vehicles are excessively concentrated on the loop, which is also a reason for traffic congestion in Beijing. In addition, due to the low density of road network in Beijing, the number of urban roads with broken roads, fewer roads, and poor road micro-circulation have also caused traffic congestion in Beijing.

3. The Mitigation Plan for Beijing Traffic Problems

Through the analysis of the current situation of Beijing traffic and its development process, the causes of traffic congestion in Beijing, combined with relevant knowledge, the random effect model is fitted and predicted, and the corresponding solutions to alleviate traffic pressure are proposed.

3.1 Relevant Theories and Ideas of Beijing Traffic Problems

3.1.1 Theory of Transportation Supply and Demand

The root of traffic congestion is the imbalance in the supply and demand of transportation. Generally speaking, the transportation supply lags far behind the traffic demand. There is a balance between transportation supply and transportation demand. At present, the supply is much smaller than the demand, that is, the supply of infrastructure to infrastructure construction is less than the growth of small cars. When the total traffic demand is greater than the total traffic supply, traffic congestion will occur.

Traffic supply and transportation demand are mutually influential. Through the continuous increase of traffic demand, the continuous improvement and development of traffic supply will be promoted to adapt to the development of traffic situation. The increase of traffic supply will stimulate new traffic demand. Therefore, the key to alleviating traffic congestion is achieved by harmonizing the amount of traffic supply and traffic demand.

3.1.2 Mitigation of Traffic Congestion Problems in Beijing

Through the elaboration and analysis of the above traffic theory, it can be concluded that the traffic situation of a city is directly dependent on its road saturation, and the road saturation depends on V/C (V is the maximum traffic volume and C is the maximum traffic capacity). Therefore, we have adopted three methods of traffic signal management, travel optimization and reduction of vehicle ownership to reduce vehicle traffic, and thus relieve traffic pressure in three ways.

3.2 Relief of Beijing Traffic Congestion Problem

3.2.1 Management Model of Traffic Lights

At peak times, traffic lights control the passage of hundreds of thousands of motor vehicles. Reasonable optimization of the release time of the signal lights in different periods, thereby reducing the maximum traffic volume and reducing the saturation of the road, can alleviate the traffic pressure.

Assume that the signal is a north-south green light and an east-west red light; then the vehicle parked at the north-south intersection will drive to the opposite side and pass through the intersection. Therefore, it can be assumed that the total number of vehicles leaving the intersection Q1 is the north-south direction of the intersection. The amount released. Similarly, the total amount of vehicles Q2 at the east-west intersection is the accumulation of vehicles in the east-west direction. In this way, the demand function QN=f(P) and the supply function QS=f(Q) in the equilibrium price model can be simulated separately.

Release amount function Q1=f(T); accumulation amount function Q2=f(T);

Moreover, since the accumulation amount and the release amount belong to the opposite concept, similar to the demand and supply function, the two function curves intersect in the first quadrant; considering that there is vehicle retention at the intersection when the signal light is suddenly changed (ie, not completely released and already exists) Accumulated), respectively q1 and q2. At the same time, considering that each car passes through the intersection time and speed is basically the same, the release amount and accumulation amount increase at a constant rate with time. The circulation of vehicles on each side of the north-south direction and the east-west direction is the same. Then the release amount function and the accumulation amount function can be expressed as

$$Q_1 = (-k_1 \cdot T + q_1) * 2$$

$$Q_2 = (k_2 \cdot T + q_2) * 2$$

The equilibrium condition of the analog demand and supply can be obtained as the time T_0. of the north-south or east-west green light. Thus, the equalization period (ie, a reasonable period) of the traffic signal is $2T_0$.

The following will take the traffic lights at the entrance of the Beijing Institute of Printing as an example to demonstrate the process of the equalization cycle of traffic lights. According to statistics, when the north-south direction changes from red light to green light, the number of vehicles staying on both sides of the road is q1. Similarly, when the east-west direction changes from green light to red light, the number of vehicles staying at the intersections on both sides is q2; During the multi-measurement period, the north-south direction is the green light T1, and the total traffic volume of the single-side lane is X1, X2, X3, etc. Similarly, during the east-west direction of the red light T2, the traffic flow of the single-sided lane is the total accumulation. The quantities are respectively Y1, Y2, Y3, ..., and thus, it can be concluded that the total amount of vehicle release and the total amount of accumulation per unit time are X and Y, respectively.

