Managing Traffic Congestion
- Case study of Hangzhou

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**Abstract**

Hangzhou as one of most important cities in Yangtze River delta is located in the east of China. With the rapid development of economy in the last three decades, Hangzhou, like many other Chinese cities, has met some challenges. Traffic congestion in Hangzhou is the one I want to talk about in this master thesis. Traffic congestion began to trouble people’s lives in the past decade, following with dramatic urbanization. People spent much more time on travelling, and their quality of life was threatened.

My thesis includes four parts: introduction of Hangzhou, theories and instruments on reducing traffic congestion, instruments have been used in Hangzhou, and recommendations for Hangzhou’s transportation.

Firstly, Hangzhou's background information was discussed in the first chapter. Population and number of vehicles can be seen as the main reasons for traffic congestion in Hangzhou. Also other problems are listed: old roads structure, mingling of different transits, low efficiency of public transit, and poor management. There are policies and planning related to Hangzhou’s traffic system from national and local governments. At the end of this chapter I presented my research question: how to reduce Hangzhou’s traffic congestion.

Secondly, I discussed theories and instruments had been used worldwide to reduce traffic congestion. Traffic principles were introduced: triple convergence and ‘offsetting by growth’, which should not be ignored when people were talking about traffic congestion. Then I separated instruments into three parts: physical instruments, market instruments, and regulatory instruments; and I discussed some instruments in these three parts.

Thirdly, my attention was focused on Hangzhou’s efforts to reduce traffic congestion. These instruments used by Hangzhou also could be divided into three parts. Since Hangzhou is in the process of rapid urbanization, physical instruments were used most widely to reduce traffic congestion in Hangzhou. But few market instruments and regulatory instruments have been adopted. I compared instruments used in Hangzhou with other cities’ instruments, and analyzed effects of instruments used in these cities.

At last, I listed some recommendations for Hangzhou to reduce traffic congestion, which could be classified as supply side instruments and demand side instruments. Hangzhou has put many efforts in
supply side, but few in demand side, and this unbalance between supply side and demand side makes
effects of reducing traffic congestion limited. In general, supply side approaches are similar with
physical instruments, and demand side approaches are similar with market instruments and
regulatory instruments. Hangzhou should continue to improve physical instruments, such as
improving public transport system, which can give people more choices for travelling. Also Hangzhou
should put much more efforts on demand side instruments, which can control the number of private
cars directly.
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1. Introduction

Hangzhou, like many other Chinese major cities, has been experiencing fast economic development and fast process of urbanization. Many urban transport problems are emerged at the same time, which decreases the quality of people’s life and threatens sustainable development of economy. My thesis is to focus on Hangzhou’s traffic congestion problem.

In this chapter, I will firstly introduce some basic information about Hangzhou city, such as growth of population and growth of vehicles. In addition, it comes to the current situation of Hangzhou’s traffic problems. Then I am going to list policy and planning both from national government and local government. At last it will come up with the thesis research question.

With the development of economy and technology, many Chinese cities have experienced rapid growth of private vehicles in the first decade of 21st century. Hangzhou is a typical one of those cities, which also is in the process of urbanization especially in the latest decades.

Image 1. Hangzhou in China

Made by author, based on Google map.
Hangzhou is the capital of Zhejiang province in the east of China, which is regarded as one of the most important cities at Yangtze River Delta. Hangzhou region contains eight districts in the northeast and five counties in the middle and southwest. The urban districts of Hangzhou are made up of six districts.

With the process of urbanization, the size of urban areas of Hangzhou is growing, and the building-up areas are expanding to the nearest two districts (Xiaoshan, Yuhang).

**Image 2. Hangzhou Eight Districts**

<table>
<thead>
<tr>
<th>Subdivision</th>
<th>Area</th>
<th>Population(thousand)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Xiacheng District</td>
<td>31.46 km²</td>
<td>398.4</td>
</tr>
<tr>
<td>2. Shangcheng District</td>
<td>18.3 km²</td>
<td>325.3</td>
</tr>
<tr>
<td>3. Xihu District</td>
<td>263.0 km²</td>
<td>617.8</td>
</tr>
<tr>
<td>4. Binjiang District</td>
<td>73.02 km²</td>
<td>144.7</td>
</tr>
<tr>
<td>5. Jianggan District</td>
<td>210.22 km²</td>
<td>442.4</td>
</tr>
<tr>
<td>6. Gongshu District</td>
<td>87.49 km²</td>
<td>307.5</td>
</tr>
<tr>
<td>7. Xiaoshan District</td>
<td>1163.0 km²</td>
<td>1,209.9</td>
</tr>
<tr>
<td>8. Yuhang District</td>
<td>1223.6 km²</td>
<td>848.4</td>
</tr>
</tbody>
</table>


1.1 Population

As is shown in the image 2 above, the size of Hangzhou urban areas (Six urban districts) is about 683 km², with 2.23 million population. The average density of population is about 3265 persons/ km², varying from highest population density of 18,067 persons/ km² in Shangcheng District to lowest population density of 1,982 persons/ km² in Binjiang District.
Table 1. Hangzhou

<table>
<thead>
<tr>
<th></th>
<th>Hangzhou (urban districts) 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>683 km²</td>
</tr>
<tr>
<td>Population</td>
<td>2.23 million</td>
</tr>
<tr>
<td>Average density of population</td>
<td>3,265 persons/km²</td>
</tr>
<tr>
<td>Highest density of population</td>
<td>18,067 persons/km²</td>
</tr>
<tr>
<td>Lowest density of population</td>
<td>1.982 persons/km²</td>
</tr>
</tbody>
</table>

Made by author, based on Hangzhou statistical investigation information, 2010.

Table 2. Hangzhou’s growth of population

<table>
<thead>
<tr>
<th>Years</th>
<th>90</th>
<th>95</th>
<th>00</th>
<th>05</th>
<th>09</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population in six urban districts (million)</td>
<td>1.34</td>
<td>1.43</td>
<td>1.79</td>
<td>2.10</td>
<td>2.23</td>
</tr>
<tr>
<td>Xiaoshan District</td>
<td>n/a</td>
<td>n/a</td>
<td>1.1419</td>
<td>1.1766</td>
<td>1.2099</td>
</tr>
<tr>
<td>Yuhang District</td>
<td>n/a</td>
<td>n/a</td>
<td>0.7918</td>
<td>0.8123</td>
<td>0.8484</td>
</tr>
</tbody>
</table>


Hangzhou urban areas’ permanent resident population was growing at the rate of 1.48% per year in the past 20 years from 1.34 million in 1990 to 2.23 million in 2009 (not including Xiaoshan and Yuhang Districts).

In addition to this 2.23 million, Hangzhou region (including five counties) contains 2.9 million floating population in 2008 (Ye Juying, 2010), but it is hard to figure the floating population in Hangzhou urban areas. In general, this huge floating population is a epitome of last 20 years development of economy in Hangzhou, where relatively high salary encourages people from the western part of China to go there searching for job. Also this situation is happening in other southeast coastal cities in China. As Ye Juying (2010) says that the growth rate of floating population has decreased in the recent years, since the development of middle part of China dried up of labour force. So it can be assumed that there will be no huger growing of floating population in Hangzhou, in the way that most of them work as cheap labour.

Since Hangzhou is one of most well-known tourist cities in China, there are lots of tourists visiting Hangzhou all the year round and at its peak at weekends and holidays, such as May Day holiday and
National day holiday which starts at October 1th. In the last year’s National Day holiday, which was celebrated with another Chinese traditional holiday the Mid-autumn Festival from October 2 to October 8, scenery spots in Hangzhou region had received 12.85 million person-time in all (Ye Xiangting, 2010). Although some of them had only travelled in Hangzhou’s counties, such as Chun’an county and Fuyang county, most of the tourists travelled in Hangzhou urban areas. This huge population flow has great influence on Hangzhou’s traffic system, and makes Hangzhou’s traffic even more congested.

Traffic congestion happened in Hangzhou, is partly caused by the growing number of these three kinds of population, which encourages further growing of transportation in different ways. In general, the growth of permanent residents created more private cars; the growth of mobile population increased the number of electronic bicycles and public transit, since mobile population mostly came from relatively poor areas and they earned lower income in Hangzhou; and the growth of tourists put much more pressure on public transits system also, as most tourists come from other cities to Hangzhou, and they usually travel by public buses or taxi in Hangzhou urban districts.

1.2 Growth of vehicles

When compared with the growth of population, growth of vehicles have more influence on traffic system directly. It has been growing rapidly in the past ten years, since the growing number of population and more related to people’s growing incomes.
Data in the image above show the number of vehicles, private cars, and motorcycles’ growth in Hangzhou in the past ten years. Vehicles’ number (not including motorcycles) grew from 126,000 in 2001 to 843,000 in 2009 which corresponds to almost 600% or in average about 35% per year. What’s more, the growth has increased almost every year from 46,000 vehicles (not including motorcycles) per year in 2001 to 250,000 vehicles per year in 2010. As a result, the total number of vehicles rose to 1.83 million in the whole Hangzhou region in 2010 (Wang Jiajia, 2010). After 2000 the number of people learning driving was growing from 130,000 to 278,000 in 2010 (Lin, 2011). It could be predicted that many of them will buy the first vehicles in their lives as soon as they get driver’s license.

Situation varies from motorcycle to other kinds of vehicles. The number of motorcycle increased at a relatively lower rate than private cars, from 202,000 in 2001 to 320,000 in 2009 by 58%. The majority of this increase happened in Xiaoshan District and Yuhang District, rather than in Hangzhou’s urban areas. The reason for this is that the Government did not permit motorcycles, and Motor Tricycles to go into Hangzhou’s urban areas (Standing Committee of Hangzhou Municipal People’s Congress, 2003).

Another kind of transport, which exerts great influence on people’s commuting is electric bicycles. This electric bicycle usually runs at the speed between 20 km/h and 30 km/h, and they do not belong to motor vehicles in Chinese traffic laws. That means every one could use this transport without
driving license. High accessibility of electric bicycles encourages more people to use it, especially mobile people with low income. The rapid growth of electric bicycles has contributed to reduction of motor cycles. People formerly using motorcycles have switched to electric bicycles after the ban of motorcycle in urban districts.

