Private Car or Bus? A Study of the Sustainable Urban Passenger Transport System in Beijing

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ACKNOWLEDGEMENTS

This thesis is the final work of my study in Lund University International Master's Programme in Environmental Science (LUMES). At the moment of finishing my study in Sweden, I am grateful for all the LUMES teachers' arduous work in the past year for providing us the precious opportunity to share the valuable knowledge here with other international participants, we have developed our learning and understanding together, most importantly, through our successful co-operation, we have established a global view together which can be essential for dealing with our global environmental problems internationally in the near future.

Hereby, special thanks are given to Ms. Ingegerd Ehn, Prof. Harald Sverdrup and Mats Svensson for their great dedication and hardworking which makes our study programme possible, I am also grateful to Asa Grunning, our programme co-ordinator of LUMES, for her patient assistance to me during my studying in Lund university.

Personally, I would like to show my sincere gratitude to STINT (The Swedish Foundation for International Cooperation in Research and Higher Education) for its generous financial support to me for my staying in Sweden, without it I would not be able to carry out my study in Lund University.

I am indebted to Ms Eva Ericsson for her great help to me on my master thesis, as the supervisor of my master thesis, she has helped me greatly on my literature study and patiently reviewed my draft several times during the whole process of my thesis work, her constructive criticism and helpful comments are very important for the final formation of my thesis.

I wish to acknowledge the invaluable comments made by Prof. Bengt Holmberg who has given important suggestions to me and provided me essential theoretic supports for formulating my ideas in this thesis.

Lei ZENG

Winter 1998, Lund
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Summary

Beijing’s urban passenger transport system is undergoing a challenge caused by booming car fleet for the recent years. The characteristics are:

- Household car fleet has been increasing very rapidly for the past a few years, and the tendency predicts a tremendous growth in the near future;

- Infrastructure construction is lag far behind the expansion of motor vehicle fleet;

- Congestion and air pollution in built-up area of Beijing are becoming big problems which are not only damaging residents’ health but also adversely affecting the city’s socio-economic activities;

- Decentralisation caused by improved living standard foreshows a big increase of satellite towns in the outskirts, accordingly, people’s trips are expecting to be longer, more frequent, meanwhile, people’s demand of a quicker, comfortable, convenient travelling mode is also increasing.

- Traditional passenger transport modes of cycling, walking are deteriorating because of air pollution, insecurity, and unfriendly infrastructure.

- The bus system in Beijing, as a main public passenger transport mode, is of slow speed, no punctuality, poor service, backward technology, together with the increasing congestion on the road, the bus is losing its popularity indicated by the declining ridership.

To guide a rational development of Beijing’s passenger transport system, there are different general suggestions on harmonising this conflict between booming car fleet and limited infrastructure, which includes: 1. Building a full-scale metro networks; 2. Restricting bikes in the inner city; 3. Enhancing infrastructure construction. In this thesis, the pros and cons of the those options are evaluated according to the principles of environmental sustainability, economic viability, financial affordability, social acceptability as well as long-term urban planning. The conclusion is: neither of the three options is able to effectively solve Beijing’s passenger transport problems.

By systematically analysing the causes of recent traffic problems in Beijing, also inspired by the good experience from Curitiba, Brazil, bus’s advantages of large capacity with effective use of limited road space are addressed, moreover, bus priority is discussed as a alternative for efficiently coping with the problems, particularly, the role of Separate Bus Lane in the built-up area of Beijing is analysed as a possible main countermeasure for achieving a rational passenger transport system in Beijing.

To apply bus priority to Beijing, some concrete measures are described in the thesis. Specific suggestions are given on where and how to set the Separate Bus Lane in Beijing according to Beijing’s socio-geographic characteristics. Based on the recent
statistic data, the possible positive effects of Separate Bus Lane are calculated and estimated.

Since one measure is unlikely able to handle all the complicated urban passenger transport problems in Beijing, some other measures are also addressed as important supplements for bus priority:

- The urban planning strategy should have certain considerations on reducing travelling distance and being bus-friendly, therefore, the high density residence sites should be designed to be close to the main bus corridors. A preliminary draft of this sort of layout is presented in this thesis. Satellite towns are increasing in number, so they are also needs to be carefully planned to give priority to bus so as to avoid cars’ adverse impact on living environment.

- City centre is the political, cultural centre, prohibition of car is suggested in this area. For the entire inner city, to guarantee most effectively use of road space, a suggestion is given to limit car use by using “Area’s Licensing Scheme”. Besides all of those regulatory measures, some economic methods are also recommended for reducing car number in the inner city.

- Cycling and walking are good traditional travelling mode which should be preserved and encouraged, therefore, bicycle paths and pedestrian areas are needed to be integrated to be important part of road network and public transportation system.
1. Introduction

Transport has increased tremendous during the last years in China, especially the use of private cars shows a rapid growth in cities. The reason is that China's motor industry was very backward before the economic reform in 1978, in the process of transformation from central-controlled economy to free market economy, more convenient and advanced transport means were urgently demanded because the backward transport system was called an crucial “bottleneck” for China's economic growth. Moreover, with the improving of people’s living standard, people are no longer satisfied with the old transport mode of cycling and walking, the private cars can provide a guarantee of individuality with a private room for travelling freely. Once affordable, owning a car is not only fashionable but also a representative of high social status, combining with other characteristics of comfort, flexibility, saving of time etc., many families are dreaming of cars. Although in the short time, majority of citizens are not able to afford it, the potential demands for car are expected to be tremendous in the near future.

In 1994, the central government of China promulgated an auto industry development policy that aims at promoting the motor vehicle industry to lead the development of the national industrial sector. The central focus of the policy is on the formation of a domestic market, particularly a market for household cars, to ensure economies of scale for the domestic industry. The policy sets a domestic car production capacity target of 1.2 million units per year by 2000 and 3.5 million units per year by 2010, with 90 percent of the products sold domestically. The policy aims to encourage private car ownership, and calls for the elimination of government controls on vehicle purchase, for car prices to be determined by the market, and for taxes on cars to be reduced. After this policy was pronounced, the mass media, common households, and local authorities delightfully proclaimed that the dream of “one family, one car” for China can be achieved in the beginning of next century.

Facing the rapid increase of car fleet in the cities, China's urban environment is undergoing an unprecedented challenge, especially in the developed coastal area and mega-cities, e.g. Beijing. Air pollution, congestion have been increasing up to an unacceptable level which affects city dwellers’ health and safety, the economic activity in the city also was badly disturbed by the chronic urban congestion dilemma, traffic accidents are keeping on growing for the past a few years. Although efforts have been stressed to develop the infrastructure every year, the road capacity is lag far behind the increasingly demands of car fleet.
To cope with the conflicts between increasing private transport demand and limited urban environmental capacity, a rational urban transport system is urgently needed to harmonise the people’s personal preference and social interests. In order to achieve this goal, a reasonable guidance should be given for a city to deal with the present problems and formulate a long-term rational urban traffic planning. It is no doubt that the present situation will finally lead to more serious traffic disaster in the near future if no decision is made to handle those problems.

Aim of this study:

Beijing is one typical Chinese city with those problems remaining to be solved, figuring out feasible countermeasures for its future sustainable transport network is a hard task for city planners. As a Beijing resident and environmentalist, I have strong interests on the issue of Beijing’s future transport mode, therefore, I focus the thesis study on:

- Analysing how car fleet is increasing in Beijing and how the traffic problems were generated by cars, particularly, how do cars influence people’s life but in turn how the new life style supported by car is affecting people’s travelling demands. Analysing how the booming car fleet affects traditional transport modes as bus, bike and walking.

- Based on the specific socio-economic condition of China, trying to discover a sustainable urban traffic planning model to cope with the contradiction among growing mega-city, increasing private travelling demand, and a vulnerable urban environment, the principles for evaluating passenger transport mode are: environmental sustainability, economic viability, financial affordability, social acceptability as well as long-term urban plan.

- Through case study of Curitiba and system analysis of Beijing’s public passenger transport system, formulating some concrete and feasible suggestions on how to reverse present situation in order to achieve a sustainable passenger transport system in Beijing.

2. Background

2.1 Motor Vehicle Growth in China: Trends and Projections

China’s motorization has been accelerating very rapidly recent years driven by the economic growth, the growth of the country’s entire motor vehicle fleet(excluding the motorcycles) experienced an annually average of 15 percent between 1984 and 1994.
Among all the increased vehicles, the passenger vehicle in China have been increased particularly quickly, with 20 percent increasing rate\(^1\).

With the improving of the family income, some families gradually are (or will be) able to afford an affordable household car. Although this trend just started several years ago, this tendency seems unavoidable. Recent years’ data shows: during 1984-1994, the number of privately owned motor vehicles increased by 28 percent per year, and the number of privately owned passenger vehicles increased by 64 percent per year. Private car data are not available, but available statistics for privately owned passenger vehicles indicate a decline in the average passenger seats per vehicle, from 22.2 seats in 1985 to 12.9 in 1994. This suggests that while most of these passenger vehicles are still for commercial use, the share of private cars in the fleet is rapidly increasing.

![Figure 1 Motor Vehicle Growth in China](image)

*Figure 1 Motor Vehicle Growth in China*
*Source: China Statistic Yearbook 1997*

Despite the impressive growth of motor vehicles in recent years, China’s per capita motor ownership remains among the lowest in the world with eight vehicles per 1000 population, of which only one is a passenger car. China’s motor vehicle ownership is not only much lower than the developed countries, but also lower than those countries with a comparable incomes. All this suggests a very low base and therefore predict a huge potential for continuing rapid motorization in the coming years.

### 2.11 Motorization Forecasts at the National Level

Motorization tendency has important impact on future’s public transport system in China, therefore, before discussing Beijing’s passenger transport system, let’s look at some projections on China’s car fleet development trend.

There are many uncertainties associated with projections of motorization levels for China, the basic features of China’s motorization currently are: low starting level, high rate of growth, and a recently announced Government policy for promoting the auto industry and domestic market.

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\(^1\) China Statistic Yearbook 1997
When compared China case with other developed or developing countries with the same experiences on auto development\(^2\), it was indicated that the level of one country's motorization are affected by various economic, cultural, political and geographical factors, but most importantly, the per capita income growth remains the single most essential driving force for the growth of motor vehicle ownership.

In China, many research agencies have done many researches on predicting the motorization trend in China's next century. According to the estimation of the Department of Transportation, Water and Urban development of The World Bank\(^3\), if assuming China's future per capita gross domestic product(GDP) growth rate keep growing by annual 8.0 percent till 2000, considering that the current high growth rate of motor vehicle ownership results partly from the rapidly growing incomes, and partly from “catching up" on the enormous pent-up demands caused by a tightly controlled supply of vehicles in the past, the two scenarios can be drawn for predicting China’s future motor vehicle development.

![Figure 2: Projections of Car Growth In China](source: Stephen Stares and Liu Zhi, Motorization in Chinese Cities: Issues and Actions)

This diagram shows the huge potential of increasing number of cars in the near future, in the scenario of low growth, the percentage growth per year during 1995-2000 is 16%, from 2000 to 2010 is predicting 12%, and 13% for 2010—2020; if taking the scenario of high growth, we can predict the developing proportion will be 23%, 15% and 13% respectively from 1995 to 2020.

### 2.12 Motorization Projections at the City Level

According to the international experiences, if not considering the intentional restriction by legislation, the passenger car ownership depends on the two main variables: per capita GDP and city population density\(^4\). Therefore, based on the assumptions below:

\(^2\) Stephen Stares and Liu Zhi, Motorization in Chinese Cities: Issues and Actions

\(^3\) The World Bank, China's Urban Transport Development Strategy, Proceeding of a symposium in Beijing, 1995

\(^4\) Stephen Stares and Liu Zhi, the World bank Transport Economists.
**Income Growth:** one scenario is lower income growth, Chinese will keep the current 15 percent per year to a stabilised 9 percent per year by 2000; The other scenario is higher income growth, per capita Chinese income maintain the current growth rate through 1996-2000, and then gradually declining to a sustainable 9 percent per year by 2005.

**Vehicle ownership growth:** A steady decline of the current 20 percent increase rate per year to the level determined by income elasticity by 2000.

**Population Density Decline:** Most large Chinese cities currently have extraordinarily high population densities, but many are now undergoing a decentralisation process. It can be assumed in the future the density in Chinese big cities will be 15000 persons/km² (Comparable to Seoul in 1990, and the target density in Shanghai's long-range urban master plan).