According to statistics, the above quantities are respectively q1=32 q2=24 X=4 Y=5 T1=31 T2=30.

Then the release function is Q1= $(-\frac{X}{T1}\cdot T+q1)$ *2=-$\frac{8}{31}$T+64

Then the accumulation function is Q2= $(\frac{Y}{T2}\cdot T+q2)$ *2= $\frac{1}{3}$T+48

According to the equilibrium condition, it can be concluded that T_0 is$\frac{T1\cdot T2\ (q1-q2)}{T2\cdot X+T1\cdot Y}$=27.1s

Then the traffic signal balance period is $2T_0$

$$2\frac{T1\cdot T2\ (q1-q2)}{T2\cdot X+T1\cdot Y}=41.1s$$

It can be seen that the calculated result is close to the data we actually collected, and it also shows that the time for setting the red and green lights of this intersection is reasonable. However, this is only a traffic light at the Qingyuan intersection. For example, the traffic lights at other intersections need to obtain their equilibrium period according to the specific statistical quantity and environment.

3.2.2 Travel Optimization Model

With the development of the economy, the improvement of automobile production technology has made the growth rate of roads unable to keep up with the growth rate of vehicles. This has led to an increase in the average density of vehicles at rest. As a result, it has spent a lot of manpower, material resources and financial resources to build roads and bridges. But in exchange for the smooth traffic, but more and more serious traffic congestion. Therefore, to control from the traffic flow, it is necessary to change from the mode of travel. Most Beijing residents take up a large proportion of short-term travel, so how to choose the right short-distance travel mode has become the biggest problem.

(1) Model assumptions

For this strategy, the assumption is: the short-distance travel range is no more than 5km; the bus lane should be considered, the bus does not block traffic except the stop signal; for the short-term travel mode, we choose The model solving process does not consider taking a variety of vehicles, the model can be considered the travel rate and cost of a variety of vehicles; regardless of the sudden special situation such as the sudden stop of the subway.

(2) Model establishment

Below we will select a section of the short-term travel in Beijing for analysis. We will first introduce the following indicators: set fi as the total cost of short-term travel, ai as a means of transportation for short-term travel, and bi as a type of transportation selected The cost corresponding to the tool, ci corresponds to the number of people traveling by traffic, di is the short-term travel rate of various vehicles, and ei is the total rate of short-distance travel. The best way to judge short-term travel is to compare the size of fi, ei horizontally. The total cost of short-term travel Σfi=ai ḃi, the total speed of short-term travel Σei=aidi collects the cost and efficiency of several commonly used vehicles such as subway, taxi, bicycle, bus, private car. (take 3-5km as an example)

(3) Model solving

Under the premise of the data of the four column charts in Figure 4, Figure 5, Figure 6, and Figure 7, the following situations will be discussed to select the appropriate mode of transportation.