Image 4. Electric bicycles

1.3 Current situation of Hangzhou’s traffic problems.

The rapid growing number of vehicles has not been followed by increased roads capacity. As a result, more and more vehicles are congested on the roads.

There is only one north-south expressway named Shangtang elevated bridge crossing Hangzhou urban districts, but no transmeridional expressway across Hangzhou’s urban districts. This Shangtang Elevated Bridge is always congested during peak hours. And most of vehicles have to drive on the ground, mixing with each other, and the high density of traffic lights make things worse. Public buses, regarded as main public tool for people’s trips, runs less efficiently, since they are mixed with low speed of traffic flows. There is no Mass Rapid Transit in Hangzhou, although more than 2 million people live there. The newly built BRT two lines are only available for few people, but criticised those drivers whose roads capacity were occupied by BRT. When the bicycle system emerged in Hangzhou it was encouraged by most of citizens, but some problems still need to be solved. Also more parking space is needed. Many drivers drive on the roads just looking for available parking space, which even makes traffic more congested.
The problems in the traffic system affect the quality of people’s lives, and development of society in all fields. Traffic congestion in Hangzhou will get worse without useful measures to solve those problems.

Image 5. Traffic congestion in Hangzhou

1.4 Policy and planning

1.4.1 Public transport policy

In 2005, General Office of the State Council published ‘Suggestions about the Priority of the Development of Urban Public Transportation’ (State council, 2005). In this document, State Council (2005) emphasized that China’s lack of land resources, high density of population in cities, and people’s low income public transportation in urban areas has high priority.

The main objectives of the policy are:

a. perfecting public transport facilities
   Improving station facilities
   Improving urban junctions of park and shift
Improving urban intelligent public traffic system

b. Perfecting public transport operating structures

Enlarging public buses system greatly
Developing urban rail transit orderly
Developing Large-capacity rapid bus moderately

c. Ensuring the road use priority rights of the public transport

Settling bus priority lane and bus priority intelligent signal control system scientifically.
Improving management of bus priority lane and bus priority intelligent signal control system

d. Enlarging government subsidies (State council, 2005)

1.4.2 Hangzhou Integrated Transport Plan


The purposes of HITP were:

a. Further perfecting development strategies and development policies of urban transportation.

b. Highlighting status of central city, setting the stage for expanding of urban future’s development space.

c. Completing urban road skeleton planning and urban rail transit network layout planning.

d. Proposing thinking of transit planning and strategy of transit organization planning in West Lake tourist area (China National Technical Committee, 2011).
Table 3. Rate of transit modes in Hangzhou in 2000

The plan shows that in 2000 more than 40% of people chose bicycle and electric bicycle as their trip modes, 28% people choose walking, 22% people choose public transport, no more than 3% people commuting by private cars, and rest of people choose other modes (China National Technical Committee, 2011). HITP did not pay much attention to reducing traffic congestion at that time, only potential traffic problems in West Lake tourist area was addressed.

HITP addressed for issues in making Hangzhou became a modernized, high efficient metropolis.

1.5 Conclusion

Hangzhou is a fast growing city like many other Chinese major cities. There are rapid growing of population, both resident people and floating people. The number of vehicles has grown at a
dramatically rate, which is seen as the direct reason of traffic congestion.

I started writing the thesis with the research question: how to reduce Hangzhou’s traffic congestion. Based on relevant theories, instruments and studies of other cities’ policies I will try to find out some reasonable instruments which may reduce Hangzhou’s traffic congestion. In the next chapter Theories and instruments on reducing traffic congestion will be introduced.
2. Theories and instruments on reducing traffic congestion

In this chapter the definition of traffic congestion would be discussed. In addition, I would talk about reasons for traffic congestion and then I present some important principles or phenomenon which should not be ignored when dealing with traffic congestion. Finally, theoretical methods of reducing traffic congestion would be discussed. This discussion is divided into three main parts: physical based instruments, market based instruments, and regulatory based instruments. Also those instruments could be classified in another way: supply side approaches and demand side approaches.

2.1 Traffic congestion

In European Conference of Ministers of Transport’s opinion (2004), traffic congestion is a situation in which demand for road space exceeds supply. Congestion is the impediment vehicles impose on each other, due to the speed-flow relationship, when the use of a transport system approaches capacity. It is hard to say what is traffic congestion exactly, since there is no standard of traffic congestion worldwide and traffic system varies from one city to another. Downs (2003) has the notion that the traffic on any given artery can be considered congested when it is moving at speeds below the artery’s designed capacity because drivers are unable to go faster. If there is a street designed 50 miles per hour, and most of vehicles’ speeds on this street are lower than 50 miles per hour, there is a traffic congestion. So in Downs’ opinion, traffic congestion is closely related with designed standard. Generally speaking, it could be defined as vehicles blocked on the street and their average speed lower than one level or people spend much more time on the road which is unendurable.

2.2 Causes of traffic congestion in metropolises

Before the middle of the nineteenth century, all cities in the world were designed or developed on the base of walking. From the time of 1860s, many cities’ structures were changed in the force of
industrialization. Narrow streets were collapsed and replaced by wider roads which are suitable for car. But with more and more cars appearing on the streets, traffic congestion became a problem in many cities in the world since 1945.

The use of vehicles plays an important role in the history of cities’ economic development. Since vehicles make people’s moving more conveniently, powerfully, flexibly and efficiently, people want to have their own cars when they get enough incomes. As is shown in table 4, there is a strong correlation between the GNP per capita and the number of vehicles in a country. Based on that it can be predicted that when residents’ income in countries like China in the southwest of the picture get closer to countries like US and Japan in the northeast of the picture, the number of vehicles will increase.

Table 4. Income and vehicles, Twenty-two countries, 2000

![Graph showing income and vehicles correlation]


The average travel time each day for residents ranges from 1.0 hour to 1.5 hours, which is similar among cities despite difference of income levels, culture, travel modes. With the development of technology and economy, many more people can travel a longer distance at a faster speed, and they change their travel modes from walking to horse-driven then bicycle, and now motor vehicle.
Rapid traffic growth generated by a growing number of private cars is one of the most important causes for congestion. The growth is most dramatic in countries with huge populations. The number of vehicles per 1,000 population between 1970 and 1981, for example, increased twofold in Brazil, threefold in Indonesia, fivefold in Nigeria and seven to tenfold in Korea (Rietveld, et al., 2003).

In Downs’ opinion (2003), a further reason for traffic congestion is that older, established cities were laid out physically in pre-automotive eras; hence they lack streets and roads suitable for handling automobiles, trucks, and buses. Enlarging the capacity of streets in old city for automotive traffic is widely opposed by local residents, since their dwellings would be torn down by widening streets. Therefore, the growth of road capacity does not catch up with growth of vehicles and this mismatch could cause lots of vehicles blocked on narrow roads.

Downs (2003) also argue that the mingling of many different modes of movement on the same roads as a cause of congestion in developing nations. The mix of old and new transport technologies, highlighted by the shared use of road space by fast moving motorized vehicles and slow-moving human-powered and animal-drawn vehicles (such as rickshaws, hand drawn carts and animal drawn vehicles), typifies many street scenes of the Third world (Rietveld, et al., 1990). It is obvious that a road hosting several kinds of travellers such as vehicles, buses, motorcyclists, bicyclists, even horse drawn carts can’t have a high efficient traffic flow, since the faster travellers have to adapt to lower speed travellers. The findings of research into the operational efficiency of various transport modes carried out by the Battelle Institute in Geneva (Bouladon, 1967) identified the misuse of transport technology as a significant contributor to transport problems also in cities of the industrialized countries. In other words, low efficiency in integration of different transits makes traffic flow more stagnated.

This kind of mingling transport system also decreases the speed of public transport, particularly public buses that are blocked on roads when they share same routes with private cars. What’s worse, low punctuality rate, poor quality, and low accessibility disappoint people when they choose it as a travel mean. Some of them are encouraged to choose private cars as their commuting tools.
For many cities in developing countries, the growing number of population should not be ignored when we talk about traffic congestion. Many of them came from surrounding rural areas, since the process of urbanization. Obviously, the aggregation put much more pressure on urban traffic system. Accompanying with the rapid growth of population, many urban problems may emerge, such as increased urban expansion, inadequate land use control, incompatible urban form and density configuration. All those problems may further aggravate traffic congestion.

One characteristic of urban dwellers in both developed countries and developing countries is the view of human time-usage. People tend to make full use of their daylight time. They usually go out in the early morning between 7:00 and 9:00am and back home between 4:00 and 7:00pm. So traffic congestions in modern metropolises usually appear in rush hours, which are in the morning between 7:00 to 9:00 a.m. and in the afternoon between 4:00 to 7:00. Certain basic human behaviour patterns in modern societies cause many people to travel during the same limited periods each day (Downs, 2003). People working in offices normally have similar working hours and students are required to go to school at certain time. All these make the number of travel trips arise markedly, and traffic flow at that time usually exceed the designed capacity of road net.

With growing employment more people will go to workplace and back to home everyday and the use of vehicles will increase. This increased traffic flow may put much more pressure on traffic system. Downs (2003) has observed that there is a substantial increase in the number of vehicles used during the 1980s and 1990s in US, although their total population only grew slowly. All those reasons should be taken into account, when we try to reduce urban traffic congestion.

### 2.3 Traffic flow principles

Reasons for traffic congestion vary from one city to another, due to their different backgrounds and situations. But when it comes to dealing with traffic congestion, some basic traffic flow principles people should paid attention to.
2.3.1 Triple convergence

Triple convergence is one of the most important principles for reducing traffic congestion. Travellers are assumed to choose the quickest route on their way to work or back home, which is shorter or less encumbered by obstacles such as signals or cross streets than other roads. As most of the drivers care about this, they will converge on the "best" routes from many points of origin (Downs, 1962).