A projection has been made:

![Car ownership projections](image)

*Figure 3: Projections of Car Ownership in the Cities*

Source: Stephen Stares and Liu Zhi, Motorization in Chinese Cities: Issues and Actions

The projections show that car ownership growth in the cities could be sustained at high rates for many years if incomes continue to grow. In addition, urban decentralisation will contribute, to a lesser extent, to the increases in car ownership.

Therefore, over the next 20 years with continuing growth and expansion, according to this estimation, Chinese cities could see the car fleet increase by 13 to 20 times, or an average growth rate of 11-13 percent per year. even though, this estimation is still regarded as an conservative projection by many Chinese scientists because the major determinant data used here is per capita income instead of upper end of income distribution.
2. 2 Urban Passenger Transport System in Beijing

In order to analyse the urban public transport system in Beijing, first of all, let’s look some Beijing’s socio-economic and geographic characteristics.

Beijing is the capital of China, it has the functions as the political, cultural and economic centres of China, it is also one of the biggest cities in the world in terms of population size and built-up area size. Therefore, a high efficient, reasonable traffic network will be very important for Beijing’s sustainable economic growth and closely connected with dwellers’ life quality.

2. 2.1 Beijing’s Population Growth and Expanding of the City Area

Beijing is located in a plain which is in the north-eastern of China, to the left of 150 km away is the Eastern China Sea, generally, Beijing consists of the city proper and the 11 subordinate towns, in this case of discussing Beijing’s public transport, I will focus on the metropolitan area, in 1996, Beijing’s population is 12.6 million including the 11 subordinate towns. Based on the statistic of 1993, however, there is 6.4 million(1993) population living in the city proper. The built-up area of the city proper is shown in figure 4:

Figure 4: Built-up area of Beijing (1986)

The population in the city proper is still keeping the increasing trend slightly, from 1989-1994, the population growth rate is 1.29% annually in the city proper.

With the accelerating of urbanisation and economic activities in Beijing, the city is expanding very quickly during the past 20 years, the construction of road and residence buildings are stretching out into the new outskirts which used to be the agriculture land, even though, people’s demand of house and road is still far from being fulfilled. The
Bus or Private car? A Study of the Sustainable Urban Passenger Transport System in Beijing

Figure 5 below will simply show how it is expanding. It is based on the satellite pictures from 1972 to 1991.

![Beijing Expansion](image)

**Figure 5. Expansion of Beijing's Built-up Area**

2.22 Beijing’s Passenger Transport Networks

Beijing has been experiencing a rapid development of road construction, the present basic structure of the traffic network can be simply concluded as: “Three Rings and Two Metro lines”. Which means the main passengers corridors in Beijing is consisted by three paralleled square-shaped main express roads and two metro lines (as shown in the figure 6 below), Combining with the other various streets and roads connecting each other and stretching to every corner of the city, together they forms a complicated layout of traffic network of Beijing. Among them, the metro system surrounding the inner-city have started operating since the year of 1984 which includes two lines with a total length of 42 km.

![Beijing Traffic Network](image)

**Figure 6 Beijing City Proper Traffic Network**

As it shows in the figure 6 above, the layout of Beijing is featured by Square(rectangle) structure, the streets in Beijing are basically straight, either with the direction of East-west or North-south, hardly see any street is curving. With the Forbidden City in the middle, one square-shaped metro line and the Second Ring Road is covering the city centre of Beijing (See middle square in figure 6), Paralleled with the

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Square Metro line, the Third Ring Road and the Fourth Ring Road are located like two expanding squares covering the inner city with regular-shaped highways.

The Third Ring Road and Fourth Ring Road as well as the Metro were built during the past 30 years due to the constantly expansion of the city, currently, even the fourth ring couldn't meet the demand of city expansion, so the Fifth Ring Road is also being planned.

Besides the metro line covering the Second Ring Road, there is another straight metro going from the industry zone in the west to the inner-city which also carry heavy-loaded passengers commuting back and force between working site and resident places everyday.

Since the Second, Third and Fourth Ring Roads are heavily passenger-loaded as the major transport corridors for meeting the demands of 6.8 million city proper citizens, normally those Ring Roads were well-designed for 6 motor vehicle lanes (3 for each direction), those roads have few traffic lights because the flyovers have been popularly adopted to avoid intersections. The specific bicycle and pedestrian lanes were also built along the two sides of the main roads where barriers being used to separate the motor vehicle road with the bicycle track (Figure 7 below)

![Figure 7: The sectional picture of Beijing's Ring Road (main passenger corridor)](image)

Besides the main passenger corridors of the three Rings, many of the other roads in the city are less space and comparably narrow, most of them don't have a barrier among the different motor lanes and bike tracks. the common roads in the downtown (the city centre of Beijing within the Second Ring Road) are like:

![Figure 8: The sectional picture of Beijing's Traditional Road (in the inner city)](image)
2.23 Driving Forces Behind Increasing Trips in Beijing

The increase of trips in Beijing is not only because the population growth, but also the housing construction strategy during the past 20 years, Beijing’s road and residence site started to develop very remarkably in the “reform era” since 1979 in its own pattern. The urban planning strategy is quiet unique and different with many other city in Europe or US, for instance, many Western cities are often shaped like a circus tent, with a sharp peak of skyscrapers in the centre, sloping off to mid-rise buildings and then low suburbs of single-family houses. Beijing, on the contrast, is bowl-shaped, with low historic buildings in its centre, surrounding by many commercial skyscrapers and residential towers. Height restrictions have limited many buildings to 3 stories within 250 m of the Forbidden City which is in the central, 10 stories within the Second Ring Road. Several distinct dynamics have shaped Beijing’s growth. The state built a great deal of housing in Beijing during 1950s, but little was built in the 1960s and 1970s, partly to discourage migration to the city. In the 1970s, after China ended Chairman Mao’s political movement, many people who used living in the countryside returned to Beijing, and others came seeking jobs. Married couples increasingly sought their own home after marriage rather than living with their parents. By the late 1970s housing was scarce and crowded. In 1979, along with new reforms, came a boom in housing construction that was much needed; even though, still in 1990, some neighbourhoods housed more than 57000 people per square km.6

![Downtown of Beijing](image1)

![New Satellite Town in the Suburb](image2)

Figure 9. Downtown and Satellite cities in Beijing

In the more socialist era of 1949-1979, most Beijingers lived and worked in the same place—“work unit” which included communal dining halls, infirmaries, etc. so the city was not highly differentiated into office, shopping, industrial, and residential areas. There were few reasons to travel across town often. But this have been totally changed in the reform era; housing is typically still tied to a job, especially for many state employees which is very common in China that the house are assigned by the state employers, the state enterprises got the subsidy from the government to build the house, and assign to employees according to their years of working, position etc. Only a few very rich people can afford the commercial houses, many workers have to depend on

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this kind of welfare from the state enterprise). But the situation of working site close to house have been changed greatly because of the increasing demand. The price of building house in the inner city is getting so expensive that many work-units buy floors of apartment buildings, or other blocks of housing in the outskirts of the city, so still many co-workers live together, but far from the work site which increase the travel demand significantly than before.

Below is the illustration of the migrating tendency of people's residence site:

![Diagram of Beijing decentralisation](image)

**Figure 10. Decentralisation of Beijing**

In the 1980s, many industrial plants were moved from the central city to outlying areas due to the demand of reducing industry pollution. Much of the new housing was also outside the Third Ring Road, in medium and high rise buildings often built on former agricultural land. In the central city, office districts and shopping districts have been built or expanded. Many new buildings were built to meet the demand of expanding economic activities, the commercial centres, financial centres, banks, headquarters of many trans-national companies, big State-owned companies, as well as various governmental agencies, international agencies, embassies are accumulated in the city centre, along with the many important historical sites, the house rent in the city centre became so expensive that many residential houses were rebuilt or changed for commercial purpose instead of residence.

Even many residential house has been moved out of the city centre, many people is still employed in the inner city, the inner city became a place mainly for working, not for living, so people's daily activities now occur in separate parts of the city, which lead to traffic has increased greatly. Very common phenomenon is that many people come to the inner city in the morning and go back in the evening, so the two time period of 8-9 AM and 5-6 PM are the two rush hours, traffic jams happened at the two period of time very often, not only in the traditional road, but also even the highway of Second Ring Road and Third Ring Road, according to a statistic in 1993, the motor vehicle
travelling speed on the Third Ring Road in the day time have been decreased to 20 km/hour.7

The most important reason for people to travel is to go to work, but the next one is shopping and entertainment8, especially in the evening and weekend. One important incentive for attracting so many trip flows back and forth between the inner-city and suburb is most of the commercial centres and entertainment facilities are located in the inner-city or very close to the downtown, in the past time, there are only two or three big commercial centres in Beijing, all of them are located among the city centre, with the expanding of the city, more commercial centres emerged during the past a few years as shown in the map below:

Figure 11: Distribution of commerce and service centres in Beijing

The migration from the inner city to outskirts also have another important impact which is reduce of walking and cycling, since Beijing have a comparably harsh weather in the winter and spring(snowing and cold in the winter, windy in the spring), once the distance is enlarged, plus with the unfriendly infrastructure, make it very difficult to make the trips by the bike or walking, so as a side effects of the expanding of the city, the demand of motor vehicle travelling is increasing substantially, on the other hand, the trips carried by walking and cycling started decreasing. Even apparently the number of bike is slightly increase, but that doesn’t necessarily indicate people will use bike more frequently, in fact, the frequency of bike-use is decreasing during the past a few years.

7 Wu Yong, Wang Jianqing and Yao Zukang, Municipal Transport Management: A Domestic View 1995
8 Li Yaming, Urban Transport Statistics in China 1995
2.24 Passenger Transport in Beijing

The main passenger transport means in Beijing are bicycles, buses, Metro and Taxis as well as the expanding private car fleet. Bikes and buses used to carry more than 80 percent daily trips in Beijing, but with the increase of people's income, the situation is undergoing a dramatic change, more and more private motor vehicles are adding into the big motor vehicle fleet which lead to more problematic congestion and air pollution, for majority people in the city, they feel it is more difficult to make a trip today than the past.

Beijing's passenger vehicle fleet

During the past a few years, the motor vehicle fleet have been increasing very rapidly in Beijing, from 1992 to 1996, the number of motor vehicle have been increased from 473,238 to 798,392 in 1996. Among them the goods vehicle is almost keeping a constant level, from 170,541 in 1992 to 180,252 in 1996, however, the passenger vehicle had a significant improvement, from 161,190 in 1992 to 430,471 in 1996, the number has been tripled during a short 4 years.

![Diagram showing the increase in motor vehicle fleet in Beijing from 1992 to 1996.](image)

**Figure 12: Beijing's Motor Vehicle Fleet (1992-1996)**
*Source: Urban Statistical Yearbook of China 1993-1997*

Figure 12 indicates the most quickly increased portion is the fleet of passenger motor vehicles, more notably, the most significant increase occurred with the small passenger motor vehicle(cars), the car have been experiencing a radical increasing process as below:

![Diagram showing the increase in small passenger vehicles in Beijing from 1992 to 1996.](image)

**Figure 13: Small Passenger Motor Vehicle In Beijing (1992-1996)**
*Source: Urban Statistical Yearbook of China 1993-1997*
Bus and Metro

There is no specific data regarding the ratio of Beijing’s bus trips among all motor transport means, but for China as a whole, among the various public motor transport means in the cities, buses and trolley buses account for 75% of the total trips which covered by motor vehicles (1984-1994). This indicates bus has been the most important motor transport modes for city dwellers in China.9

Basically, the maximum carrying capacity of a bus corridor in China is 8,00010 passengers per hour per direction in the peak hours. But virtually the actual operating load of bus and trolley passed this limit even as far as in 1970s or 1980s. Especially in 1980s, to solve the problem of demand far beyond the supply of bus capacity, more buses were used and headway were shortened. Articulated buses had been increased during this period of time. In Beijing, to meet people’s increasing travelling demand, bus fleet has been slightly increased recent years, bus lines also have been expanded due to the growing of the city.

Metro is a kind of mass rapid transit system which is characterised by the mass ridership and high speed which are two of the most important requirements people is demanding for their travelling. Compared to bus system in China, the metro is only account a very marginal share because there are only 3 cities currently have metro system in China. however, In the specific case of Beijing, the metro system has two lines covering 42 km, it has been playing a very important role for undertaking a huge passengers trips in the city centre of Beijing. Beijing’s metro lines are surrounding the inner-city (which is exactly under the ground of Second Ring Road), the metro have played a very important role in Beijing’s passenger transport since it was open in 1986. In 1994 it carried about 1.5 million trips per day, and 15 percent of all public transport passengers. The maximum peak flows were 24,000 to 25,000 person per hour per day. Roughly 40 percent of passengers access the metro by bus, 10 percent by bicycle and 40 by walking.