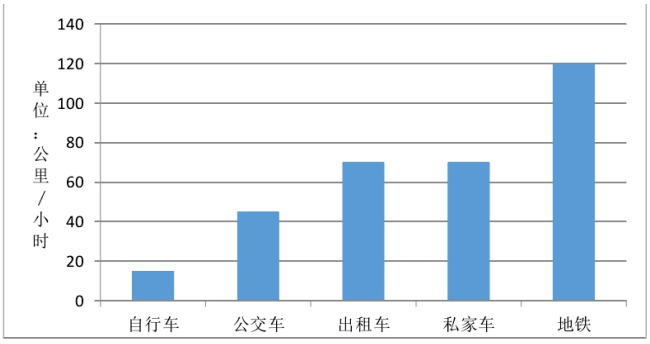

Figure 4. Speed of Various Modes of Travel When the Road is not Crowded

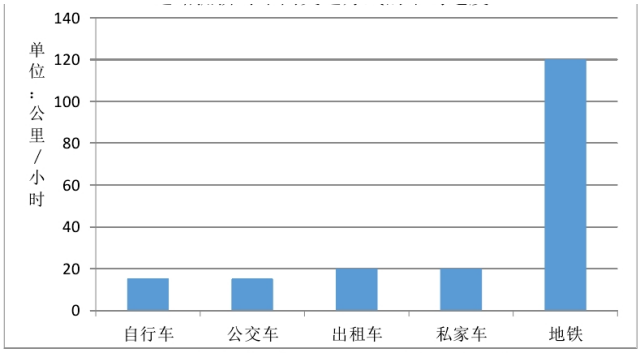

Figure 5. Average Speed of Different Modes of Transportation When the Road is Crowded

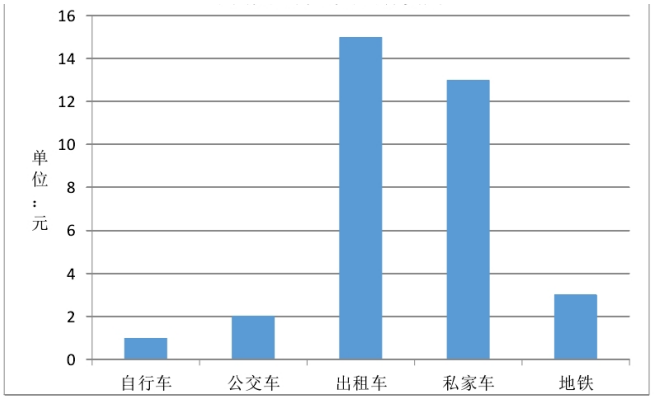

Figure 6. Travel Expenses for Different Modes of Transportation

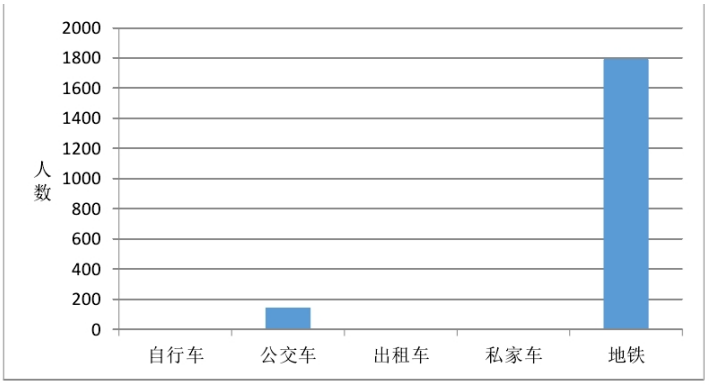

Figure 7. Maximum Passenger Capacity of Various Modes of Transportation

(a). Road conditions: When congested, the three types of transportation such as subway, bicycle and bus should be preferred (the order is from front to back); when it is smooth, the subway, bus, and two modes of transportation should be preferred (ranking in order) From front to back)

(b). Travelers: When the number of passengers is 1, the bicycle or subway should be preferred.

When the number of trips is greater than 1 and less than 5, the subway or private car should be preferred.

When the number of trips is greater than 4, you can choose according to the actual situation.

Therefore, in combination with the concept of saving energy and protecting the environment, it can be concluded that in order to solve the problem of urban traffic congestion and the sustainable development of transportation, to develop a harmonious society, to build urban civilization and improve people's quality of life, when traveling in short-term travel in Beijing, The best option is for bicycles and large motor vehicles (bus or subway) without having to worry about road congestion. However, it is also necessary for Beijing citizens to use their proposed models and algorithms to calculate their actual $\Sigma fi=aibi$, $\Sigma ei=aidi$ according to their own travel routes, to conduct comprehensive comparison and analysis, and to choose the plan that suits them best.

3.2.3 Automobile Demand Curve Model

As the automotive industry is still the pillar industry of the country, at this stage, it is still not appropriate to curb the development of the automotive industry. However, it is possible to suppress over-use of small cars by adjusting the demand situation of the car. The modeling analysis will be carried out through the demand curve.

(1) Model assumptions

According to the analysis, the assumption is made: the conditions required to increase the price of small cars and increase the cost of car ownership are not considered; only the curve relationship between demand and price itself is considered, and other factors are not considered.