Suppose there is a route that is better than other routes in city. Obviously, travellers will choose this route since it is faster than the other routes. More and more travellers converge on this route and at a time this route becomes congested. Then drivers would find out that the time they spend on this route is roughly the same as the time spent on the way they chose before. In general, there is a traffic flow balance between “best” route and other routes. That is to say, for individual traveller, there is not much difference whether you choose the “best” route or not.

There are three types of convergence that appear when an new road is open or an old road is improved: travellers who formerly chose alternative routes during peak hours turn to the new road (spatial convergence); travellers who formerly did not drive in peak hours start to travel during those periods (time convergence); and travellers who formerly did not travelling by vehicles switch to driving (modal convergence).

So many drivers shift from those three types of convergences to the new build or improved route, before long, its traffic capacity is reached and its top limit exceeded. This outcome is almost inescapable if peak hour traffic was slow already before the high way was improved (Downs, 2003).

It seems that for individuals, a new built road will not reduce their travelling time. But for whole society, a new highway produces lots of benefits through expanding road capacity. There will be a bigger amount of traffic flow on roads net in each hour. More people can drive at peak hour, which is usually suitable time for daily life. And the peak traffic congestion time each day will shorten if other factors, such as total amount of transport volume do not change. More people can commute during the convenient time, which are also the peak periods.
As one unintended effect of triple convergence, public transportation may decline since some people who formerly made this choice now may switch to the expressway. This result may have a negative long term influence on traffic flow.

These three types of convergence represent the short term impacts influencing mainly people who already live in this area. But arterial roads also have a long term convergence impact when increasing the capacity of the road system. For example, more people want to settle near the expressway, because of its convenience. As a result, road expansion maybe encourages the development of real estate and businesses along the expressway. And new traffic flows added by those new settlers will offset some part of the benefits, which old road’s users expected to have from upgrading of road at the beginning. So, it seems difficult to remove peak-hour traffic congestion only by enlarging the capacity of roads net. Investment in new road capacity represents one limited instrument to reduce traffic congestion.

### 2.3.2 Offsetting by growth

Another principle is “offsetting by growth”. Rapid population growth tends to offset the beneficial impacts of any particular remedy adopted to reduce traffic congestion (Downs, 2003). Areas with a rapid growth of total population or the number of cars, always experience severe traffic congestions, despite the instruments have done.

But if there was no such remedies, condition of traffic flow would have been worse than they are now. So it is more suitable to say that such remedies may prevent the traffic congestion from being even worse or contribute to make an increase the traffic volumes possible.

Downs (2003) have the notion that one way to prevent the quality of life from deteriorating in a fast-growing area would be to slow its growth rate. Such kind of tactic would be infeasible, since traffic congestion is just a side effect of social development. Eliminating urban traffic congestion at the
sacrifice of social economic growth is not accepted by people. In this case, we should have the notion that trying to reduce traffic congestion probably would be offsetting by rapid growth of vehicles, and the congested degree remains.

According to those principles, it seems impossible to eliminate traffic congestion completely. And in some fast growing cities, they may also find it hard to reduce traffic congestion.
### 2.4 Instruments for Reducing Traffic Congestion

Table 5. Classification of instruments for reducing traffic congestion

<table>
<thead>
<tr>
<th></th>
<th>Supply side</th>
<th>Demand side</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical instrument</strong></td>
<td>-Building more roads or expanding existing ones</td>
<td>-Building special roads for trucks only</td>
</tr>
<tr>
<td></td>
<td>-Building more transit facilities and increasing service and amenities in existing transit systems</td>
<td>-Clustering high-density housing around transit stops</td>
</tr>
<tr>
<td></td>
<td>-Improving highway maintenance</td>
<td>-Using traffic-calming devices to slow flows</td>
</tr>
<tr>
<td></td>
<td>-Adding rowing response teams to remove accidents</td>
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<tr>
<td></td>
<td>-Upgrading existing city streets</td>
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<tr>
<td></td>
<td>-Developing means of transit feasible in low-density areas</td>
<td></td>
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<tr>
<td><strong>Market based instrument</strong></td>
<td>-Converting free HOV lanes to HOT lanes</td>
<td>-Road pricing with tolls set to raise peak-hour flows</td>
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<td></td>
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<td>-Commuting allowance for employees</td>
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<td>-Charging high taxes on gasoline, parking during peak hours</td>
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<td>-Eliminating tax deductibility for employers for providing free parking</td>
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<td>-Increasing automobile license fees</td>
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<td></td>
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<td>-Cashing out free parking provided by employers</td>
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<tr>
<td><strong>Regulatory based instrument</strong></td>
<td>-Traffic management centres -ITS mechanisms for speeding traffic flows</td>
<td>-Prohibiting certain license numbers from driving on specific days</td>
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<tr>
<td></td>
<td>-Deregulating public transit activities</td>
<td>-Changing deferral work laws that discourage people from working at home</td>
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<td></td>
<td>-Staggering work hours for more workers</td>
<td>-Ramp metering on expressways</td>
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<td>-Encouraging more people to work at home</td>
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<td></td>
<td></td>
<td>-Keeping minimum residential densities higher</td>
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<tr>
<td></td>
<td></td>
<td>-Limiting growth and development in local communities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Improving the jobs/housing balance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Concentrating jobs in a few suburban clusters</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Making some lanes HOV lanes</td>
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</tbody>
</table>

Made by author, based on Downs, 2003.
Newman and Kenworthy (1999) mainly focus on reducing automobile dependence through three main approaches: technological improvements, economic instruments, and planning mechanisms. Tactics listed in the market based part usually include regulatory factors. Such as HOT lane set aside the alternative expressway is a regulatory tactics that have to be imposed by regulations. All those tactics were summarized as economic instruments by Newman and Kenworthy. Another way to analyze the congestion problems is separate approaches into three parts: physical based instruments, market based instruments, and regulatory based instruments.

Physical approaches mean reducing traffic congestion by all kinds of facilities. Such as expanding roads capacity, building a metro system, and improving the quality of public buses. They are the most fundamental ways to deal with traffic congestions and always to be the first choice when traffic congestion was emerged in cities and also it would be most efficient way to reduce traffic congestion at the beginning of congestion’s emergence. Other two kinds of instrument are both applied on the base of these instruments.

Market approaches, also called economic instruments, are designed to influence travellers’ choice of types of trips through monetary value in order to make full use of scarce resources such as road capacity. Different travel models are charged based on how scarce their capacities are. The residents are expected to choose the type of travel that gives them most benefits or has the lowest price. One example is that drivers choose way which is for free and not a toll road that across a congested area during the peak periods. The key point of market based approaches is that people have to pay fee when they use some scarce facilities.

2.5 Physical based instruments

Physical instruments decrease traffic congestion usually by building something or improving something. Most used physical instruments are increasing road traffic capacity, building more transit facilities and increasing service and amenities, upgrading existing city streets and clustering high-density housing around transit stops.
2.5.1 Increasing road traffic capacity

When cities are trying to reduce urban traffic congestion, the first idea is often building more roads, to allow increasing traffic volumes. The more capacity of roads net, the more traffic flows in each period. Supplying more roads capacity or improving the old roads net seems feasible and necessary in the areas at a rapid growing of population or vehicles. However, if the increasing of roads capacity does not catch up with the growing rate of population and vehicles, traffic flow would even go worse than before.

Once there is a peak hour traffic congestion in a city’s roads net, maybe the traffic congestion would be reduced by expanding road capacity in a short term. But this effect could be offset by many factors. First one is that rapid growing of population and number of vehicles could easily increase traffic loads, particularly in cities of developing countries. Also triple convergence could put much more pressure on expended roads net. When most of drivers realize new roads can save much time, they will switch their travelling time, travelling routes, and even travelling modes to this improved road, thus the intensity of traffic congestion will come back to the level as before in the near future. What’s more, expanded road even induce more people settle down near those new roads in long term. By the influence of those reasons, reducing traffic congestion through enlarging road capacity is undefined. It is quite difficult to measure what extent the benefits of expanding a road will be offset by the added demands it induces in the long run (Downs, 2003).

As mentioned before, when the whole capacity of the traffic system is enlarged, more travellers could travel during the peak hour. The total traffic flows in this area improve, since more vehicles can drive on the enlarged roads per time. So enlarging the capacity will bring benefits to whole society, no matter whether it reduced traffic congestion or not. Thus, the individual remedy of expanding the capacity of roads without other remedies is not a solution to reduce traffic congestion, but an approach to increase the whole traffic flows.
2.5.2 Improving public transport

Providing for convenient, safe, regular and reliable public transport is an essential requirement for any urban area (Richards, 1990). Buses, light rail or railways are the main public transport in most cities. According to various situations, there are different priorities in different cities.

Public transportation has quite different effects on reducing urban traffic congestions when compared with other kinds of instruments. Theoretically its huge capacity and high rate of using road resources makes it become the most efficient way to cut down traffic problems. Also a cheap price will make it affordable for almost everyone especially in developing countries’ cities.

The image 6 shows the efficiency of three kinds of means of using road resource, one bus’ capacity corresponds to more than 50 cars’ capacity, which shows us how traffic flow can be influenced by choosing different way of trips. If people choose public buses for commuting, it seems there would be no traffic congestion at all.

Image 6. Comparison among the cars, buses, and tram system

Notice: 160 cars = 3 buses = 1 tram

On the contrary, a world without a public transportation would be a disaster. As Bunting (2004) said, replicating present American mobility everywhere would expand the world fleet of vehicle to 4.52 billion. And the vehicles on streets of metropolises would just blocked without moving. Public transport seems to be a saviour in many cities filled with private cars.
So building more or improving existing public transits and facilities could be a useful way to reduce traffic congestion. But the development of public transport does not run smoothly in most of cities. One important reason is that most people prefer private cars to public transits, because of the flexibility and the accessibility of private cars, which I have discussed above. For example, drivers of private cars theoretically always have the advantages of saving time compared to people in public buses on the same route. People who choose to travel with public buses have to go to the bus station, wait for the bus, and the trip takes comparatively long time because the bus would stop at many stops before the destinations is reached, while drivers of private cars could save such time.