Table 1. Riderships of Metro and Bus in Beijing

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<tbody>
<tr>
<td>Trips carried by Bus (million/year)</td>
<td>3060</td>
<td>2863</td>
<td>2999</td>
<td>3158</td>
<td>3054</td>
</tr>
<tr>
<td>Trips carried by metro (million/year)</td>
<td>428</td>
<td>491</td>
<td>533</td>
<td>558</td>
<td>444</td>
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Bicycle

China is called “a sea of bicycles”, bicycles play very important role in people’s daily travel, it has the characteristics of low cost, saving space, environment friendly, flexibility etc., therefore, it appears to be the most friendly transport means for the ordinary people, people use bicycle for the short distance trips, for instance, bicycles are used for travelling from house site to work site when the distance is less than 8-10 km (most commonly is less than 5 km, more than 5 km most people will prefer buses or

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10 Wu Yong, Wang Jianqing, and Yao Zukang, Municipal Transport Management: A Domestic View
people also use bike for most of their daily activities once the distance is able to be covered by bike less than one hour, going to school, shopping, going to the cinema etc., particularly during the past 20 years, with the economic growth of China, people’s life style is changing, correspondingly, the trips and travel distance also increase greatly. As an affordable and convenient transport mean, bikes become one of the most favourite traffic tools, in Beijing, the number of bikes increased from 2.9 million in 1980 to 7.89 million in 1993.

**Taxi and Mini Bus**

Due to lack of investment, no priority to guarantee the bus transport confronting with the booming car fleet. Commuters, floating population and residents who couldn’t bear the crowding, poor service and low speed of buses have turned their eyes to taxi and minibus, or in many cases, they’d rather use bikes than buses. As a result, minibus and taxi transport has developed dramatically in the past few years. In spite of those traditional transport means, the taxi also has been playing a more and more important role in Beijing, apparently, taxi has the advantages of quicker, easy to reach, no limitation of stations etc. Those characteristics are more attractive than buses, with a comparable low price in Beijing, the taxi have been increased very quickly in the past a few year in Beijing, in 1996, Beijing's taxi number reached 56,686. Taxi now carries more than 15% percent of total person-trips in Beijing.

A minibus usually has 17 to 19 seats, and operates mainly in the downtown area and along public bus routes. The minibus fare is slightly higher than that of bus, but the seating condition of minibus is better and it can stop any time to pick up passengers or let passengers off randomly, as a supplement of poor bus service, mini bus have been increased very quickly in the past a few years in Beijing. For example, the number of mini bus in Beijing has been increased from 437 in 1992 to 1319 in 1996, and the mini bus lines also have expanded from 30 to 10311.

**Infrastructures**

To meet the demand of motorization as well as release the congestion in the city centre, Beijing municipality has invested greatly on the infrastructure building for the past 20 years, the city landscape has been changed significantly, for instance, Beijing’s Third Ring Road and Fourth Ring Road were built in the past 20 years which totally changed the city’s transport network. During the past a few years, a lot of new flyovers for motor vehicles emerged in a quick speed which brought a big change to the city.

The detailed data of how the infrastructure has been expanded is not available, but from the data of motor vehicle flyovers and pedestrian bridges we can see the significant increase in the past a few years.

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11 Li Yaming, Urban Transport Statistics in China, 1995
2.3 Environmental Challenges Caused by Expanding Car Fleets

With the rapid increase of the motor vehicles, especially the booming car fleet, the congestion and air pollution became the biggest problems for China’s big cities. On one hand, people want to enjoy the freedom, flexibility of transport offered by the motorization, on the other hand, the limited environmental capacity of city can’t contain the increasingly number of cars. Urban infrastructure is undergoing an unprecedented pressure, the local dwellers are suffering from the worsening air quality which is undermining people’s health, below is the analysis of effects generated by car fleets.

2.3.1 Natures and Costs of Traffic Congestion

The first result of traffic congestion is that journey need more time to fulfil. Chronic traffic congestion can even result in fewer journeys being made because people are not prepared to do much more than the arduous journey to and from their workplace. Normally people all have an unconscious, but more or less fixed, daily travel time budget— if this budget is used up on essential travel, there is nothing left, no energy or inclination to make additional journeys for leisure or other nonessential journeys. This can be interpreted as a reduction in the quality of life in a congested city.

Congested traffic also impose higher cost to individual and the whole society, because:

A. Time cost money, whether this is directly in the wages of goods vehicle, bus and taxi drivers, or in the lost time of business executives, school children and shoppers caught in traffic jams. Also, congested traffic conditions means that additional time has to be allowed to make more journey for the greater uncertainty of travel, wasting even more time.

B. More vehicles are required to do the same job. For example, slower traffic means that a wholesale delivery van can service less shops in a day. To deliver the same
number of goods would require the distributor to invest in a larger vehicle fleet which
accordingly increase even more traffic congestion.

C. Engines are less efficient at slower speeds, and consume more fuel. According
to an example, dropping from 20 km/h to 15km/h will cause an average car to consume
about 25 percent more fuel for every kilometre travelled. Stop-go conditions are even
less efficient, with the engine idling during stops, and with frequent speed-change
cycles.

More importantly, an individual might weigh these costs and still decide that a
journey through congested traffic is worth making for reasons of personal convenience.
By doing so, however, the individual is unconsciously making travel more difficult—
slower, more uncomfortable, and more costly—for everyone else already travelling. In
fact, the costs and time penalties imposed on others in congested conditions can be
larger than the costs incurred directly by the individual. This is particularly true for the
car travel which is the most inefficient user of road capacity.

For the motorists, they choose to travel on congested roads by car because they are
responsible for their own costs, and have no liability for the additional costs they
impose on others. In other words, motorists do not pay the full price of their travel and
this encourages excess traffic. So actually, the congestion is, to a certain extent, created
by the systematic underpricing (prices greatly below cost) of all modes of urban
transport services.

2.32 Urban Air Pollution (Motor Vehicle Emission Trend)

Although presently the vehicle population in China is relatively low comparing to
other countries, air pollution problems caused by motor vehicles have started damaging
the big cities. One reason is that the vast majority of the vehicles in use in China are
driven in major cities. In addition, while some of the vehicles in China are
manufactured by joint-venture enterprises and by enterprises under the license of
developed countries, another portion are designed, developed, and manufactured by
domestic companies using designs that are more than 20 years old. One result is that the
CO and hydrocarbon (HC) emission levels in these engines are estimated to be about 10
to 20 times the levels emitted from the controlled vehicles in the Europe or North
America.

Furthermore, the operating speed of motor vehicles in the major cities is quite low
due to the crowded streets and mixed traffic (motor vehicle, motorcycle, bicycle, tractor,
even carts); the average speed inside the Third Ring Road of Beijing is lower than 20
Km/h in the daytime, which results in a high level of CO and HC emissions.

Therefore, pollution levels in the major cities of China are already unacceptable
high, especially for CO and HC. CO and HC levels frequently exceed healthy levels,
and their ambient concentrations is the same pace as the vehicle traffic patterns, that is,

\[12\text{ Perter W.G. Newman and Jeffrey R. Kenworthy, The use and abuse of driving cycle research: clarifying the relationship between traffic congestion, energy and emissions, 1984}\]
there. They tend to peak during the morning and evening peak traffic time. Within the city proper in Beijing, the average concentration of CO exceeds the limit prescribed by the National Ambient Air Quality Standard. Moreover, the concentration levels in the street and in the residential areas near the street are much higher than the average values. Finally, the proportion of days exceeding the standards is increasing in parallel with the increase of motor vehicles in use.

According to an air quality survey of Beijing in the late 1980s as summarised below, motor vehicles contribute about half of the total CO, HC, and NOx emissions coming from all pollutant sources.

Table 2: Motor vehicle emission pollutants' contribution in Beijing's Urban Area (Within the Third Ring Road) (percent)

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Winter Time</th>
<th>Summer Time</th>
<th>Annual Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>26.1</td>
<td>60</td>
<td>39.1</td>
</tr>
<tr>
<td>HC</td>
<td>62.7</td>
<td>86.8</td>
<td>74.8</td>
</tr>
<tr>
<td>NOx</td>
<td>38</td>
<td>54.7</td>
<td>46.2</td>
</tr>
</tbody>
</table>


Motor vehicle is also an important contributor of CO2 emission, as it is well known that China is a country with coal as main energy source which contributes to huge global warming gas emission, the expanding car fleet will undoubtedly worsen this situation, there is no details on how much proportion the CO2 in Beijing are from the transport, but for the example of Sweden, it was known that there was 40% percent of total emissions of CO2 in Skåne is from transport in 199313, which implies even the proportion in China is not as high as Skåne, with the increase car fleets, the CO2 emission from transport in Beijing can be predicted a significant increase in the near future.

NOx generated by motor vehicle in Beijing is also predicting an significant increase. NOx is an important element leading to asthmatic symptoms which damages people’s health, moreover, after NOx was oxidised to nitric acid in the troposphere, it can cause acid rain, the acidification caused by NOx and burning of coal will have further damage to Beijing’s urban surroundings, in addition, the presence of NOx is also a prerequisite for the generation of photochemical smog14.

Lead is another pollutant of concern in the major cities of China. Lead level in the urban area of major cities such as Beijing were used to be 1 to 1.5 μg/m3, and even reach 14 to 25 μg/m3 in some high polluted area15, but this situation has been changed after Beijing municipality started to spread the use of non-lead gasoline in 1996.

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13 Eva Ericsson, course literature from the course of “transport and environment” in LUMES, Lund University
14 Andrew R.W. Jackson & Julie M. Jackson, Environmental Science
15 Michael P. Walsh, Motor Vehicle Pollution Control in China: An Urban Challenge 1995
Generally, particulate problems caused by motor vehicles in Beijing are minimal. One reason is that driving motorcycles is restrained in many major cities of China including Beijing. In addition, the proportion of diesel-fuelled vehicles is relatively small compared to other countries. Most of the diesel vehicles are heavy-duty trucks, which are not allowed to drive in urban areas. In Beijing, therefore, the only significant diesel vehicle population is buses. Serious smoke suspended particulate matter, and SO2 pollutant in China mainly result from the coal burned by power stations, plants, and residents.

Based on the current vehicle emissions rates and the likely future growth in urban road traffic, adding with there are few programs to detect illegal emission levels and enforce standards, one can foresee a tremendous growth in vehicle-related air pollution problems in the near future. To reverse this tendency, government policy is urgently needed for taking measures to deal with those problems.

2.33 Accident, noise

As a side effect of motorization in China, the traffic accidents have been increasing for the past a few years, police record shows that there are more than 71,000 people died in auto accidents with 160,000 injured across China in 1995, the number of death is 7 percent increase over the previous year. In the urban area of Beijing, there were 9079 traffic accidents happened in 1996, with 442 death and 2024 injures\textsuperscript{16}, which indicates there was in average more than 1 people killed per day by traffic accident in urban area of Beijing.

Noise is also emerging to a big problem for the city dwellers in Beijing, road traffic is the major noise source leading to this problem, traffic noise in Beijing is a major nuisance in everyday life. Night sleep, in particular, but also rest, other leisure activities and other concentrated work are very susceptible to noise. Noise not only is damaging people’s health, but also is a important reason why more and more people try to avoid walking or cycling in or near busy roads, sitting in a comfortable car is comparably much quieter and pleasant.

3. Description of Problems: Present Passenger Transport System in Beijing

Motorization occurring in China currently have brought a lot of problems to the cities, the expanding of car fleet is significantly changing the frame of Beijing’s passenger transport system and furthermore to influence city dweller’s life qualities, below are some descriptions of urban passenger transport problems generated by car fleets in Beijing.

\textsuperscript{16} China Statistic Yearbook 1997
3.1 Deterioration of Beijing’s Bus System

3.1.1 Congestion’s Impacts on Bus Service

With the deterioration of road mobility, traffic congestion affects all road users, but bus users are particularly badly affected in the ways of losing punctuality and reliability. For example, bus dispatchers regularly send out buses on a route that takes one hour to complete. To maintain a 6-minute headway, 10 buses will be needed since the first bus will return in time to make the next journey after the tenth bus has departed. If traffic congestion increases so that it now takes half an hour longer to complete the route. In this case, the dispatchers have to make a decision among the two choices: either send buses out less frequently—now 9 minutes—or put more buses on the route—15 buses now are needed to maintain the 6 minute headway. The second choice is not realistic in the short run, but in a long run, a bus company might be able to acquire more buses to maintain the schedule. No matter what way to deal with this, service to passengers will deteriorate with definitely longer travel times and, if extra buses are not provided, longer waiting time.