(2) Model establishment

We set Q to supply small cars, P for small cars, D for citizens' demand, e for demand elasticity, Q for demand, △Q for demand increment, and △P for price increment. In which we need to consider the elasticity of demand prices, we can limit the ownership of small cars through the supply and demand curve below. The demand for small cars in society can be expressed by curves. When the price of small cars and their associated use costs increase, the demand for small cars in society will decline. Conversely, when the price of small cars falls, the demand for society will increase. This relationship is functional. It is monotonously decreasing. The image is a descending curve, as shown by curves 1D and 2D.

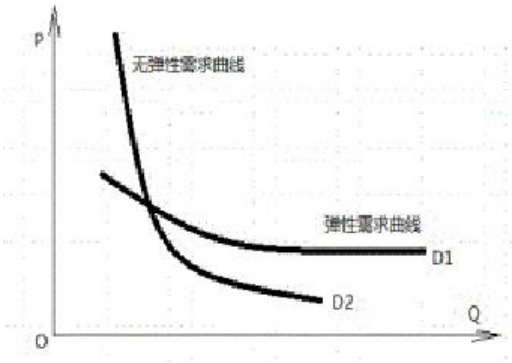

Figure 8. Demand Price Curve for Small Cars

Let P and P(Q) be the demand curve equations: $e = -\frac{P}{Q}\frac{dP}{dQ} = -\frac{P}{QP'(Q)} \Rightarrow e \approx \frac{|\Delta P|/Q}{\Delta P/P}$

(3) Model solving

We can use the above curve to formulate corresponding policies. If the demand elasticity coefficient e is equal to -2.5, its demand will drop by 2.5%, so we can see from the image and data analysis that the price of the car is adjusted, which reduces the demand for small cars and thus reduces the demand for small cars. The possession of small cars, while reducing the road saturation in Beijing, finally achieved the goal of solving the traffic congestion problem in Beijing.

3.3 Model Analysis

3.3.1 Management Model of Traffic Lights

This model can determine the relationship between the traffic signal time and the vehicle's residence time at the intersection by measuring the total time of the vehicle staying at the intersection and the north-south, east-west green and red light time. According to the equilibrium theory, the corresponding equilibrium period is obtained. Thereby optimizing the time of traffic lights and alleviating traffic pressure. However, if it is really implemented, it needs to collect a large amount of data for solution analysis and comparison. In actual life, there will be a relatively large workload, and the implementation time is long, and the actual situation of different intersections needs to be corresponding according to this method. Equilibrium cycle.

3.3.2 Travel Optimization Model

Choosing the right short-term travel mode will help ease traffic pressure. By combining the speed, travel expenses and passenger capacity of different modes of transportation in different situations, we can select the appropriate mode of travel for the masses in combination with the concept of protecting the environment and sustainable development. However, this model needs to be further compared and analyzed according to the different characteristics of different groups, and it is impossible to give a specific solution. It is also necessary for Beijing citizens to use their proposed models and algorithms to calculate their actual Σfi=aibi, Σei=aidi according to their own travel routes, to conduct comprehensive comparison and analysis, and to choose the plan that suits them best.

3.3.3 Automobile Demand Curve Model

Although it cannot suppress the development of the automobile industry, it can reduce the excessive use of automobiles. This model analyzes the demand for the car and the supply of the car, and establishes the supply and demand curve. We can reasonably analyze the relationship between the supply and demand of the car, and set up a suitable system to reduce the car ownership and ease the traffic pressure. The supply and demand curve may be affected by many factors, so it is necessary to solve the model in detail according to different changing conditions.