Bus Rapid Transit (BRT) system may remove this disadvantages of public bus, since it has buses only right-of-ways, which were regulated only available for public buses. Through this bus only way, buses could not be blocked on the normal routes with private cars, which encourage more people to choose BRT instead of private cars. In this case, the design of bus only right-of-ways is more closely related to regulatory instruments rather than physical instrument. However, according to triple convergence, the effects of reduced congested roads attribute to BRT system will soon be offset by new added people, who formerly chose alternative routes during peak hours change to the new road; travellers who formerly did not driving in peak hours start to travel during those time; and travellers who formerly did not travel by vehicles switch to driving.

Metro system and light rail have more capacity and higher punctuality rate than BRT and normal buses. These two public transits are regarded to be framework of urban transportation particularly in metropolises. People congested on roads would shift to metro system, if it is faster and spend less time. But soon there would be an equilibrium between metro system and private cars, when people found driving a car on less congested roads takes less time, then they will switch from metro system or other modes back to private cars. This shifting among different modes would not stop until the time spend on different modes are almost same.

One feature of metro system is that the speed of it would not be reduced even when carrying more passengers. So it is possible that when the metro system reaches its maximum capacity it is still faster than using other transportation modes. For example, Tokyo’s metro system reaches its maximum
capacity during peak hours.

All this public transports may not eliminate traffic congestion, but they reduce the potential congestion which would emerge without them, and may reduce traffic congestion to the level that driving vehicles cost same time as public transportations, if there is enough capacity of public transports. One more important argument for expanding public transport may be that it expands the total capacity of traffic flow, which is key point for development of society.

2.5.3 Bicycle policies

Cycling is now considered by policy makers in many cities as a suitable way of city’s transport. There are several good examples of cycling in cities, since it could be enjoyable, healthy and cheap to use. In Richards’ opinion (1990), generally in cities of up to 250,000 people, if the topography is flat, more people may use cycle because distances are short. Copenhagen and Amsterdam, whose sizes of population are much bigger than Richards’ scale, have created bicycle systems that are quite popular.

Since cycling is flexible and take much smaller space than other transport means, it could be designed as the last one kilometer in people’s commuter combined with bus and metro system. Most people would not choose bus system or metro system, if the distance to the station of bus or metro is more than 500 meters. But if there is a bicycle between house and bus station, people may prefer this choice. In this context, using of bicycle would not be limited by the size of city.

Whether people like cycling or not are influenced by several factors. Since cycling is driven by manpower not engine, the topography of city should be flat. Weather is another an important factor, chilliness and sizzling weather are both unacceptable for people to choose cycling.

Policy makers can do improve the security and environment of cycling both in parking and street to encourage people to choose cycling. Cycling should not be mixed with other transport means,
otherwise it could make traffic more crowded and dangerous. People will not choose bicycle as a mean of commuter if they feel it is not safe enough. More cycle ways in cities is a precondition of encouraging cycling system. As Richards (1990) said cycles normally require the provision of objects to which they can be locked on the street, as theft is universal, except in China, where cycles are licensed. Actually, cycles thefts still exist in China, although they are licensed, there are not enough efforts to stop stealing. The most efficient way is provide a safe parking space.

Probably bicycle would be suitable for some part of people’s trips, if there is a safe and flat cycle way, beautiful scenery around city. For some tourism cities, cycling could be a attractive choice for tourists to visit the city rather than car or public transport.

All these physical instruments are the first step to deal with urban traffic congestions, and most of them are designed to meet people’s desire of travelling. Generally speaking, they increase the total capacity of traffic flows, and more adopted by cities in developing countries, where are much more lack of infrastructure. Effects of physical instruments for reducing traffic congestion sometimes could not be remarkable even offsetting by triple convergences and rapid growth of vehicles. However, without physical instruments, traffic system may even be worse. In other words, physical instruments would reduce those potential congestions caused by rapid growth. Also physical instruments would have more effects on reducing traffic congestion when they are combined with market based instruments or regulatory instruments.

### 2.6 Market based instruments

Market based instruments has usually been used on the base of physical instruments, Since most of them are listed in demand side, being used to depress people’s desire to use private cars in specific time or specific area and encourage them to choose more efficient way for trips. Market instruments contain fuel taxation, road pricing, parking pricing and so on.
2.6.1 Taxes

Taxing has been used as an instrument to manage traffic demand in many cities around the world. Transport demand consists of a group of factors generating the total volume of travel (Potter, 2007), which contains travel length, travel modes, number of routes, time of trips, and so on. Instruments of tax for reducing congestion also involved in almost every factor of transport demand management.

The taxation instruments can be divided into three main parts: tax on the initial purchase of a vehicle; ‘circulation’ tax on the ownership of vehicles (annual registration tax and company car taxation); tax on the use of vehicles (fuel, tolls, road space and parking). Obviously, purchase tax has an influence on people’s choice of travelling modes. Also circulation tax such as registration tax influences the choice of travelling modes. There are many more kinds of taxes on the use of vehicles compared with the purchase tax, which includes fuel, tolls, road space and parking taxes.

In many countries, purchase taxation instrument has been used mostly to reduce environmental impacts rather than to reduce traffic congestion. Consumers will pay higher tax when they choose big engine vehicle, which is encouraging people to choose vehicles with low emissions. Purchase taxation will discourage people to buy a vehicle when dealing with traffic congestion, while it has no effect on people who have vehicles. Circulation tax has more influence on reducing the use of vehicles. It may encourage drivers to sell their vehicles when the circulation tax is high enough. And automobile ownership ratio will decrease.

Fuel tax is different from sales taxes, which levy all goods with a certain percentage of the good price. Fuel tax is charged at a rate per unit of fuel; per litre for liquid fuels and per kilogramme for gaseous fuels (Ison & Rye, 2008). The useful instrument of fuel duties impacted on transport demand management (TDM) is distinguishing user’s type. For example, public transport could be charged at a lower rate than private vehicles.

One important feature of fuel duty is that it has a wide positive influence on the total factors generated by transit, and not only has impact on modes choice, but also has effects on travel length.
and vehicle occupancy. However, the benefits of fuel duty can’t be reflected in short time, and also it is hard to watch the effects of it.

All these taxes will reduce traffic congestion theoretically. But they also seem unfair to drivers who don’t travelling on congested roads in peak hours. Tax instruments have an effect on all drivers, and may even have negative effect on economy development. The instruments shall focus on reducing traffic congestion in peak hours rather than reducing using of vehicles all the time everywhere.

2.6.2 Road user charging

Road pricing is used in many cities to reduce traffic congestion in city centres or expressways through charging fees from drivers. The main argument for charges on express ways is normally not an ambition to reduce traffic congestion but to finance the investment in the express way. Since the road tolls, a large number of vehicles would not move onto those roads. Theoretically, the higher road pricing is, the less people would choose this pricing route. Thus, traffic congestion on those roads net would decrease. The traffic flows would be improved, more vehicles could use roads net per hour. According to this, traffic congestion would be reduced as soon as there is enough high road pricing. The road traffic flow would be more efficient, as more drivers switch travel time from peak hour to non-peak hour, even shift travel mode from vehicles to other transits, such as bus and light rail.

One point of road charging criticized by opponents is that it is unfair to low income drivers. If the road pricing is not affordable for those people, they may have the notion that the roads were designed for rich persons. How bad this effect is depends on the specific context. But as traffic congestion become worse and worse in many cities, road pricing still is widely accepted by policy makers despite withdraws.

The types of road pricing could be classified into two main kinds: area pricing and roadway facility pricing (Downs, 2003). In the type of area pricing there is specific area, mostly cities’ downtown with congestion problems, ruled by policy makers. Vehicles moved into cordon line around the area should be charged. But it is free or at a low pricing rate for residents that lives in the area using vehicles, and
it should be also free for buses, and other public transits.

The other type of road pricing is charging the use of entire roadway, instead of certain areas. Payment is needed for every vehicle entering these roads net in certain peak hour, and the charges are high enough to discourage congested flows. This approach is normally not used in cities to reduce congestion.

2.6.3 Parking policy on traffic congestion

There are various types of parking policies, which focused on different factors such as parking location, parking supply, and parking price. Thus the results of those policies usually vary between each other. McShane and Meyer (1982) argue that some of these goals are certain to conflict while others may be served concurrently.

Parking policy control and management can also influence on trip generation, trip distribution, travel modes and travel time. Thus parking could play an “active” role in the transportation system. Litman (2006) has the notion that more focus on parking management could increase the utilization of land and transport in urban areas. It can be used as a price instrument to influence transportation.

Many parking policies are designed to control and reduce parking space in city’s downtown areas. In general, employers supply a large share of the parking space to employees. With free parking space, employees are encouraged by company go to work by private vehicles, especially when the price for parking spaces is high in downtown area.

It is difficult to reduce this system with company paid by some regulations in practice. People do not want to lose a benefit they have gained. One useful instrument is “cash-out” plan, which employers give employees a free parking space or some money standing for the parking fee. So it depends on employees whether they keep on using vehicles without getting this subsidies or switching travel modes from driving to public transport or vehicle sharing. In this case, employees who still commute
by vehicles would felt that the parking spaces offered by company are not free any more. In theory, the number of people commuting by vehicles would decrease, which was a quite big part of traffic flows in peak hour. So the total traffic volumes could be lower than before, and there will be a more efficient traffic flows.

Because of triple convergence, the reduced commuting traffic flows will be soon offset by convergence. People formerly travelling in non-peak hour may shift to peak hour, and people formerly travelling by public transit shift to travelling by vehicles. Also there is another approach to charging parking fees, charging all vehicles, which move into city centre in peak hours. This method focus on reducing the amount of commuting traffic flows, rather than reducing shoppers or traffic flows which do not park in city centre. However, just like charging roads fees in city centre, this peak hour parking price makes people feel it is an added tax. Thus, there may be some problems in implement of this method.