Moreover, even the bus company finally figured out a way to buy more buses to maintain the headway, the cost of service will increase so that the fare will also rise, eventually leading to lower service and high fares. Simultaneously, poorer service and rising fares, which in turn encourages passengers to find some other way to make their journeys, adding further to congestion. Thus develops the downward spiral of increasing congestion, rising costs, poorer service, higher fares, reduced patronage, and even higher congestion that confronts urban bus operators.

Actually buses are the biggest victims of congestion, for instance, the expressway in the city proper of Beijing normally has 3 motor vehicle lanes for one direction, the midst one is the fast speed lane which bus is not allowed to use, as a result, bus have to only use the rest of the two lanes which have been accumulated with private cars, increasing fleet of taxis, vans, and frequently, the lawless cyclists. Obviously as big vehicle, bus don’t have the flexibility in terms of speed and volumes to compete with any other smaller motor vehicles. Consequently, bus in Beijing have lost their appeals to citizens gradually, now the bus speed in inner-city is only 10-15 km/hour\(^\text{17}\) (including the time for bus stops), more or less the speed of bikes.

3.1.2 Recent Trend: Bus Ridership Decreases in Beijing

Comparing to the development of small motor vehicles, big passenger vehicles’ increase in Beijing is far behind the cars, for instance, the public bus in the city only have a slight increase during the 5 years, from 4389 in 1992 to 5891 in 1996. As for the mini bus, it had a remarkably increase from 437 in 1992 to 1319 in 1996, which

\(^{17}\) Wang Jinxia, Zhang Kuifu etc. The reform and development of China’s urban public transportation enterprises. 1995
represent that the private-owned mini bus lines are very competitive under the condition of congestion is worsening and car fleet is expanding.

Among the various public motor transport means in the city, buses and trolley buses account for 75% of the total trips which covered by motor vehicles.

Table 3 Some Facts of Beijing’s Bus System (1992-1996)

<table>
<thead>
<tr>
<th>Year</th>
<th>number of bus (including trolley bus)</th>
<th>Bus Lines</th>
<th>Bus (including Trolley bus) total route length (km)</th>
<th>Bus and Trolley Total Ridership (million passengers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>4900</td>
<td>247</td>
<td>3337</td>
<td>3060</td>
</tr>
<tr>
<td>1993</td>
<td>4890</td>
<td>253</td>
<td>3490</td>
<td>2863</td>
</tr>
<tr>
<td>1994</td>
<td>4984</td>
<td>269</td>
<td>4075</td>
<td>3000</td>
</tr>
<tr>
<td>1995</td>
<td>4984</td>
<td>284</td>
<td>4496</td>
<td>3158</td>
</tr>
<tr>
<td>1996</td>
<td>6427</td>
<td>383</td>
<td>7275</td>
<td>3054</td>
</tr>
</tbody>
</table>


From the table 3 we see from the aspects of the number of vehicles, lines of vehicles and route length of different vehicles, from 1992 to 1996, more or less they all achieved a significant increase, but ironically, when we look at the ridership, the bus and trolley’s ridership didn’t have any increase almost for 5 years. Moreover, if we consider the increased population and floating population\(^{18}\) in Beijing, that indicate a notably decline of bus service. On one hand there is a remarkably increase of trips and travel distance in Beijing, on the other hand the riderships didn’t have any increase for 5 years. This obviously prove that the bus service in Beijing for the past 5 year has been definitely declined.

The most important causes for Beijing bus’s losing the customers are not only because more people are able to afford the cars, but more essentially, the bus service is on a way deteriorating which couldn’t keep track with people’s travel demand. Something must be done to change the backward picture of Beijing’s bus system. In the circumstance of stiff competition on the road, there is nothing increasing bus number can do, because no matter how much buses number increase, or how longer the length of bus lines have been expanded, the slowest bus speed is the greatest obstacle for keeping people’s optimism on bus transit while the travelling speed is becoming the first consideration of choosing transport mode.

3.13 Poor Bus Service in Beijing

Another problem for Beijing’s bus is backward technology and uncomfortable boarding environment, which is also highly demanded by the riders, since bus is slow,

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\(^{18}\) Floating population means those rural population who come to the city for a temporary work but don’t belong to the city (without an urban citizen ID)
not punctual, too cold in the winter and too hot in the summer because of no air-conditioner, furthermore, due to the frequently delay of schedule, many buses in the rush hour are over-loaded, many passengers have to stand in the bumpy bus with a rather low speed, standing is tiresome, if the weather is bad, with an unbearable atmosphere because of the high passenger density on the bus, there is not any pleasure to take the bus at all, once financial condition permit, people will avoid using buses.

3.14 Low Efficient Bus Management System

Those problems discussed above in Beijing’s bus system was caused by the special administering system, all the bus and trolley bus are run by the municipality of Beijing, the bus fare is rather low compared to any other city in the world (for example, in the inner city of Beijing, normally 1 Y for one bus trip), which lead to a huge subsidies annually from the local government. There is no any competitions in the bus sector, because only one state owned bus company can legally provide the bus service and be acknowledged by the municipal government by a huge subsidies. Eventually there is not any incentives for the bus company to improve their service. Since the bus company have the monopoly right, there is no point for them to do any innovation or improve it’s service, the benefit of the operation is not directly connected with the service and ridership, which on one hand lead to a low efficient operating of bus system, on the other hand the scarcity of fund is an constant big problem for the city municipality, this is one of the most important institutional reasons accounting for the decline of bus service in Beijing.

So overall, Beijing’s backward bus system and poor bus service can’t keep track with people’s increasing travel demand, to reverse this adverse situation, some immediate measures is urgently needed.

3.2 Potential Trip Decrease of Cyclists and Pedestrians

It is no doubt that bike is the most important transport means for Beijing citizens, bicycle trips are 54% of the total trips demands\(^{19}\). Even the car fleet is expanding in the city and many families are planning to buy family cars, but currently they are still not able to afford it right away, therefore, presently the cyclists are still the majority among all the commuters in the city proper of Beijing. Once the travel distance is below 5-8 km, people will prefer to take the bike rather than go by bus, bikes are economic, pragmatic as well as convenient for daily short travelling. But the bad news is that the booming car fleet is increasingly undermining people’s preference of bikes, that is because of the reasons below:

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\(^{19}\) Li Yaming, Urban Transport Statistics in China, 1995
3.21 “Road is too dangerous for walking”

In the case of Beijing, many roads in the city proper don’t have barriers between the motor vehicle lanes and non-motor vehicle tracks. Mixing the high-speed motorised vehicles with the unprotected cyclists and pedestrians, make the cyclists and pedestrians very vulnerable in accidents. Particularly, with the rapidly increase of car fleet, when facing the congestion, all the drivers and the cyclists are struggling to go quicker to pass the traffic jam zone, especially in the rush hour of commuting to work or going home, many serious accidents happened in this period of time. Once accidents happened, the most serious victims are always the cyclists or pedestrians because they don’t have any effective protection. As discussed before, the road traffic in Beijing is killing more than 1 people and injuring 7 people everyday in average, and the main victims are cyclists or pedestrians, isn’t that frighten if you are fond of walking in that kind of city?

According to a investigation made by the Beijing Municipality Traffic Bureau, many people who used to walk also are suffering from the unsafe road situation in Beijing, for instance, parents go to pick up their kids in the kid-garden and primary schools are more and more common because the parents are worrying about their kids’ safety when they walk on the road or cross the street. For those elderly and the disabled, the heavy motor vehicle fleet make their life even harder because there is no grace for them to walk slowly on the street, moreover, it might be impossible for them to cross the main road with such a heavy traffic in Beijing.

3.22 “Air is too dirty for cycling”

As another side effect of expanding car fleet, the deteriorating air quality in the cities also force people to give up bikes, for instance, on the same road, obviously the cyclists breath more dirty air than those motor drivers whose motor vehicles generated heavy pollution but they were protected by the vehicles. Many citizens in Beijing complained the air quality have been worsening to the level they couldn’t go to work by bike as before because the year-round exposed to the polluted air already brought them frequent headaches, fatigue, coughing, breathlessness and smarting eyes. In the dense-polluted roads of Beijing, some pedestrian and cyclists even wear respirator when they go through those area.

With the expanding of car fleet, the air quality in Chinese big cities are getting worse, which is a definitely bad news for the cyclists and pedestrians, even for the short travel of less than 5 km, more and more people prefer to take the bus or taxi.

3.23 “Infrastructure is not friendly anymore”

To meet the demand of booming car fleet, Beijing municipality advocated to build the more expressways, flyovers to relieve congestion and facilitate the speed of motor vehicles, as a side-effect, the cyclists found they are in a very vulnerable position and a inferior status in terms of road use. It is gradually much difficult to use the roads because the barriers, flyovers make them have to travel much longer distance than before for completing trips, gradually, the inconvenience caused by car is emerging to be a big obstacle for the cyclists to keep being optimistic on bikes. Nevertheless, even the bike is facing such a adverse road environment, the current financial problem of
buying a car in short term also kept many people sticking to use bikes, but the risk is: the financial factor is becoming the most crucial factor for keeping most people use bike, on the other words, once affordable, the bikes are very likely given up easily even currently the bikes are still undertaking the most of the trips for ordinary people.

Walking was one important transport means in the past time for people to fulfil their daily trip, however, they also got the same problems of barriers as cyclists, many people gave up walking because of that. In a sense, pedestrians are the biggest sufferings of the motorisation, for example, they can cross the street on the footpath before the expressway was built, but now the highway prevent them doing so because the road are paved wider which was also closed just for motor vehicle use, although the city planner designed some small pedestrian bridges for pedestrian to cross the road, but most commonly, the distance between two walking bridge is at least 1000 meters, that is very tiresome for people to walk so long just for crossing the street which is much easier before. This on one hand is turning more people from walking to cycling, on the other hand increase the use of motor vehicle, people are getting more and more relying on the motor vehicle, because it is obviously the most favourable way in terms of road as well as the city’s expanding size.

3.3 Taxi and Mini Bus Fleets are Exacerbating the Congestion

As we discussed before, taxi accounts on 15% passenger trips in Beijing, even the taxi is becoming an important transport mode in Beijing, one thing important to be acknowledged is that taxi is not a good transport means for releasing traffic jam, on the contrary, it is a big contributor to congestion because it scatters in everywhere of the city, parking randomly, picking up passenger by any chance, expanding taxi fleet will be a big problem for Beijing.

It is true the mini-bus has some advantages before cars because it can carry more passengers and save space to a big extent, moreover, in a sense the minibus also alleviated the crowd situation of public-owned buses. However, they also contribute to traffic disorder. In particularly, because they don’t have fixed bus stations, they can stop at anywhere to pick up passengers, this affect adversely the regular operating order of buses and trolleybuses at their terminals and stops, mini buses have a limited carry capacity (less than 20), so actually it is not a very effective option for relieving the congestion in China’s megacity. It’s role in city’s transport system is still questionable. Some cities in China now have many more minibuses than ordinary buses. Due to its problems, some cities have issued special local traffic rules to restrict the further expanding of minibuses.

Overall, the major problems facing Beijing’s passenger transport system are: 1. People’s demand of personal transport are increasing which lead to stiff competition on road space; 2. Congestion and air pollution are accelerating in the city an undermining people’s life quality; 3. Private car fleet significantly affects the traditional transport modes of cycling and walking, cycling and walking are gradually losing their
popularity; 4. Bus service have been affected greatly by the car fleet in the ways of reducing riderships and losing its attraction.

3.4 Different Views on Solving the Problems

From the last Chapter we know the basic cause of Beijing's transport problem is the expanding car fleet, mixing with the slow moving bicycles flow, which have brought the serious congestion to the city. The congestion lead to low speed which eventually results in a higher air pollution. Moreover, the congestion and air pollution also are undermining people's preference of cycling and walking, all of those caused by car fleet forms a vicious circle.

To shift the low efficient passenger transport system in Beijing, there have been various ideas on how to deal with those problems. For example: Further develop underground; Abandon cycling in city centre; Enlarge or rebuild infrastructure in the inner city; Restriction of car use in the inner-city. Etc.. Following are the analysis of pros and cons of those different alternatives.

**Suggestion 1: Full-scale Metro Network for Beijing**

The proponents' strong points for advocating the necessity of expanding Metro in Beijing are: 1. Metro can solve the problem of traffic congestion; 2. As a historical city, the infrastructure shouldn't be expanded unlimitedly, 3. The resettlement of huge population need a space-saving way to facilitate the transit system, and 4. the huge pressure on land growth of everything make a sophisticated metro system urgently needed. 5. the current bus capacity is far behind the demand forecasts, 6. The speed, reliability and comfort of metro is nothing other public transport mode can compete, which is also helpful for establishing an good image of international metropolitan city with a high quality of life and business efficiency. so overall, there is no alternative to avoid large-scale developing metro.