4. Conclusions and Recommendations

As an international metropolis, Beijing's urban road traffic problem is very prominent. The measures introduced by the traffic management department have only played a role in temporarily controlling traffic congestion problems, and cannot solve traffic congestion problems for a long time. First of all, Beijing has successively introduced the restriction of single and double numbers, the number of small buses, and the numbering policy. When these policies were first introduced, they did control the traffic congestion to a certain extent. However, as the number of motor vehicles increases, the number of vehicles on the road increases, and the problem of traffic congestion becomes more and more serious. In terms of single and double limit, it limits the number of motor vehicles on the road, but as the total number of vehicles increases, this number is also increasing. Therefore, it is impossible to solve the

fundamental problem only by controlling the number of vehicles or motor vehicles. Therefore, it is possible to make research from traffic lights, travel mode selection, and automobile demand curve to alleviate the traffic pressure in Beijing.

The first is the traffic signal problem. Traffic lights are indispensable for every street. During the peak period, the release time of the signal lights in different periods is optimized, which reduces the maximum traffic volume and can alleviate the traffic congestion problem.

Second, the choice of transportation mode for short-distance travel. According to our research, bicycles, buses, and subways have great advantages in short-distance travel. Bicycles are energy-saving and environmentally friendly. When the bus is not crowded, the price is relatively reasonable. The subway is not affected by road traffic, and the travel speed is faster. Choosing these three modes of travel can effectively alleviate the traffic flow of road traffic. In addition, the relevant departments should pay attention to the problem of taking a private car even in short-distance travel, in order to reduce the use of short-distance travel private cars. Of course, we must also consider the actual considerations. When there are problems such as emergencies, we must choose the appropriate mode of travel according to our own situation.

Third, with the increase of urban population and economic development, we cannot control the ownership of automobiles in a certain amount. At the same time, the automobile industry is also the pillar industry of the country. At this stage, it is still not suitable to curb the development of the automobile industry. However, by adjusting the economic leverage, increasing travel costs or increasing the cost of car ownership, the demand for small cars can also be reduced. Some people in the country are driving a private car as a status symbol. When many people do not need to use a car, they can reduce their use. Therefore, it is possible to consider the use of central area congestion charging and high parking charging strategies to curb the excessive use of private cars, and to adjust demand and supply with economic leverage to alleviate road traffic congestion. At the same time, it is necessary to give priority to the development of public transportation, especially to pay attention to the construction of parking facilities around the subway interchange station outside the supporting central area. It is also recommended to increase the cost of car ownership and control the ownership of cars by levying a license plate tax, controlling the supply of license plates, and levying a high tax on the second car on a household basis. This can alleviate the traffic pressure in Beijing.

In general, the need to reduce traffic on the road and reduce the detention of vehicles on the road is also for reference only. Solving the problem of road congestion in Beijing is a long-term exploration process that needs to be determined in light of the actual situation, and many other factors must be considered.

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Appendix

(1) Model procedure for Beijing Traffic Congestion Index 2007-2017

```
x=[2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017];
y1=[ 7.6 5.84 5.41 6.1 4.8 4.7 5 5.5 5.7 5.6 5.6];
cftool
```

(2) 2007-2017 Beijing Motor Vehicle Ownership Model Program

```
x=[2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017];
y2=[ 312.8 350.4 391.8 480.9 498.3 520 543.7 559.1 561.9 571.8 590.9];
Y3=polyfit(x,y2,3);
xx = min(x):.1:max(x);
YY = polyval(y3,xx);
plot(x,y2,'*');
hold on;
plot(xx,y2y2,'r')
```

(3) Traffic signal model program

```
clear
```

ezplot('(3/22)*t^2+15/88(88^2-176*t+t^2)',[-100,280])

(4) Use the symbol description:

Symbol	meaning
Year	X
Traffic congestion index	Y1
Motor vehicle ownership	Y2
Traffic light transition period	T
Number of vehicles arriving at the intersection from north to south	H
Number of vehicles arriving at the intersection from east to west	V
Green light time in north-south direction (ie red light time in east-west direction)	t
The time when the east-west vehicle stays at this intersection	y
Total cost of short-term travel	f_i
Choose a means of transportation for short-term travel	a_i
the fee for a chosen vehicle	b_i
Short-term travel rate of vehicles	d_i
The total rate of short-term travel vehicles	e_i
Number of people traveling	c_i
Number of small cars	Q
The price of a small car	P
Number of citizens' needs	D
Demand elasticity coefficient	e
Demand	Q
Demand increase	△Q
Price increment	△P