There are some differences between charging on roads and charging on parking. With the help of electronic smart cards, implement technique of roads pricing has improved a lot and is easier than that of parking pricing. Furthermore, parking pricing can’t charge long-distance lorry and vehicles driving through cordon area.

There are many advantages with market-based instruments. The most important one is that it offers different choice to drivers. Drivers can choose one route or a means of travelling that they prefer, which could save money or save travelling time. There will be equilibrium between marginal prices of behaviors and their marginal social costs. Travellers may feel some kind of freedom when compared with regulatory instruments, which usually give no choice to travellers. They will have much less resentful when they drive on HOT lane or other choice, since it is their own’ choice.

Another obvious advantage is that market instrument can collect substantial money, through charging the behaviours that cause traffic congestion. And the money collected from private cars could be distributed to public transit sector. Downs (2003) also maintain another advantage that all drivers have the same set of choices in contrast to regulations. The authorities need not cheat different
travellers in different ways. Market based instruments are more flexible and need much less administrative cost from the transportation authorities.

The same standards of road pricing mentioned above for everyone seems give much more burden to relatively low-income people who already have car. They would be the major part of population who shift to other modes or other time and other routes, which could be called triple divergence. So the precondition for using market instruments is that there should be a good infrastructure and public transport system. When people feel driving a car cost too much, they must have an opportunity to shift to public transport, without feeling loss much time.

2.7 Regulatory based instruments

Like market instruments, most regulatory based instruments could be list in demand side approaches, being used to control the use of private cars in specific time or specific areas. Ramp metering on expressways, HOV lanes, prohibiting certain license numbers from driving on specific days are most used regulatory instruments.

2.7.1 Ramp metering

Ramp metering is an instrument used to increase the traffic capacity of expressways or freeways. This method tries to control the number of vehicles per time that enter limited access expressways and highways through controlling traffic lights on ramps. Ramp metering was designed to make full use of expressways, and try to offer a highest traffic flows through ramp metering. Without such a control of traffic flow on ramps, vehicles would move onto those expressways and slow down former traffic flow. Especially in peak hour, they will reduce travelling speed automatically since there are too many vehicles. Such a slow-down leads to a lower vehicles passing rate per hour, then slow down further the road carrying capacity per hour.

In order to improve the efficiency of road carrying, ramp metering could reduce the number of
vehicles passing road per hour. When there are fewer vehicles on the road, the interval between two vehicles is longer compare to a situation without ramp metering. So drivers will drive faster since the longer interval between two cars, which is a guarantee of safety.

One problem with ramp metering is that it may lead to a long queue on ramps, when there are a huge number of vehicles moving onto the expressway, which is the case during peak hour. In this case, the traffic congestions formerly existed on limited access roads switched on the entrance of ramps. Also if there is not enough space for vehicles lining up outside the limited-access roads, the long queue waiting for entering limited-access road will spill its congestion out onto other city roads and streets, which may create congestion problem in other parts of the transport network.

Through controlling the traffic flow, ramp metering encourages more vehicles to move onto this route from other city streets. More drivers would wait outside the entrance of ramps, until total travel time spent on this way is the same as that on alternative routes. In other words, an equilibrium for drivers between the limited-access ramp metering route and other streets in city is achieved. On the other hand, some drivers do not want to be congested outside the entry ramps. Ramp metering pushes those drivers to other routes.

In Downs’ (2003) opinion, it is hard to know in advance which of these contrasting effects that will dominate in any particular situation. But it could be calculated through contrasting the number of vehicles that passed through the route before using ramp metering per hour with that after the route using ramp metering. Normally, the added capacity of traffic flows could be regarded as the result of two effect’s conjunction.

2.7.2 Using High-Occupancy Vehicle (HOV) Lanes

High-Occupancy Vehicle lanes are designed only for those vehicles carrying more than two or three persons and for public bus. Most people prefer to drive alone, since it is more comfortable, more convenient. But road carrying capacity would drop to a very low level, if a large number of single
drivers travel on the roads net. HOV lanes encourage those single drivers to participate in car pools, in order to reduce the number of vehicles without decreasing traffic capacity. Also with the improvement of traffic flows, there will be more vehicles attracted to move onto roads net especially during peak hour. Also this instrument would shorten the periods of peak congestion.

“High-Occupancy” standards are different in different areas, but mostly the demand is two or more than two persons in each vehicle. High occupancy lanes, which are built aside the normal lanes, will encourage drivers to switch onto this HOV road, which is faster than lanes beside distinctly. HOV lane will have obvious advantage in saving time when normal lanes beside are heavily congested during peak hours. One important thing is that drivers would not choose HOV lane, if traffic congestion on general travel lanes is not bad enough. Time saving advantage is a vital element for HOV lanes. Once drivers have shifted from general lanes and realize that congested lanes have improved, they will shift back onto general lanes again. Thus HOV lane could not improve traffic flow remarkably, since there is such equilibrium.

The traffic capacity of HOV lane usually has fewer vehicles per hour than general lanes and the road carrying capacity of HOV lanes are smaller than general lanes. It is better to build a new road as HOV lane, since changing general lane into HOV lane may decrease the total road carrying capacity. When drivers realize the traffic congestion is worse than before, such as they spent more time on travelling or more drivers congested on the narrowed lanes, they will be enraged.

A vital factor of HOV lanes is how intensively transit vehicles such as large buses are using them (Downs, 2003). The road carrying capacity would be hugely improved compared with adjacent general lanes, when the HOV lane fully can be used by public transits. As public transits could carry many more persons than other vehicles, and there is faster traffic flows on HOV lane, when public transport moving on HOV lane. However, people do not want to share rides with others distinctly. The higher number of persons required, the less number of vehicles will drive on HOV lanes.

Since the distance between people’s jobs and housing are longer than before and with the development of IT industry, working hours and places are becoming more flexible than before, ride
sharing becomes less attractive to people. Furthermore, drivers would feel uncomfortable, when they ride strangers. Big companies and clustered companies play an important part in encouraging ride sharing. Employers could motivate employees to choose ride sharing through cashing out free parking. Those employees will get some benefits from changing to ride sharing. And the persons who share ride with each other are at same companies or same clusters, so their safety could be guaranteed effectively.

When compared with market instruments, regulatory instruments make it possible to decide which behaviours shall be encouraged or forbidden. For example, ramp metering rules specific number of cars could drive on expressway per time. In this way the traffic flows on the expressway is directly controlled. Since this trait, regulatory instrument is a more predictable instrument to reduce traffic congestions than market instruments. The main shortcoming of regulatory instruments are that they are designed in the same way to all people, so people have no opportunity to choose the way they prefer to. For example, prohibiting certain license numbers from driving on specific days prohibit specific kinds of people who could not drive on specific days.

2.8 Conclusion

Urban traffic congestion usually is defined as vehicles are blocked on the street and their average speed is lower than the designed standard. There are many causes of traffic congestion, which varies from city to city. In general, they could be summarized as the growth of vehicles and population, insufficient road space, mingling of different transport modes, poor quality of public transportations and infrastructures, and also low efficient management.

When we try to solve the urban traffic congestion problem, we should take some principles, such as triple convergence and “offsetting by growth” into account. According to those principles, many efforts done by different instruments would be offset. Even so, it is worth trying those remedies, as they may reduce the potential added traffic congestions. The instruments for reducing traffic congestion can be divided into three parts: physical based instruments, market based instrument, and
regulatory based instruments, which also could be listed as supply side approaches and demand side approaches.

Physical instruments aim at increasing the total capacity of traffic flows, but effects of physical instruments for reducing traffic congestion sometimes could not be remarkable even offset by triple convergences and rapid growth of vehicles. However physical instruments are the base of market instruments and regulatory instruments, they would have more effects on reducing traffic congestion when they are combined with two other kinds of instruments. Most market instruments and regulatory instrument are used when there is a thorough public transportation system. So people have more choices between different traffic modes. Regulatory instrument is more predictable and gives a more direct reduction of traffic congestion than market instruments. But at same time, people have fewer choices and flexibility when controlled by regulatory instruments.

Individual instrument could not remedy urban traffic congestion, and sometimes not even could not reduce traffic congestions. A better approach to deal with urban traffic congestion is combining different remedies together. A multifaceted instrument gives a bigger possibility to reduce traffic congestion distinctly. However successful instruments may not eliminate traffic congestion, since substantial traffic flow is a symbol of cities’ prosperity. Also because of triple convergence, traffic congestion could not be wiped out completely. It is especially important for areas with a high density of population and rapid growth to combine different approaches organically, though much of the effort will be offset by growth.
3. Instruments used in Hangzhou

In this chapter, attention is focused on Hangzhou’s attempt to reduce traffic congestion. Instruments Hangzhou has used will be introduced and compared with other cities. Then the effects of these instruments will be analyzed and discussed. These instruments are divided into three parts: physical instruments, market instruments, and regulatory instruments. Since Hangzhou is experiencing the process of urbanization now, physical instruments have been undertaken more relatively than two other kinds of instruments.

3.1 Physical instruments

Hangzhou has mainly focused on physical instruments when dealing with urban traffic congestions in the last decade. The instruments include expanding road capacity, improving public bus traffic, building BRT system, improving transport facilities, building metro system, and setting public bicycle system.