Based on the experience of Beijing, the advantages of metro are very evident in term of increasing the quantity and quality of public transport, certainly, on the other hand, it could also significantly influence the land use policy and city structure.

Even though, China as a developing country, the limitation of advocating metro is very evident. When many opponents acknowledge the advantages of developing metros, they also mention the financial problems of construction and maintain metro. Because so far, in three big cities of China where metro is in operation, none of them is near being financially viable. None is likely to operate at a surplus at least for some time. For instance, Guangzhou is building its first metro line of 18.5m, which is estimated Y 12.75 billion(1Y=1SEK) cost, despite the expensive construction fee,
Guangzhou municipal government forecasts annual operating subsidies for 12 years. In the case of Beijing, Beijing funds about 30% of its direct operating costs from fare revenues. Secondly, construction of metro is very time-consuming, even the money have been collected finally, the completion of the metro will be many years after planning, socio-economic change is rapid, leading to profound changes to the structure of demand, and in particular trip lengths, which are difficult to forecast with confidence. It is very hard to guarantee whether the plan will be out of date when the project is completed. Thirdly, since the metro is mostly built underground, once the route is designed, it takes a long time to complete, after finished, the route is fixed and lack of flexibility. The design of routes are very risky since it has to have a long term prediction which is very hard to make. So in a few words, the large-scale metro construction is not only unaffordable, but also risky, it could be a good way for transport mass population, but there is also the possibility that the gain is much less than expected because China is undergoing a rapid socio-economic transition.

The initiative of metro for many city is to relieve the tension of congestion, but according to the statistic from many cities with metro in the world, almost none of the cities offered any evidence of any long-term reduction of traffic congestion. the reality always is: the new problem is generating when the old was solved. The metro can help to shift part of bus passengers to the metro so as to improve the quality of public transport, but with few car trips are willing to diverted to metro. In the case of Beijing, the metro under Second Ring Road was proposed to release the traffic jam in the inner-city, city planner not only built the metro, but also expressway above the metro, even though, the congestion is getting worse continually, the road space that is released by the new infrastructure is filled up by newly generated traffic very quickly. So in this sense, metro have little to do with the congestion.

Another important impact metro might raise is the land use policy of the city, in the circumstance of decentralisation, the metro give a strong incentive on continuing development of a strong city centre, it will have a very complex impact on the structure of the city. Whether it will has positive or negative effects is still remained to be seen. Overall, the pros and cons of metro can be concluded as:

<table>
<thead>
<tr>
<th>Reason for Building a Metro</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Will improve public transport?</td>
<td>Yes</td>
</tr>
<tr>
<td>2. Will relieve traffic congestion?</td>
<td>No</td>
</tr>
<tr>
<td>3. Will be financially viable?</td>
<td>No</td>
</tr>
<tr>
<td>4. Will promote land use policy?</td>
<td>Not clear</td>
</tr>
<tr>
<td>5. Necessary to carry forecast passengers?</td>
<td>Not sure</td>
</tr>
</tbody>
</table>

20 Roger Allport, Investment in Mass Rapid Transit, 1995
Suggestion 2: Restricting Bikes in the Inner City

It is obvious that the bicycle is also one of the big contributors of the traffic jam in the city proper of Beijing, because although bike is small, flexible, it’s vital disadvantage is low speed. In the inner-city, the traditional road is narrow without any separation of motor road with cyclists road, the chaotic mixture leads to a very low speed of both bicycle and cars, in the rush hours of Beijing, the speed of cars are normally less than 20 km. Currently the mixed transport situation virtually is the root cause of low efficient traffic system in Beijing. The low-speed motor vehicle also emit more pollutants than the normal speed, moreover, the low speed in turn make the trip need much longer time to complete, that external time means not only a lost of money, but also generating more pollutants. To meet the demand of motorisation and effectively use the road in the inner city as well as keep a high mobility of car fleet, many car-owners and some city planners in Beijing suggests discouraging bicycles in city centre. Their point is the restriction of bike will increase the speed of car significantly so as to reduce the congestion. Based on same kind of concept, Guangzhou, the third biggest city in southern China, had imposed some local law in the some streets of city centre not allow using the bike.

However, the problem raised by restricting bicycles in town is: there is no substitute for the common people if they abandon their bicycles. So if we arbitrarily make the decision right away, that means most people who can’t afford the cars would have to shift to use the public transport of bus or metro, however, for the inner city, the traditional building structure and road space is not capable to build more bus stops or open more new bus lines in the crowded avenues, therefore most people have to walk a long distance from the terminal of bus or metro to the place they want to go, consequently, the taxi will come to the city centre more often, combining with the private cars, buses, the traffic congestion will unlikely be relieved. Moreover, it is very vague how long it can last for the cars to have a higher speed because more space in the inner city will positively lead to more cars coming to the inner-city, eventually the extra space made by bikes will be filled out by car again shortly. Majority people’s long distance walking also can be regarded as a sort of reduce of life quality. On the other hand, more people’s using motor vehicle, the air pollution and congestion generated by the increasing motor fleet in the inner city will be unlikely decrease, on the contrary, it will continue to damage the air more seriously which eventually harm people’s health.

Overall, in my opinion, restricting bike in the city is unrealistic for Beijing, the gain is uncertainly higher mobility of car users for a while, but the pay will be majority people’s life quality.

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21 Guangzhou Daily, April 1994
Suggestion 3: Building or expanding more roads in the inner city

At the beginning of 1980s, the city planners has unintentionally followed this idea of expanding the avenue in the city proper to meet the demand of city expansion, but finally they realise the infrastructure is always lag behind the increase of demand\(^\text{22}\). No matter how much to build, the road is always congested. Some urban planners argue the historical sites in the city proper should be perfectly protected so we should not make a big change about the layout of the roads.

In my opinion, the real issue is not only the concern of protection historical sites, but also what is our expectation of the future layout of the city? Should we continue to concentrate on the city centre or evenly redistribute the population in the city? Which will be more adequate? What will be people’s preference in the future? Do the city planner has a clear picture of Beijing’s future? Should we keep the old structure of all the important business centre and public facility focusing on the city centre? or how do we foresee the trend of population growth and the socio-economic change and accordingly plan a new structure for the city? All those questions are still remained to be answered.

This is also closely connected with the question of building metro, to rebuild the infrastructure in the inner city is not only because it is costly, but also the consideration of whether in the future people will like go to the city centre as frequently as today, for the past few years Beijing already started a process of decentralisation, the national policy of developing the family cars predicted a likely promising increase of car fleets in the near future, the question is: what will happen after the car is popular among the ordinary people? In the suburb of Beijing, more than ten satellite towns have been emerged recently, some of these town has planned a completed public service facilities, school, postal office, bank, cinema, supermarket, for instance, in the north-east of Beijing, a new town called Wang Jing which even have a biggest supermarket in the Beijing, so most people can get everything they want locally, they have little need to go to city centre for shopping now. Moreover, many business companies also follow this trend to move to those satellite cities in order to access bigger space and expand their business, so the job opportunities are increasing significantly in the suburb towns, this new trend on one hand leads to partly less long distance trips because many people might go to work within the same community, on the other hand also partly increase trips since there are also possibility that many people maybe go to other suburb community to work. This reflected a trend that happened in Western country before, both of the two possibilities will not be benefited from the rebuilding of inner-city infrastructure. If this trend continue, it will be doubted if the metro and rebuild infrastructure will be necessary. In a long run, the estimation of frequency of passengers’ travelling on the expressway of inner city and metro will be very vague and uncertain.

In a few words, in my opinion, there is little rebuilding infrastructure in the inner-city can do for improving the traffic in Beijing because the basic conflict is between people’s personal travel demand and the limited infrastructure capacity. It seems the infrastructure will unlikely keep pace of people’s huge demand, the future city’s layout

\(^{22}\) Beijing’s 7th-five-year(1986-1990) plan and 8th-five-year(1991-1995) plan
is not clear, people’s transport preference is not certain, so totally it is very risky to invest heavily on the inner-city infrastructure.

4. Objectives and Scope

Based on the problem definition and analysis of different alternatives, the objective of this thesis is to discover a sustainable transport model for Beijing’s urban passenger transport system which could fit in Beijing’s metropolitan characteristics and it’s specific geographic, socio-economic condition. Basically, it should have, in some extent, the features of environmental sustainability, economic viability, financial affordability as well as social acceptability, which can be interpreted as a innovative passenger transport system with the features of:

- Based on the present infrastructure condition, to transport the maximum number of passengers.
- Mitigate vehicle’s adverse impacts on the health and welfare of urban residents, particularly, air pollution generated by motor vehicles should be minimised.
- The financial strategies for the system is realistic for investment and operations.
- Have a high social and economic returns in terms of the full resource costs of inputs.
- Acceptable for the all sectors of society, particular can be accessed and accepted by the majority citizens, the poor as well as other disadvantaged members of society.

5. Methods

In order to discuss the possibility and feasibility of bus priority as well as car restriction etc. To copy with Beijing’s transport problem, a combination of methods are needed for this study:

- Literature survey/studies. Relevant important data and literature are from Lund University Library, United Electronic Library of Sweden, Library of Department of traffic planning and engineering in Lund university, also, Ms. Eva Ericsson, as my supervisor of this thesis, has provided many valuable literature for supporting my composing of theories. Most latest data about passenger transport in Beijing is got from Ms. Ping Zheng who has given me great assistance with some essential data in respect to Beijing’s current public transport system.

- System analysis. System analysis has been applied to clarify the causal relationships among the various determining elements of Beijing’s passenger transport system.
Calculation of effects. Based on the relevant data, some statistics have been carried out in order to compare the different effects of various transport modes, calculation also applied in the process of making estimation.

Case study. The Crutiba's transport mode and urban planning structure will be introduced as an example to illustrate why and how to carry out bus priority, and how to formulate a rational long-term traffic and land-use plan for a sustainable urban passenger transport system.

Synthesis of results from all the methods.

6. Theory and Analysis

6.1 General Comparison of Bus and Car

First, bus is currently one major public passenger transport means for normal people in Beijing. Bus trip rate in Beijing is 0.39 (per person per day), which reflects the huge demand from bus users. Compared to other transport means, bus have advantages in the ways of high passenger capacity and environment friendly.

Saving space greatly. Taking account of the average car occupancy rate (1.5) in city traffic, around 50 cars are required, with their correspondingly greater spatial requirements, to transport the same number of people as a single bus. The table 4 shows how different the car and bus are in terms of the space requirement.

Table 4 Comparison of space-saving of car and bus

<table>
<thead>
<tr>
<th>Transport Mode</th>
<th>Fully Occupied Car</th>
<th>Car with one person</th>
<th>Bus full</th>
<th>Bus 1/3 full</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed(km/h)</td>
<td>40</td>
<td>40</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Space Required Per Person(m2)</td>
<td>20</td>
<td>60</td>
<td>9.4</td>
<td>28.1</td>
</tr>
</tbody>
</table>

Source: Transport for a sustainable future—the case for Europe, p79

In spite of the less road space, the buses only demand one parking place because most of the buses have the same destination and departure station, on the other hand, for those people using the car, they use car to transit from home to work site, which demand at least two park places, if counting in their daily other leisure activities, shopping etc., the more parking places will be required by cars.

Less energy consumption. The car’s energy consumption per passenger is far higher than that of buses. To transport one person by car, a car’s energy requirements
per person kilometre are either ten or twenty times greater compared to a half-full bus (seats only, this is the example from Germany, in China the bus are always full-loaded in the day time), or a fully-loaded bus. Moreover, bus operators are able to tailor their vehicles to transport demand by modifying service densities and vehicle sizes. depending on transport demand, small, standard or articulated buses may be operated, helping to curb unnecessary energy consumption and minimise pollutant emissions.

**Reduce air pollution.** It is obvious that pollutant emissions from cars, in terms of the number of people they transport, are a great deal higher than those from buses, as the table 5 showing below, generally, the per capita pollutants generated by cars are much higher than buses. The surveys in Germany investigating pollution from harmful substances have shown that a 24% journey shift from cars over to public bus would mean a reduction in harmful emissions from traffic of between 20 and 30%.