3.1.1 Expanding road capacity

Like many other cities, building more roads and expanding existing roads have been the most widely accepted approaches to deal with traffic congestions at the beginning of urbanization in Hangzhou. The roads capacity increased steadily at the rate of 2.38% per year from 2000 to 2009, and at the end of 2009, area density of roads net in Hangzhou is 690.0 km/1000 km², population density of roads net is 2.23 km/per thousand (Zhou, 2010).
Table 6. Roads data in Hangzhou

<table>
<thead>
<tr>
<th>Years</th>
<th>00</th>
<th>01</th>
<th>02</th>
<th>03</th>
<th>04</th>
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<th>06</th>
<th>07</th>
<th>08</th>
<th>09</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of roads in urban districts (millions m²)</td>
<td>11.8</td>
<td>19.4</td>
<td>23.5</td>
<td>25.6</td>
<td>29.0</td>
<td>41.0</td>
<td>42.2</td>
<td>41.9</td>
<td>42.6</td>
<td>44.9</td>
</tr>
<tr>
<td>Total length of roads (km)</td>
<td>1,050</td>
<td>1,298</td>
<td>1,349</td>
<td>1,466</td>
<td>1,558</td>
<td>1,782</td>
<td>1,942</td>
<td>1,993</td>
<td>2,030</td>
<td>2,117</td>
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<tr>
<td>Area density of roads net (km/1000 km²)</td>
<td>342.2</td>
<td>423.1</td>
<td>439.7</td>
<td>477.8</td>
<td>507.8</td>
<td>580.8</td>
<td>633.0</td>
<td>649.6</td>
<td>661.7</td>
<td>690.0</td>
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</table>

Made by author, data from Hangzhou statistical investigation information and Zhou (2010). Notice: before 2005, roads in rural areas are not included.

A great part of the newly built roads were combined with the process of urbanization in new urban areas outside core districts, and only few roads were expanded in old centre districts. The newly built roads reduced potential traffic congestion in these new districts where many new residential buildings emerged. But the further potential congestions still exist. When we compared Hangzhou’s growth rate of new built roads 2.38% per year with the growth rate of vehicles number that exceeds 20% per year in the last decade, the rate of road capacity per vehicle was decreased every year. The new growth of roads capacity was filled by the rapid growth of vehicles.

We may have a broader view of Hangzhou’s transport system and traffic situation by comparing with other cities. Guangzhou city located in the south of China has roads length of 5,434 km with the size of 3,843.43 km² in urban districts in 2008 (Guangzhou Statistics, 2009). Area density of roads net is about 1,414 km/1,000 km² in 2008 in Guangzhou, which is much higher than Hangzhou’s 690.0 km/1000 km² in 2009. As is shown in the table 7, the roads in Guangzhou have been expanded, and from 2001 to 2007, per capita area of roads has also improved.
Table 7. Roads data of Guangzhou

<table>
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<th>05</th>
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<tr>
<td>Length of road(km)</td>
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<td>4447</td>
<td>5,076</td>
<td>5,208</td>
<td>5,335</td>
<td>5,434</td>
</tr>
<tr>
<td>Area of roads (1,000 m^2)</td>
<td>58,99</td>
<td>61,94</td>
<td>83,250</td>
<td>86,630</td>
<td>90,000</td>
<td>93,050</td>
</tr>
<tr>
<td>Area density of roads net(km/1000 km^2)</td>
<td>1,095</td>
<td>1,157</td>
<td>1,320</td>
<td>1,355</td>
<td>1,388</td>
<td>1,414</td>
</tr>
<tr>
<td>Per capita area of roads(m^2)</td>
<td>10.22</td>
<td>10.61</td>
<td>13.49</td>
<td>13.85</td>
<td>14.13</td>
<td>10.50</td>
</tr>
</tbody>
</table>


Guangzhou has a clear classification of roads levels, including high speed way, expressway, bridge way, main stem, collector streets, and so on. Theoretically, this classification of roads levels could separate different kinds of traffic flows efficiently and improve quality of the traffic system. However, traffic flows did not improve with the growth of Area density of roads net in Guangzhou. The speed of traffic flows has decreased on most of those roads shown in the table 8 from 2003 to 2010, particularly in the recent two years.

Table 8. Average speed of vehicles in evening peak periods in Guangzhou (km/h)

<table>
<thead>
<tr>
<th></th>
<th>03</th>
<th>04</th>
<th>05</th>
<th>07</th>
<th>08</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>High speed way</td>
<td>70.5</td>
<td>90.3</td>
<td>84.4</td>
<td>82.2</td>
<td>51.3</td>
<td></td>
</tr>
<tr>
<td>Expressway</td>
<td>48.6</td>
<td>51.7</td>
<td>49.5</td>
<td>55.2</td>
<td>39.8</td>
<td></td>
</tr>
<tr>
<td>Bridge way</td>
<td>32.7</td>
<td>39.7</td>
<td>40.4</td>
<td>34.4</td>
<td>21.9</td>
<td></td>
</tr>
<tr>
<td>Core districts</td>
<td>21.5</td>
<td>17.3</td>
<td>21.0</td>
<td>22.1</td>
<td>20.0</td>
<td></td>
</tr>
<tr>
<td>Haizhu district</td>
<td>21.7</td>
<td>22.6</td>
<td>24.1</td>
<td>18.2</td>
<td>21.0</td>
<td>18.7</td>
</tr>
<tr>
<td>Tianhe district</td>
<td>29.2</td>
<td>23.6</td>
<td>26.8</td>
<td>25.0</td>
<td>21.3</td>
<td>15.9</td>
</tr>
<tr>
<td>Baiyun district</td>
<td>14.2</td>
<td>25.0</td>
<td>18.6</td>
<td>24.6</td>
<td>21.5</td>
<td>18.7</td>
</tr>
</tbody>
</table>

The size of Hangzhou eight districts is about 3,068 km², which is smaller than Guangzhou’s 3,843 km². And Hangzhou’s population (eight districts) 4.24 million in 2008 is smaller than Guangzhou’s 6.46 million.

Guangzhou’s case shows that with the growth of area density of roads net, traffic flows did not improve, on the contrary, the average speed on the roads decreased. Hangzhou has an area density of roads net 661.7 km/1000 km², which is lower than Guangzhou’s 1,414 km/1000 km² in the year of 2008. In ‘Hangzhou Integrated Transport Planning’ (China National Technical Committee, 2011), government emphasized the purpose of completing urban road skeleton planning, which means there would be more roads built in future. What would Hangzhou’s traffic be when Hangzhou continue to build more streets even as much as Guangzhou’s?

According to theories discussed in chapter two, one probable result is that new added roads capacity soon will be offset by the rapid growth of population and vehicles in Hangzhou. For many years, vehicles seem to be the symbols of modernization. Those new expanded roads would further encourage people to buy vehicles. Just like what has happened in Guangzhou, more vehicles are driving on Guangzhou’ roads net, and made traffic system more congested.

The main purpose of Hangzhou government’s policy to expand roads capacity was to enlarge traffic capacity in order to develop the economy. Without doubt, roads capacity would be enlarged with expanded roads, and there would be more vehicles driving on those roads net. More people, especially those living in rural areas, could move on roads net. Xiaoshan district and Yuhang district will be more closely connected with Hangzhou’s urban areas. Other kinds of measures have to be used to deal with these congestions. If the government gives public transports, such as public bus, higher priority on these newly built roads, the situation of traffic could be better.

In my opinion, only building more roads could not reduce Hangzhou’s traffic congestions. However, it is impossible to stop expanding road capacity, since this measure is used to enlarge the whole traffic volume of Hangzhou, in order to stimulate economic growth. One possible way to reduce traffic congestion without decreasing economic development is to integrate the building of roads with other
kinds of instruments.

3.1.2 Improving public transport

Improving public transport could be seen as the most important instrument Hangzhou has adopted. BRT system and metro system were introduced in the last decade, which are regarded as the framework of traffic flow in the future. Hangzhou’s government has also tried public bicycle system as a supplement of public transportation systems.

3.1.2.1 Public bus

Public bus was the most important public transit of people’s commuting in Hangzhou in 2000, with about 22% of all commuting trips. But this rate is lower than commuting by walking (28%) and commuting by cycling and electric cycling (42%) at that time. The number of buses in Hangzhou Public Transport Group has grown from 2004 in 2000 to 4186 in 2005 and the number of bus lines has increased from 172 to 368 at the same time (Hangzhou Public Transport Group, 2006). In 2009 there were about 6889 buses and 532 bus lines (Hangzhou Public Transport Group, 2009).

Table 9. Hangzhou public buses

<table>
<thead>
<tr>
<th>Year</th>
<th>00</th>
<th>05</th>
<th>09</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public bus number</td>
<td>2004</td>
<td>4186</td>
<td>6889</td>
</tr>
<tr>
<td>Line number</td>
<td>172</td>
<td>368</td>
<td>532</td>
</tr>
<tr>
<td>Total length of lines (km)</td>
<td>2153</td>
<td>4902</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Source from Hangzhou Public Transport Group 2006 and 2009, modified by author.

The types of buses used have changed over time. New buses are more suitable for especially the old and younger people. The old buses had no air-conditioner and chassis are relatively high. They usually contain two or three steps behind the bus doors. In contrast, the new types of bus have air-conditioner and have no or only one step, which improved bus condition, boarding and alighting efficiency. In some bus stations, electronic displays were arranged to inform people waiting for buses.
about how long they should wait. Obviously, this kind of design could not improve the punctuality rate and speed of bus, but it does well to passengers’ feeling, especially in a big bus stations, where there are several bus lines. Passengers, whose bus, for example, will come in ten minutes, can take a rest on the chairs in the station for up to ten minutes, rather than always stand and watch whether the coming bus is the one they need or not. This design is also a supplement, where the punctuality rate is relatively low, since there is traffic congestion or other kinds of reasons, particularly in big cities.

Image 7. Public transport facility

Many instruments have been taken to improve public bus system. But they did not attract more people to choose buses, because of the weaknesses of bus transportation compared to other trip modes. In other words, not enough priority is given to public buses. For example, there is no Lights priority for public buses and public buses are always blocked in traffic flows of private cars. If road capacity was allocated based on the number of travellers more roads capacity should be allocated to public buses instead of using it through free competition by different vehicles. Then public buses could move faster, and attract more people formerly using other trip modes.

### 3.1.2.2 Bus rapid transit (BRT) system

Besides the instruments put on normal public buses, another important attempt of Hangzhou in public transport system is BRT. In 2006, the first BRT line B1 was settled across city centre from west to east in Hangzhou. By now, there are four lines of BRT in Hangzhou. Most of the BRT roads are
regulated only for BRT buses, except, due to the limitation of road capacity, a small part of roads in city centre. The BRT buses are 18 meters long and rated load member 160 (Wang, 2007).

Image 8. Bus Rapid Transit in Hangzhou

Ticket entrances were arranged at stations similar with subway station instead of charging in the bus, which reduced the boarding time. And the height of platforms was the same as the height of bus floors, also speeding passengers’ boarding rate. The buses only right-of-ways in Hangzhou were separated from the rest of the road by small yellow roadblocks instead of being totally separated from normal bus lanes. This makes Hangzhou’s traffic more flexible. Other kinds of vehicles can share this bus only way if there is an emergency, such as ambulance, fire truck and so on.

Image 9. Buses only right-of-way
According to the survey of Wang (2007), the BRT system had in the first month in average 38 000 passengers per day, and after 12 month in average 45 200 passengers per day. The BRT buses reached a speed of in average 25.5 km/h, compared with 12-14 km/h for ordinary buses. Obviously, this BRT system has some advantages over ordinary bus system.

At the end of 2010, Hangzhou Urban Planning Bureau published a ‘Revised Hangzhou Bus Rapid Transit lanes net planning summons’. In this planning, by 2015 year, there will be a radial BRT lanes net, including 12 lanes, 254 km in all. B2 lane would be adjusted, since it overlaps with the new subway route. And in 2020, there will be a total of 18 BRT lanes with length of 395 km in all. Also some of those lanes would be adjusted because of the new subway routes.
According to ‘The Rome Manifesto—Public Transport is Mobility for All’ (International Association of Public Transport, 2005), urban space should be allocated to passengers by number of people rather than vehicle, although private cars play an important role in individuals’ life and industry. Then in
Hangzhou’s case, the capacity on one lane is about 200 vehicles per hour carrying maximum 1,000 persons. In comparison, the capacity of one BRT lane is more than 3,000 persons per hour (Xu, 2007). If all those people that use the BRT system shift to private car, there should be a need for three more lanes on each road.

Although, BRT is reducing traffic congestion, there were many critics on BRT system at the first years. The critics can be summarized into two arguments: One argument was that road capacity were reduced since BRT lanes occupied some of lanes which formerly were shared by all kinds of vehicles. Private car drivers that experienced the reduced road capacity mostly expressed this problem. One example of the change caused by BRT is Tianmushan Road, North Ring road, and Kenshan East road, those transmeridional roads are the main roads in connecting east and west part of Hangzhou. Some parts of those roads were two-way four lanes before BRT lanes were arranged. But with two of those lanes occupied by Buses, there is only one lane for one-way (Image 8). Sometimes the private cars in normal lanes were congested, but there is no vehicle in BRT lane. This view makes drivers express dissatisfaction on BRT system. The other argument was that there are more traffic accidents caused by small roadblocks that separates the BRT lane from the rest of the roads. Traffic accidents caused by small roadblocks were widely covered by medium, which makes more people unsatisfied with BRT system.

The buses only right-of-ways in Hangzhou were separated from normal way by small yellow roadblocks instead of totally separated from normal bus lanes. Although this design has its advantages, which makes it more flexible for traffic flow, it also became a weakness of BRT. If BRT ways were totally separated, one obvious improvement would be faster speed of BRT transit and high efficiency of moving. Secondly, using high fence instead of small yellow roadblocks can eliminate the traffic accidents, which was criticized by many people. And this design would also have stronger psychological suggestion on drivers that BRT is a total different kind of transit, it should be differentiated.

In general, BRT in Hangzhou has some unique advantages: low investment, shorter construction cycle than rail system and larger capacity than normal public bus. BRT was assumed to share a great part of
traffic flows, particularly in a situation when there is no subway yet.

### 3.1.2.3 Subway system

Subway system could be seen as the most efficient public transit in metropolises, because of its huge capacity. The development of economy and the growth of population, has now made Hangzhou suitable for building subway system.

Image 12. Centre districts and three satellite cities


Image 13. Metro net planning 2050 in Hangzhou

In 2005, ‘Hangzhou Rail Transit Net Planning (revised)’ was approved by State Council (Hangzhou Metro, 2010). Metro No.1 and No.2 are under construction with the designed length 82.2 km in all. According to the plan, metro No.1 route will connect three satellite cities with centre districts more closely (red “Y” line in image 12). Also the other routes, which will be built in next decades, are going to string those small towns around centre districts. By 2050, there will be eight subway routes in Hangzhou.

A large number of people will choose subway when they go to workplace or back to home. The metro will also encourages people who live close to subway routes to trip by subway rather than private cars, and inspires mobile population to settle near the subway routes. In the year 2030, Hangzhou’s population is expected to reach the interval 6.48 and 6.91 million (Yi & Ye, 2008). A great part of the new inhabitants will be encouraged to settle near subway routes.

Singapore is a city well known for its efficient public traffic system. Since 1970s, Singapore has put great efforts on public transportation. The public traffic system in Singapore contains metro, light way, public bus, taxi and so on, with the total length of metro reaching 109.4 km, including 65 stations; and light way 28.8 km with 65 stations; 260 public lines with 3599 public buses in 2005 (Wu & Li, 2007). As is shown in table in 2005 more than half of the trips in Singapore was made by the public transits system.

<table>
<thead>
<tr>
<th></th>
<th>Metro and light way</th>
<th>Public buses</th>
<th>Taxi</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate of trips (%)</td>
<td>17.6</td>
<td>34.8</td>
<td>12.4</td>
<td>35.2</td>
</tr>
<tr>
<td>Total traffic flow (1,000,000/day)</td>
<td>1.41</td>
<td>2.79</td>
<td>0.99</td>
<td></td>
</tr>
</tbody>
</table>

Made by author, based on Wu & Li, 2007.

Singapore’s public transport has many advantages. First of all, it has highly integrated traffic modes. The light way transit is connected with metro system, and public buses stations are located close to metro lines. People do not need to go out from stations, since many stations were designed based on the ‘door to door’ principle. Also, One-Card is used in its public traffic system. In addition, there are
112km length of buses only right-of-ways, which are only available for public buses during the most congested five peak hours every day (Feng et al., 2008).

The market share, in terms of trips, for Hangzhou’s public transportation system increased from 8.5% to 21% between 1997 and 2000, but between 2000 and 2005 it did decrease to 20%. When compared to Singapore’s 52.4% public transits rate, Hangzhou’s low rate should firstly attribute to its simple transit modes. There is no subway system and no light way system in Hangzhou and a majority of the public buses have no access to buses only right-of-ways and other kinds of traffic priorities.

Table 11. Rate of transit trips in Hangzhou (%)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking</td>
<td>21</td>
<td>28</td>
<td>29</td>
<td>30</td>
</tr>
<tr>
<td>Bicycle (including electric bicycle)</td>
<td>61</td>
<td>43</td>
<td>39</td>
<td>34</td>
</tr>
<tr>
<td>Public transit</td>
<td>8.5</td>
<td>21</td>
<td>21.5</td>
<td>20</td>
</tr>
<tr>
<td>Private cars</td>
<td>8.5</td>
<td>7</td>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>1</td>
<td>1</td>
<td>1.5</td>
<td>2</td>
</tr>
</tbody>
</table>

Source from: Chen, 2009, modified by author.

In cities with integrated public transit systems like Singapore’s, more people will be attracted especially from walking and cycling people. Also with the effects of market and regulatory instruments, more drivers will shift to public transit. The rate of private cars in Hangzhou is 14% in 2005, but increasing because of the rapid growth of vehicles. Investing and perfecting on public transit in Hangzhou can significantly change rate of transit trips.

3.1.3 Bicycle system

Besides these major transport systems planning, Hangzhou also has put many efforts on bicycle system. In 2008, Hangzhou became the first city in China to install a bicycle system in The West Lake scenic area, north areas, and west areas, with 61 bicycle rental sites and 2500 bicycles (Wang Xiuxiu, 2010). People can rent a bicycle by a prepaid bicycle rent card or ID card and return the bicycle at any rental sites they want. The fee of renting a bicycle is quite cheap: free in one hour, 0.11 Euro between one and two hours, 0.22 Euro between two and three hours, and 0.33 Euro per hour if more than three hours (see in table 12).
Table 12. Fees of public bicycles

<table>
<thead>
<tr>
<th>hours</th>
<th>1</th>
<th>1-2</th>
<th>2-3</th>
<th>3+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fee (Euro/hour)</td>
<td>0.11</td>
<td>0.22</td>
<td>0.33</td>
<td></td>
</tr>
</tbody>
</table>


The original purposes of bicycle system run by Public Transport Company was to extend service and to expand accessibility of public transportation (Zhang, 2009) by improving, connecting with public buses. With the support from of government, the investment of bicycle system is growing and now there are 2177 bike rental sites and more than 50,000 bicycles cover urban districts (Wang Xiuxiu, 2010).

In 2000, more than 40% of the people in Hangzhou used bicycle as their transport means. With the development of private cars, less space were left for bicycles, and more people chose private cars as commuting tools. The emergence of public bicycles was widely accepted by citizens. On some congested roads using bicycle can save time in comparison with public buses and private cars. It is widely accepted not only by local people but also by travellers.

Copenhagen is one of the most bicycle friendly cities. A great part of people trip by bicycle in their daily lives, and cycling is seen as natural for Copenhageners. The city has a relatively long bicycle history. As early as the 1970s, there were some bicycle roads nets in urban districts. And many people went to workplace by bicycle from then on, although the number of vehicles grew at the same time.

Also every year, there is a Bicycle Account made as an assessment of cycling development in Copenhagen. Copenhagen city of cyclists (2008) shows that the percentage of people cycling to work or education increased from 30% to 37% between 1996 and 2008. In order to reduce CO₂ emissions and meet sustainable development, ‘Cycle Policy 2002-2012 City of Copenhagen’ was established aimed at reaching rate of cycling mode to 40% from total trips.
A bicycle-sharing program, named City-Bike, was induced in Copenhagen in 1995. It was owned by a non-profit institution set by government. The quantity of bicycles in the program reached its peak at 2,500 in 2000, but decreased to about 2,000 bicycles in 2006 (Santos Canals et al., 2006).