<table>
<thead>
<tr>
<th>Pollutants(g/pers.km)</th>
<th>Cars</th>
<th>Buses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>1.5</td>
<td>0.9</td>
</tr>
<tr>
<td>Nitrogen oxide</td>
<td>2.9</td>
<td>0.5</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>21</td>
<td>1</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>240</td>
<td>70</td>
</tr>
</tbody>
</table>

*Source: Herbert Hußmann The bus Transit system and its contribution to promoting mobility and quality of life, 51st international congress Paris 1995*

**Flexibility of Bus Route.** In the sense of urban planning, buses transit have magnificent advantages than any else transport means in the city, the bus route can be flexibly adopted to the new trend of city decentralisation or people's changing preference, the existing infrastructure doesn’t need to have any big change to be able to open a new bus line, the cost of the new bus lane and building bus stops is much less than any other infrastructure construction, since the cost won’t be high, the fare of bus ticket also can keep comparably low which can be more friendly to city ordinary residents, so eventually more people will like to travel by bus.

Although bus has so much remarkable advantages than the any other transport means, if there is no priority on bus, once affordable, for majority people, they will chose the car. it is obvious that the car still have much more attraction than bus since it has the private room, more comfortable, freedom of travelling etc. moreover, the mobility that car provide to individual is a sort of guarantee of the individuality and personal development, making it part of the freedom and quality of life of individuals as they themselves determine their working life, social and leisure activities. Furthermore, if bus don’t have priority, the worsening congestion in the inner-city will undermine the penitential and advantages of buses, consequently leads to less and less ridership because once congestion happens, the buses will be the slowest vehicles on the road. This has been described in the Chapter of Problem definition.
6.2 System Analysis: Why does Beijing need bus priority?

Based on the discussion on Chapter 1, the situation in Beijing is: City proper population is keep on growing slowly, but the expanding of the city is in a rapid process, the demand of more space and house motivates people move from the city centre to outskirts, separating work site with residence site creates much more trips than before. This increasingly trend is becoming an unprecedented challenge to Beijing’s infrastructure, which also influence people’s preference of traffic means, the traditional transport means of cycling and walking have also been affected significantly due to the congestion, air pollution and unfriendly new infrastructures.

6.2.1 Interactions of car, bus, pedestrian and cyclist in Beijing

Since China is advocating the development of domestic car industry, increase of people’s income and decrease of the cost of car and tax are predicting a substantial increase of car fleet in the near future in Beijing, the implication of this kind of transformation is reflected by a radical conflict occurring in Beijing’s urban passenger transport system, which can be simplified as the causal diagram below:

![Figure 15: Causal Loop of Car, bus and Bike in the City](image)

As described in the figure 15 above, the situation caused by car are like a vicious circle, frequent congestion is generated by more cars in the city, the increase of congestion definitely lead to slowing bus’s speed and punctuality which are two most important determinants for influencing bus’s ridership. As a result, people gradually shift their preference to personal car which leading to further demand of car transport. Most notably, more cars in the city will create more demand on parking spaces, accordingly, opening more place for car parking also enable more cars access to city.

On the right side of the loop, it can be understood how the car fleet influence pedestrians and cyclists. When congestion happens frequently, the more highways and flyovers are required to be built for relieving the congestion, which can release
congestion in certain extent, but itself is actually big obstacle for cycling and walking. That is why people think travelling by bike and foot are more difficult nowadays than before, eventually, this will lead to a tendency of declining cycling and walking in the city.

From this causal loop we can see the consequences of cars expanding: leading to both less bus passengers and less pedestrians as well as cyclists, which eventually lead to people’s shifting their preference to private motor vehicles.

In Beijing, the rapid expanding of the car fleet inevitably lead to this result, the congestion has been worsening during all the past a few years, the biggest victims are the bus users, cyclists as well as pedestrians. Time consumed by waiting and traffic jam are unbearable, waiting for the bus which supposed to come in 5 minutes but sometimes people have to spend more than 30 minutes just for waiting. For passing a traffic jam, it is not unusual for passengers to wait for half hour on the bus. Moreover, although the car fleet is expanding, the passenger trips covered by cars are only very small portion among all the passenger trips, that means the minority people have occupied the majority road. This is unfair and unreasonable since the majority still have to count on the buses and bikes. Consequently, the traffic jam and declining bus service make common dweller’s life quality worse.

6.22 Motorization and Infrastructure

Decentralisation of the city also plays a very important role on transport flow and the trips in the city, as illustrated before, the continually separating of living site with the working site are greatly increasing the daily trips in the city, we can explain it by the figure 16 below:

![Causal Loop of Motorisation and Infrastructure](image)

Figure 16: Causal Loop of Motorisation and Infrastructure

First of all, it is evident that the accessing to private motor vehicles will give freedom of travelling to people which make it possible for people to move out of the city centre
for a bigger house, nicer environment and cheaper rent. This is a trend have been proven by the Western countries' same experience.24

With the more and more people willing to move to outskirts of city, more satellite cities are forming as a result, this has happened in Beijing already, the new emerging satellite cities will inevitably lead to three consequences: more infrastructure demand, more trips, as well as longer travelling distance.

Unlike people live and work in a same community before, the new life style make people travel from one community to the other for working, shopping or leisure activities. More travelling demand will lead to more infrastructure requirement, but more infrastructure will in turn provide a necessary prerequisite for expanding car fleet. Since now people demand more trips and the travel distance is much longer than before, the new travelling demand unlikely can be covered entirely by bike or walking, as a result, the demand of car use increased correspondingly. So in a few words, the car enable the decentralisation, however, decentralisation in turn creates more demands for car travelling.

As it was discussed before, car has the characteristics of high mobility, flexibility, comfort and convenience. Particularly, for most ordinary people, the high mobility and time-saving are the most important factors determining their alternatives of transport. Recently, the China’s national policy of developing domestic car industry indicates that the government will unlikely to restrict the purchase of the cars, so the problems facing Beijing’s city planners are: how to make a rational traffic plan for Beijing to avoid the coming disaster of congestion, air pollution, increasing accidents caused by the surging car fleet, meanwhile, people’s increasing demand of higher life quality should also be guaranteed. In order to discourage people’s unnecessarily purchase and use of car, city planners should at least give those penitential car passengers an acceptable substitute which can both guarantee them a high mobility and good service.

6.23 The Role of Bus Priority in Beijing

In my opinion, bus priority is a good alternative for achieve the goal of both guaranteeing a high mobility and avoiding congestion, the concrete method is to give prioritised road right to buses, for example, set Separate Bus Lane specifically for bus in the critical roads of city, the mechanism of Separate Bus Lane can be analysed as below:

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24 According to a interview of one Swedish family in Dalby, Sweden, spring of 1998.
Assuming bus priority has been applied to the city, from the causal loop above it is easy to foresee the consequences. First of all, a direct workout of more Separate Bus Lanes is higher bus speed because the specific lane can guarantee bus having a privilege of not being disturbed by congestion, with the improvement of bus speed, as we discussed before, the headway can be shortened because covering the same distance require less time now. Shorter headway in turn implies bigger bus capacity: same number of buses can carry more passengers than before.

Because bus can successfully avoid the congestion after the Separate Bus Lane was applied, the bus will be more on time than the case without bus priority, which consequently leads to more bus reliability, that means people will more trust and rely on bus’s service, subsequently, with the growing of bus credibility, more people will prefer to take bus rather than other transport means.

Bigger bus capacity and higher reliability together can consequently make a big difference on bus’s image, a modernised bus system should be able to provide a sufficient, convenient service to passenger so as to reduce people’s unnecessarily using of car. however, as I analysed before, the car has so much advantages than any other transport modes, the only measure of bus priority is not enough for reducing car number in the city, therefore, car restriction is needed to apply to the inner city to be a compulsory supplement for guaranteeing less car use and less congestion, less cars on the roads will in turn to further increase the bus speed.

Overall, we see a virtuous circle emerges after Separate Bus Lane is applied to the city proper, therefore, in large scale, the importance of bus priority must be acknowledged. It is clear that a choice must be made to rectify Beijing’s public transport problem, without choice is also a choice, but that will lead to a disaster of traffic turmoil, compared to all the other transport means, the bus priority is a more reasonable choice for relieving Beijing’s traffic congestion, reducing air pollution and leading to a sustainable future.

Figure 17: Causal loop of the role of Separate Bus Lanes: a “virtuous circle” for a sustainable transport system.
6.3 Successful Experience of Urban and Traffic Plan from Curitiba

Bus priority is not only a literal theory, in fact, in Curitiba of Brazil, several decades ago this unique experience has been applied, although Curitiba also had the same pressure from population growth and city expansion, but its unique integrated transportation network and urban plan strategy mitigated the adverse effects in a great extent. Today, internationally, Curitiba is a good example of successfully achieving a sustainable transport system and urban plan in the Third World.

Box 1 Integrated Transportation Network in Curitiba

Curitiba is the capital of Parana in Brazil, south America, its metropolitan population increased from 300,000 citizens in 1950 to 2.1 million in 1990, Curitiba has a unique rational traffic plan which is regarded as a model for applying to other cities.

Curitiba doesn’t have a gridlock centre fed by overcrowded highways. During the 1970s, Curitiba authorities instead emphasised growth along the prescribed structural axes, allowing the city to spread out while developing mass transit that kept shops, workplaces and homes readily accessible to one another. Curitiba’s road network and public transport system are probably the most influential elements accounting for the shape of the city.

Each of the five main axes along which the city has grown consists of three parallel roadways. The central road contains two express bus lanes flanked by local roads; one block away to either side run high-capacity one-way streets heading into and out of the central city. Land-use legislation has encouraged high-density occupation, together with services and commerce, in the areas adjacent to each axis.

The city augmented these spatial changes with a bus-based public transportation system designed for convenience and speed. Interdistrict and feeder bus routes complement the express bus lanes along the structural axes. Large bus terminals at the far ends of the five express bus lanes permit transfers from one route to another, as do medium-size terminals located approximately every two kilometres along the express routes. A single fare allows passengers to transfer from the express routes to interdistrict and local buses.

The details of the system are designed for speed and simplicity just as much as the overall architecture. Special raised tube bus stops, where passengers pay their fares in advance (as in a subway station), speed boarding, as do the two extra-wide doors on each bus. This combination has cut total travel time by a third. Curitiba also runs double-triple-length articulated buses that increase the capacity of express bus lanes.

Jonas Rabinovitch and Josef Leitman, Urban Planning in Curitiba, Scientific American March 1996
Ironically, the reasoning behind the choice of transportation technology was not only efficiency but also simple economics: to build a subway system would have cost roughly $60 million to $70 million per kilometre; the express bus highway came in at $200,000 per kilometre including the boarding tubes. Bus operation and maintenance were also familiar tasks that the private sector could carry out. Private companies, following guidance and parameters established by the city administration, are responsible for all mass transit in Curitiba. Bus companies are paid by the number of kilometres that they operate rather than by the number of passengers they transport, allowing a balanced distribution of bus routes and eliminating destructive competition.

As a result of this system, average low-income residents of Curitiba spend only about 10 percent of their income on transport, which is relatively low for Brazil. Although the city has more than 500,000 private cars (more car per capita than any Brazilian city except the capital, Brasília), three quarters of all commuters—more than 1.3 million passengers a day—take the bus. Per capita fuel consumption is 25 percent lower than in comparable Brazilian cities, and Curitiba has one of the lowest rates of ambient air pollution in the country. Although the buses run on diesel fuel, the number of car trips they eliminate more than makes up for their emissions.

In a summary, the most important lessons Beijing can learn from Curitiba are:

1. Top priority is given to public transport rather than to private cars; road right is given to cyclists and pedestrians rather than to motorised vehicles.

2. Land-use legislation encouraged high-density occupation, together with services and commerce, in the areas adjacent to each main traffic axis.

3. Bicycle paths and pedestrian areas are an integrated part of the road network and public transportation system.
The ring roads are the main passenger corridors in Beijing, they are not only shoudering the tremendous commuters, but also are puzzled by high-frequency congestion, even though, those roads are comparably broader than any other streets in the inner city with three motor vehicle lanes for each direction, therefore, it is feasible and necessary to apply the Separate Bus Lane on the Second Ring Road and Third Ring Road. The concrete way to apply Separate Bus Lane is to separate one specific track for bus use only, as shown below:

Besides the Separate Bus Lane in the major expressway, in the inner city of Beijing, a cross Bus Priority Lane also can be applied for passengers to penetrate the city centre. Which is illustrated in the figure 21:
7. Results and Applications

Base on the comparison of different ideas on Beijing’s passenger transport problems in Chapter 4, it is evident that the large-scale building of metro, expanding of infrastructure, abandon of bikes are not able to really get a sound workout, they are either unaffordable or unrealistic, or risky in investment. However, one way can be affordable, realistic and flexible is the bus priority. According to the specific transportation condition in Beijing, considering the theory of Bus Priority as well as experience of traffic planning from Curitiba, I formulated some concrete measures for dealing with current traffic problems in Beijing.

7.1 Apply “Separate Bus Lane” to Beijing

As we discussed before, the congestion and air pollution are two biggest problems puzzling Beijing’s passenger transport system, among them the expanding car fleet is the root cause which leading to a deterioration of bus system. The most important principle of transport planning is that transport is about moving people and goods, not vehicles. Bearing this in mind, to reverse this situation, first of all, the most urgent measure should be given is applying bus priority right away.

Bus transport is one with the lowest social costs and highest comprehensive benefits among various modes of urban transport. Not only does it offer the social benefits of urban transport, but it also provides low-price services to middle and low income urban households.

Since the bus is the most friendly transport tool for the normal people in terms of the price, most Beijingers are still depending on the bus for commuting, therefore, the first objective of developing Bus priority is to keep this part of customers stick to bus even in the circumstance that their income has increased to the level of being able to afford a car, and the second objective should be to gradually reduce the number of present car passengers, the potential private cars owners as well as taxi passengers by providing high quality bus service.

Based on those goals, “Separate Bus Lane” should be widely applied to the main passenger corridors in the built-up areas of Beijing. In my opinion, the bus priority could be firstly applied to Beijing’s main passenger corridors as below:
The way to apply bus priority in the traditional road of inner city is to separate some traditional roads in the inner city for pedestrian and bus use only, because the traditional roads in inner city are narrow and regular-shaped, so it is feasible to choose one of the paralleled roads to be set as bus only lane. Therefore, as figure 21 show above, by using two crossed bus lanes to penetrate the city centre, people who is not used to bike or walk can also access into the city centre by bus, which will be a necessary part of Beijing’s innovative bus network.

Case of ChangAn Avenue

Actually as the sectional picture has shown in figure 20, starting from late June, 1997, Beijing municipality have decided to streamline the traffic flow by trying to give bus priority on one specific road of avenue of ChangAn, which is the main street in the middle of Beijing, the temporary new Bus Priority Lane was opened in 1997 because ChangAn street is one of the busiest avenue travelled by public transportation. A total 52 bus routes and 956 buses will pass through ChangAn Street carrying over 350,000 passengers daily.

After the special bus lane have been opened, based on some initial respond in Aug. 1997, the average speed of the buses has improved by 15% in Chang An Street where the Bus Priority Lane have been applied, although the private car-drivers, taxis complained it very much, the commuters examined it as a great innovation and it really helped them to fasten their trips especially during the rush hours.

This bus priority lane in Chang An Street is first in China’s history, it’s open has brought lots of arguments. To examine that the “Separate Bus Lane” is the an necessary choice for Beijing’s present chaotic passenger transport, we can look at some facts below:

Assuming that the priority has been given to bus on the most heavily travelled roads of Second Ring Road and Third Ring Road, let’s have a simple simulation to see how
the passenger transport situation could be changed. Especially, How much more passenger trips buses can take after applying the Separate Bus Lane?

Normally maximum carrying capacity of bus in China is 8,000 passengers per hour per direction in the peak hours, while the high capacity bus in the specific bus line in Crutiba carry 23 thousand passengers in one hour. To reverse this backward situation on Beijing’s road, it is clear Separate Bus Lane can play an important role because it can not only guarantee regularly operating of buses, higher speed, but also significantly increase of the capacity with same amount of buses. First of all, let’s look at how much headway the new bus lane can increase or how much carry capacity can be expanded after imposing priority to buses

Below is the basic data regarding Beijing’s bus passenger ridership in 1996

Table 6 Beijing’s Bus System in 1996

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Bus and Trolley</th>
<th>Bus and Trolley Lines(km)</th>
<th>Total Length of Bus and Trolley Lines(km)</th>
<th>Trips by Bus and Trolley(million)</th>
<th>Average Length of each bus line(km)</th>
<th>Average trips taken by per bus per day</th>
<th>Average bus number for each line</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>6427</td>
<td>397</td>
<td>7275</td>
<td>3054,331</td>
<td>35.8</td>
<td>1302</td>
<td>16.2</td>
</tr>
</tbody>
</table>

Source: Beijing Statistics Yearbook 1997

From the table 6 we know the average bus number for each line in Beijing is 16.2, and the average length of each line is 35.8 km. As the average speed of bus in Beijing is 10 -12 km/hour in the daytime(in average, the bus speed in rush hour are less than 10 km/hour, 15 km/hour in the daytime), to cover the length of 35.8 km, bus needs 214 minutes to cover the whole distance, that implies the headway of 13.2 minutes with the speed of 10 km/hour(including the time for bus packing up passengers), however, if we apply the Separate Bus Lane in order to increase the speed of the bus, we can calculate what difference it can make by quoting the empirical equations below:

\[
\frac{\Delta n}{n} = \frac{Ev \cdot \Delta v}{Av \cdot Tv}
\]

\[
Ep = \frac{Ev \cdot P}{Av \cdot Tv}
\]

Ep: Fare elasticity\(^{27}\);
Ev: Price elasticity;
P: Bus fare\(^{28}\);
Av: Cost of waiting time\(^{29}\)

\(^{26}\) Bruzelius, 1979, Resefrågan. Modeller och beräkningsmetoder baserade på elasticitetstud(TFD). Stencil S 1979:3
\(^{27}\) The detailed explanation of the Fares Elasticity is in the appendix, since Beijing is large city, so I assumed its Ep is -0.28
\(^{28}\) Beijing’s bus fare is very cheap, in average, it is 1Y(1SEK) for one trip in the inner city
\(^{29}\) this sum in Sweden is generally assumed 30Kr/h, since Chinese’s average salary level is about one tenth of Sweden, I assumed it is 3Y(3SEK)/h in Beijing
Bus or Private car? A Study of the Sustainable Urban Passenger Transport System in Beijing

\[
T_v: \quad T_v \text{ is equal to } (T_v2-T_v1)/2, \quad T_v2 \text{ means the waiting time after changing bus speed, } \\
T_v1 \text{ means the waiting time before changing bus speed.}
\]

\[
\Delta n: \quad \text{The changed number of passenger trips}
\]

\[
n: \quad \text{Initial number of passenger trips(before changing bus speed)}
\]

\[
\Delta v: \quad \text{Difference in waiting time(before and after changing bus speed)}
\]

\[
V: \quad \text{Initial waiting time(before changing bus speed)}
\]

Based on the equation above and the data regarding Beijing’s bus system in Table 6, a calculation has been done aiming at examine the possible increase of capacity for each bus, the result is shown in Table 7 below:

Table 7 A estimation of increasing bus speed’s impact on the number of passenger trips

<table>
<thead>
<tr>
<th>Bus speed(Km/hour)</th>
<th>Average Length of each bus line(km)</th>
<th>Average number of operating bus for each line</th>
<th>Headway(Time between two buses)(minutes)</th>
<th>Time for each bus to finish one trip(minutes)</th>
<th>Number of increased passengers per bus per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
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In this table, some equations are:

- Time for each bus to finish one trip = Average Length of each bus line/Bus speed
- Headway = Time for each bus to finish one trip/Average number of buses for each line
- Number of increased passengers per bus per day are calculated by the equations in page 45

This is one simple simulation of how much more passengers can be carried by bus if the speed has been increased by the Separate Bus Lane in the circumstances of without any changes of bus number and length of bus line. It is clear that the simply increase the speed of bus will lead to double bus passengers or even more. The implications of Bus Priority are not only that bus can undertake more trips, but also the reliability. The higher transit speed offers people a higher effective way for travelling, the bigger capacity can greatly change the situation of over-crowed density on the bus, that can make the trip more pleasant. Both of the two factors are very important for attracting passengers to prefer bus, and both of them can be significantly improved by Separate Bus Lane.

The benefits from Separate Bus Lane are not just those above, as we discussed before, the bus company in Beijing have been depending on the municipality’s subsidies for keeping running, the increase of riderships will also increase the profits from the fare, that can change this problematic situation in some extent. Furthermore, improved bus service also can benefit the special group of people in the society, the very young and old, the physically handicapped, etc. they are not able to use bike or drive car, but the convenient bus may bring a easy-accessed service to them.
Applying the Separate Bus Lanes to the Second and Third Ring Road in Beijing can encourage the bike use in the inner-city, as Beijing's traffic map shown, the space between the two Ring Road are about 2-4km, that indicate wherever people want to go within the Third Ring Road, it is always less than 2 km to reach one of the terminals of Separate Bus Lane. 2 km is the most optimal travelling distance for bike. If there are convenient Separate Bus Lanes on the Second and Third Ring Road, people can easily combine the bus and bike to fulfil their travel demand in within the Third Ring Road. In this sense, Separate Bus Lane can greatly contribute to keeping people's preference on bikes.

7.2 Integrate Bus Priority with Urban Planning

One important lesson Beijing can learn from Crutiba is to combine long-term urban planning with the traffic plan. Currently Beijing have this kind of ring structures which are not traffic high efficient, with the continually expanding of the city, the long-term rational urban plan must consider the people's increasing transport demand. the relocating of the residence site and commerce centre should not follow the present structure of expanding the square-structure to Fifth-Ring, Sixth-Ring and so on. Instead, we can get some insight from Crutiba's experience to develop a kind of axis structure out of Beijing's Fourth Ring Road for meeting the demand of decentralisation. During the 1970s, Curitiba authorities instead of emphasising growth along the prescribed structural axes, allowing the city to spread out while developing mass transit that kept shops, work places and homes readily accessible to one another. Moreover, the land-use in Curitiba encouraged high-density occupation, together with services and commerce, in the areas adjacent to each axis, all of those measures created a new high-efficient, environmental friendly urban passenger transport system.

If applying this thought into Beijing's city urban planning, it may have long-term impact on citizens' preference on bus. If Beijing municipality have some legislation or economic measures to encourage building residential house along the proposed main passenger corridors as shown in Figure 22, eventually this will lead to organically combination of bus traffic network with people's residential site, people will more conveniently access to main bus lines. On one hand it would provide a convenient and reliable bus service to the dwellers who living along the road, on the other hand it is very high efficient in terms of saving travelling distance. And furthermore, Bus Priority can be given to high density passenger corridor according to the passenger's travelling demand, that can guarantee sufficient and high efficient service for those dwellers. As show in figure 22, we can plan some main roads which are vertical to the ring roads so that they can penetrate the city centre from the suburb, this kind of traffic-friendly design can shorten travelling distance significantly, as a result, the unnecessary car use can be reduced and the congestion on the road can be relieved.
Since the tendency of decentralisation seems an unavoidable process for Beijing, it is predictable that more and more small satellite towns will be emerging on the outskirts due to the improvement of people's living standard and the increasing demand of living space. In this case, a bus friendly layout will be essentially needed to be carefully involved into the outskirts urban plan.

Based on these principles, I suggest that the bus priority should also be applied into the outskirts satellite town, as illustrated in the figure 23 below.

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**Figure 22: Suggested Prospective Urban and Traffic Planning.**

**Figure 23: Suggested layout of satellite town in the outskirts of Beijing**
Because buses will be given priority, only the buses can penetrate into the satellite town while all the other vehicles are only allowed to take the roads surrounding the town. The kind of layout have some distinctive advantages:

1. Easy for local residents to access the public buses and guarantee bus speed in satellite town. Because the Bus Only Lane is designed in the middle of the residence zone, most new residential building are ranged along the two sides of Bus Only Lane, it will be very convenient for local residents to take bus to commute between satellite town and the inner-city.

2. Eliminate the adverse impact of motor vehicles. Since only bus are allowed to get into the town, all the other motor vehicles fleets passing by will be prohibited from getting into the town, moreover, the parking lot is located along the highway, which means even taking the car people don’t need drive into the town centre. All of these can reduce the air pollution, noise tremendously, meanwhile, there is no need to build broad road in the town for motor vehicles anymore, so the traffic barrier’s impact can be eliminated, eventually, people will feel it is much safer living in the town than the urban area of Beijing, with an better air quality and friendly infrastructure, it can be foresaw that more people will like to use bicycles or walking, psychologically, most residents will feel the town is more friendly than ever before.

3. Reduce travelling demand. An completed service facilities in the satellite town can provide sufficient service for people's daily demands, if most of people’s leisure, shopping demand can be met in the satellite town, the demand of travelling will be obviously reduced.

7.3 Car Restriction in the Inner City

Separate Bus Lane can improve the number of bus passengers and improve the public transport in the city significantly, but only Separate Bus Lane is not enough for releasing the tension of the city congestion, another important method which have to be carried out hand by hand with the Separate Bus Lane is the traffic restriction. Although we can expand street and road capacity by constructing some new roads, but construction its own is not sufficient to solve the congestion because the car fleets will always exceed the capacity of road. After giving priority to buses, which also means sacrificing some others. Separate Bus Lane alone will make congestion for other vehicles more serious, therefore it need the supplement of the measures of traffic restriction.

Economic Measures

There is one phenomenon noticeable is the sum of individual costs are not equal to the total social cost(Discussed in the Chapter 1.3), a driver, when considering whether or not to use a particular road, will only consider the costs that are directly perceived or charged to him(namely, all direct costs such as those for gasoline, tires, direct wear and tear on his vehicle, etc.) as long as the road’s capacity is sufficient to accommodate his
use without slowing or otherwise interfering with anyone else's use, no particular problems are created. Traffic, however, sometimes increases to the point where an additional user interferes with other users by creating congestion on the road. At this point, the new or additional user would underestimate the costs of his using the road because he would fail to take into account delay or congestion costs he imposes on others. On other words, since the individual driver only perceives his own congestion delays and not those he imposes on others, private costs fall below social costs. This, in turn means that too many (that is, an inefficiently large number of) travellers will use the road (because the perceived price, or cost, of usage is too low).

To rectify this situation and bring private costs back into balance with social costs, a toll should be imposed for using the congested road. In essence, where there is congestion, market forces can result in an optimal level of usage only if a toll is imposed on users.

The proper toll should vary from place to place and by time of day. The highest tolls would be needed on the most centrally located facilities at the most congested peak commuter periods. For the case of Beijing, determining optimal tolls for all relevant times and places and then implementing them are very difficult due to that system is costly and demand advanced equipment. And it is also difficult to select the place to set the toll stations because there are too much intersections connecting the Second Ring Road and Third Ring Road with roads stretching out to outskirts. But instead of setting toll stations, Beijing is still able to assess congestion costs by using area's licensing scheme. Any cars intending to get into the crowded city centre within 3rd Ring Road in the peak period have to pay for a license, by increasing the costs of automobile trips to congested areas, area restraint should encourage people to carpool and switch from auto to reliable public transit which can be provided by the Separate Bus Lane.

However, one thing we must make clear is that there is no way we could eradicate all congestion, but by using the toll we can relieve the congestion in a big extent.

The fuel tax is also an very effective way for discouraging people's using private cars. Fuel is consumed roughly in proportion to the amount of distance travelled or the time of engine working: if congestion is widely spread throughout the area and throughout the day, it may therefore be too expensive to travel to the city centre for the car owners, even the short distance will consume much gasoline, fuel tax is not only very helpful for reducing the car trips in the city centre, but also greatly contribute to reduce the air pollution in the city, currently the gasoline price in Beijing is less than 3 Y(3SEK) per litre, this price is too low to efficiently influence car owner's unnecessary use of car.
Regulatory measures

To regulate the car flow in the city, the tax and toll will play main role, but the non-economic method is also very important for achieving some purpose which can't be done by taxation, for example, the city centre-the area within the Second Ring Road of Beijing is the cultural, political centre as well as major tourists attraction of Beijing, many state governmental sectors, ministries, embassies, business centres are accumulated there, the building style is keeping its old fashion as hundreds years ago, the narrowly old-fashion avenue is unlikely able to stand the overwhelming car fleet, on the other hand, to guarantee the public transport vehicle to carry maximum passengers, the road right should give to buses which may have thoroughly priority than any other vehicles. To protect the historical sites and avoid congestion, cyclists also should be encouraged in the inner-city, the private cars, as the biggest contributors of congestion and air pollution, have to sacrifice, as I suggested, it should be necessarily prohibited entering into this region. In this case, the Beijing municipality can stipulate accordingly local rules to streamline the rational traffic order in the city centre (as figure 24 shown, the area in the middle should be forbidden for private cars).

7.4 Giving Road Right to Cyclists and Pedestrians

A mature modernised transport mode is unlikely can be achieved by only one transport mode, in Beijing, the existing metro and bicycles also can be effectively planned to supplement the bus priority in order to totally form a completed, convenient, affordable, feasible rational passengers transport network, although bus priority have the various advantages, but taking the city as a whole, there are also many places which are not able to be reached by the bus terminals due to the special characteristics of the Chinese cities: very compact, dense built-up area and many narrow streets. In those cases, bicycles could be the best supplement to connect people to access the buses. Because bike has the characteristic of convenience (door-to-door service, scheduling flexibility, ability to circumvent congestion), combined with its relatively low capital
cost, no pollutants, they should be protected by municipal transport rules and give a special attention, after the Separate Bus Lane has been widely applied on both the Second and Third Ring Road, bike combining with the buses can be the best option for passengers to commute between the outskirts and inner-city.

Beijing has 42 km’s metro which cover the route of Second Ring Road and carry substantial passengers everyday, as the rapid transit transport, metro’s capacity and speed is comparably superior than bus and bikes. Although metro is very expensive to build and not clear for the city’s layout in the future, the existing metro should be utilised efficiently. Overall, the existing metro system, combining with the prevalence of Separate Bus Lane, with the help of flexible bikes to be feeders connecting scattered residence sites with the bus and metro, a stereo rational passengers transport network can be formed for relieving Beijing’s congestion in a great extent, maximum passengers can be transported, air pollution can be reduced, this flexible mode also can be adopted to unexpected urban development mode in the future, in a few words, this new system will lead Beijing’s passengers transport toward a rational track and facilitate China’s economic development.

7.5 Privatisation of Public Transport Enterprises

To change the backward image of Beijing’s bus system and attract more riderships, the most important step is to spread the Separate Bus Lane, but to reform the present administration system of bus enterprises is also one important step for securing this goal. The increasing demands of passengers require that the transit system must be flexible and innovative. Experience suggests that privately-owned systems often do this better than the publicly-owned. Below was the successful case of Curitiba:

Box 2: Urban Buses in Curitiba, Brazil

The urban bus system in Curitiba is one of the most efficient and cost-effective in Brazil, while recent performance improvements have in part been due to a combination of well-chosen transportation and land-use planning decisions, one of the most important changes has been the elimination of municipal involvement in the provision of passenger services. Instead, over the last two decades, Urbanizacao de Curitiba (URBS) has evolved itself from the role of service provider into a regulatory body responsible for system administration and planning, as well as property management for publicly owned transportation infrastructure.

Private bus companies in Curitiba operate under parameters established by municipal decree in 1987. In place of the previous systems of territorial concessions, the decree established a system of permissions, which reimburse bus companies subject to the number of scheduled kilometres that they actually travel. A simple two-page document sets out the basic legal framework and standard form for all permissions.

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with fares calculated based on URBS experience and private firms’ operating costs, including both those that vary with kilometres travelled (maintenance costs, personnel and administrative costs) and capital costs.

Currently there are 10 buses companies operating specified routes in Curitiba, with companies tending to concentrate their routes in certain areas of the city. Some routes are shared, especially central area routes, interdistrict routes, direct routes, and certain express routes that serve more than one area of the city. Classification of companies and consequent assignment of routes is done according to the size of bus fleets, with the largest bus companies operating over 200 buses and the smaller ones around 50-60 buses.

The expansion in ridership and capacity after privatisation has been dramatic. In 1974 the first of the cities express buses operated along two arterial routes and carried 54,000 passengers per day. By 1982, the existing system of five structural roads carried approximately 400,000 passengers per day. Today, after improvements in fare collection and distribution, vehicles, and route extensions, the system transports more than 1,000,000 passengers per day at cost and service levels that have outstripped other large-and moderate-sized Brazilian cities.

At the present time, all the big urban buses in Beijing operations are owned, managed, operated, and regulated by municipal authorities. Standards, operational parameters (staff per bus, etc.) and fare levels are generally prescribed at the national level. Innovative practice and efficiency gains based on local conditions are difficult (often discouraged) and the conflicts presented when the regulator of service performance is also the operator contributes to deteriorating service. From the case of Curitiba, we found two points are most important for high-efficiency running of the city bus: 1. Local control of operational parameters and fares, and 2. Autonomous operating entities separate from the planning/regulatory function.

To improve the bus service in Beijing fundamentally, first, the level of standards, fare and operational procedures should be determined by the local government instead of central government, because the different regions have different socio-economic development level, they should have the right to determine the standard which is most appropriate and acceptable to their community.

Second, the competition mechanism must be applied to the bus enterprises, the privatisation of bus company is essential for achieving this. Because if the buses owned and operated by public enterprise, bound by public regulations and procedures, as well as no tangible reward for innovation or service improvement, the public company does not have the same incentive to increase ridership and income by being more attentive to customer demands or institute cost-saving procedures. In fact, the reverse is often true; efficiency gains could threaten the jobs of employees. Owned by state, the municipal bus companies in Beijing also rely on government budget allocations to buy new vehicles or spare parts, as well as the construction or repair of terminals and stations. Consequently, in times of reduced budgets, no replacements can be financed and service deteriorates. In order to improve Beijing’s bus service for meeting the needs of high service quality with the high mobility, it is crucial that the government should only take the responsibility of providing strategic planning, setting the standards of
service and regulating compliance, the concrete service should be left to the private sectors.

8. Discussions and Conclusions

The current chaotic situation of Beijing’s passenger transport system have to be reversed by some systematic countermeasures. An efficient public passenger transport system is urgently needed to cope with Beijing’s transport problem before it become incurable. Based on the concrete social, economic and geographic conditions in Beijing, introducing Separate Bus Lane in large scale is one feasible way to both release the congestion, make the transportation activities more friendly to urban surroundings and reduce urban air pollution. The four main measures recommended in this thesis for attaining a rational passenger transport system in Beijing are:

- Give priority to buses by applying “Separate Bus Lane” in Beijing’s main passenger corridors.
- Car restriction in the inner city.
- Combine urban development strategy with traffic planning, particularly, proposed mass residence sites should be close to the major bus lanes, satellite town in the outskirts should be planned bus-friendly.
- Preserve the present bikes and metro system to supplement bus service, acknowledge and protect cyclists and pedestrian’s road rights.

Besides these methods for streamlining the transport system, it is notable that the urban planning will play an extremely important role for determining people’s trips and travelling distance, especially for megacity like Beijing with a increasing population and growing demand of life quality. The layout of new commerce and service centres, new residential sites have to be carefully planned to be more convenient for city dwellers to use public transport as well as reduce air pollution, the local land-use policy has to be adjusted to change the present city expanding model to a more transport friendly one, etc..

China’s automobile development policy is aiming at increasing household car ownership so as to form a modernised car industry which can change China’s backward transportation image and stimulate the economic growth. However, policy makers have to recognise that the development strategy should have a all-sided considerations, economic development shouldn’t be the only determining factor, environmental capacity should also be counted in because a uncompleted consideration will easily lead to a policy failure. It is important to bear in mind that today’s temporary solution might be the cause of future’s big failure.
Since many Chinese cities are planning more and more metro systems to meet people’s travelling demand which will cost a lot of money and need long construction period, at this moment, traffic planners should pay attention to not think “too big”. It is good to have a long term plan for a city, but in most cases, based on the existing system to figure out a most reasonable way to minimise present problems in an acceptable short term could be more realistic and flexible, also more financially feasible. Therefore, it is good to combine both long-term plan and short-term plan in order to be adoptive to occasional socio-economic transition. Because there are too much uncertainties involved into a long-term strategy, even a marginal neglect could possibly lead to a blunder.

The purpose of transport is to move people and goods, not vehicles, this is the most important principle which should be used to guide Beijing’s passenger transport strategy, improvement of motorization isn’t necessarily equivalent to improvement of dweller’s life quality. Moving people and goods in a most efficient way instead of only considering moving vehicles in maximum extent should be the start point of any city traffic planner’s consideration. Correctly and clearly understanding this will lead to a sustainable future for Beijing’s urban traffic system.

Appendix 1

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**Bruzelius, 1979, Resefterfrågan. Modeller och beräkningsmetoder baserade på elasticitetstal (TFD). Stencil S 1979:3**
Appendix 2

![Diagram showing fares elasticities for different travel characteristics]

Note: In view of the wide variability of measured elasticities, this representation in different categories is necessarily very approximate. The solid black areas indicate the most likely range of values, while the shading on the ends indicates that values may exist well outside this range. A question mark indicates that the conclusions are somewhat speculative.

Fig. 1 FARES ELASTICITIES FOR DIFFERENT TRAVEL CHARACTERISTICS