The number of people tripping by bicycle is about 150,000 (Copenhagen city of cyclists, 2008). In Hangzhou 34% of people are using bicycle as their means in 2005, which is similar to Copenhagen’s 36% in 2006. One thing Hangzhou could learn from Copenhagen is the attitude of Copenhageners towards cycling and the way government encourages people to choose bicycle. Cycling is as natural for Copenhageners as brushing their teeth (Copenhagen city of cyclists, 2008) for those 36% of people who prefer to use bicycles when they go to their workplaces, although vehicles are affordable for most of them. 34% of people in Hangzhou chose bicycle because of its flexibility and cheap price, though more and more people regard it as a healthy way.

Although public bicycle project was supported widely in Hangzhou, there are some problems with the system. The bicycle rental sites are divided into three main parts (Qian et al., 2010): core districts,
business districts, residential districts. One problem in residential districts is that it is hard to rent a bicycle and hard to find a bicycle parking space in rental sites in peak hours. As shown in the table 13, rental times are mainly focused on peak hours. So because in peak hours more people use bicycles, some people find it hard to rent a bicycle or return one during rush hours. This problem makes it difficult for people to use public bicycle regularly when they go to workplace, and discourage people to use it.

Table 13. Rate of rental in different hours

Source from: Qian et al., 2010. p. 74.

Another problem that happened more frequently in city core districts is the quality of automatic borrowing system. Sometimes borrowing machine shows you have borrowed a bicycle, but you cannot get the bike from lock. On the contrary, sometimes borrowing machine does not show that you have borrowed a bike, but you can take the bike from lock. The problem became visible first when you return the bike at another rental sites, when you are told that you cannot return, since you have not borrowed a bike according to the borrowing system. This mismatch of borrowing system created discontent.

One vital element for bicycle system is the regulatory support of government and whether they put enough attention to this transit. In the past years, governments in some Chinese cities did their best to build ‘modern’ cities, with no room for outdated things like bicycle. As a result, the space of bicycle ways was compressed even eliminated in the process of urbanization. A bicycle road net is base of
bicycle public system.

The physical instruments I have discussed provide Hangzhou's people more choices for trip modes. The expansion of the road capacity and more people having their own car, has increased total traffic volume in Hangzhou. But it has probably not reduced traffic congestion without other kinds of instruments. There are some improvements on public buses, such as the growing number of public buses, more facilities built in stations, but buses are still blocked by private traffic flows on many roads, and have not enough traffic priorities for public buses. BRT system was adopted by Hangzhou’s government, but only served few people, and more BRT lines are still unavailable. Subway system is under construction, but it cannot serve people in a short term. Bicycle system was introduced and widely accepted by most of people, but sometimes it does not run smoothly.

Although the government has adopted many different instruments, vehicles are still growing rapidly since it has advantages over other modes. So physical instrument should be combined with market instrument and regulatory instrument when dealing with traffic congestions.

3.2 Market Instruments

Hangzhou has adopted some market based instruments mostly for other purposes than reducing traffic congestion. Few market instruments have been adopted to reduce traffic congestion. However, other cities’ experience may help Hangzhou to reduce traffic congestion.

3.2.1 Road pricing

The road toll in China is mostly used on the expressway net, which was designed to finance the investment in the motorway network rather than to reduce the number of cars. Those roads usually connect different cities instead of linking different parts within a city. As for Hangzhou, the Ring road and those radial roads toward to other cities are priced, aiming at paying off loans of building roads.

Many drivers are dissatisfied with road toll, while the loans have already been paid off for several
years. However the road toll is still over there, without any further explanations. It seems road pricing was regarded as an earning tool for those companies and government investing in the expressways. But with increasing dissatisfaction and slower development of logistics industry, those roads pricings are predicted to be cancelled in the future.

Currently there is no traffic congestion on those expressways. However, in the future there might be traffic congestions also on the expressways net, which will be complete during the 12th five years plan covering Hangzhou urban districts. With the growing number of private cars, like many American cities, these expressways may soon be congested. One possibility is that the government will charge road tolls of those expressways in order to pay off loans of it. It is hard to know whether this kind of road pricing would also reduce the number of vehicles. If the road pricing does not reduce private cars, maybe it is possible to raise the toll fee. The charging would be complex and confusing if there is no clear explanation, and probably drivers will not accept it.

Road pricing is also charged on some roads that is part of the ‘Four Themselves Project’. This ‘four Themselves project’ means ‘loan by themselves, building by themselves, charging by themselves, and paying off loan by themselves’. Themselves refer to investor or interest groups, who were encouraged by government to invest in roads infrastructure in 1990s.

Since 1975 Singapore has carried out an area pricing scheme aimed at improving the traffic condition in downtown Singapore. Singapore’s area licensing scheme has reduced the amount of commuting driving to the CBD from 56 percent in 1975 to 23 percent in 1983 and increasing the public mode split
from 33 percent to 69 percent. The traffic flow improvements achieved by this revenue-producing scheme would have required $1.5 billion in road investment. Finally, car ownership models based on wealth were suggesting Singapore should have had more than 300,000 vehicles in 1982, whereas it had only 184,000 (Newman & Kenworthy, 1999).

Payment was initially needed when vehicles move into city centre from 7:30 to 9:30 a.m. Later the time span has been extended from 7:30 a.m. to 6:30 p.m. From the table 15 we can learn that by 1975, traffic capacity moving in the cordon area decreased by 44 percent; by 1998, the traffic volume entering the cordon zone was 31 percent lower than in 1975, despite the fact that the total number of vehicles in Singapore was 73 percent larger than in 1975.

Table 14. Characteristics of eight major road pricing schemes

<table>
<thead>
<tr>
<th>City</th>
<th>Electronic system starting date</th>
<th>Entry charge for a small vehicle (USD)</th>
<th>Toll ring area (km²)</th>
<th>Average daily crossings</th>
<th>Annual revenue (million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trondheim</td>
<td>1991</td>
<td>2.40</td>
<td>50.0</td>
<td>74,900</td>
<td>25.00</td>
</tr>
<tr>
<td>Oslo</td>
<td>1991</td>
<td>2.40</td>
<td>64.0</td>
<td>248,900</td>
<td>196.00</td>
</tr>
<tr>
<td>Bergen</td>
<td>2004</td>
<td>2.40</td>
<td>18.0</td>
<td>84,900</td>
<td>36.00</td>
</tr>
<tr>
<td>Stockholm</td>
<td>2006</td>
<td>1.33-2.66</td>
<td>29.5</td>
<td>550,000</td>
<td>n/a</td>
</tr>
<tr>
<td>Singapore</td>
<td>1998</td>
<td>0.33-2.00</td>
<td>7.0</td>
<td>235,000</td>
<td>80.00</td>
</tr>
<tr>
<td>Rome</td>
<td>2001</td>
<td>3.75</td>
<td>4.6</td>
<td>75,000</td>
<td>12.3</td>
</tr>
<tr>
<td>London</td>
<td>2003</td>
<td>15.0</td>
<td>22.0</td>
<td>110,000</td>
<td>320.00</td>
</tr>
<tr>
<td>Santiago</td>
<td>2004</td>
<td>6.42</td>
<td>n/a</td>
<td>250,000</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Source: Ison & Rye (2008), modified by author.

Table 15 also shows public transport travelling have increased markedly from 33 percent to 46 percent in 1975 and 69 percent in 1998. Now they are using electronic fee collection system and there is no need to wait on the charging ramps. A smart-card that records credits when vehicle moves into cordon area by a memory chip in the card, is inserted in the vehicle. Then driver could pay the bill later, and the records information would be erased. In 1998, Singapore’s traffic congestion has been further reduced, with the help of smart-card system.
Table 15. Effects of road pricing in Singapore

<table>
<thead>
<tr>
<th>City</th>
<th>Traffic effects</th>
<th>Congestion</th>
<th>Public transport effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Singapore 1975-1998¹</td>
<td>-44%; -31% by 1988</td>
<td>Average speed increased from 19 to 36 km/h</td>
<td>Modal shift, from 33% to 46% trips to work by city bus, 69% in 1983</td>
</tr>
<tr>
<td>Singapore, 1998²</td>
<td>-10% to -15%</td>
<td>Optimized road usage, 20 to 30 km/h roads, 45 to 65 km/h expressways</td>
<td>Slight shift to city bus</td>
</tr>
</tbody>
</table>

Notes: 1 Although called Area Licensing Scheme, the system was a cordon toll rather than an area license. 2 Electronic fee collection introduced. Sources: Ison & Rye, 2008

Through roads pricing, Singapore improved its traffic flows significantly. Based on Singapore's experience road pricing seem to be an attractive instrument in combating traffic congestion. Road pricing has not been used in Hangzhou's core centre districts. It would be possible and reasonable for government to charge congestion fees in Hangzhou's core centre districts. As has been discussed in theoretical chapter, theoretically, the higher road pricing is, the fewer people will choose this pricing route. Thus, traffic congestions on those roads will decrease. The traffic flows will be improved, more vehicles per hour can use the roads. Any traffic congestion will be reduced, as soon as there is enough high road pricing.

It should be noticed that the effects of roads pricing depend on the context. Roads pricing did succeeded in Singapore, but may not be successful in present Hangzhou. One important reason is that there are no other kinds of transit which can substitute private cars. Perhaps, public buses system can be an alternative. If higher priorities are given to public buses, such as roads priority, signal priority and roads pricing, some drivers may turn to public buses. Another choice is public bicycle, just like Copenhagen, but there need to be enough bicycles in rental sites and no problems with borrowing machines. However, in Hangzhou the climate, extremely hot humid summers and chilly dry winters, is a problem. BRT is another choice, if there is a BRT traffic net, it may attract people using it instead of private cars. So if roads pricing is used to reduce Hangzhou's traffic congestion, the effects may not be as good as in Singapore. In a situation when there is a good public transport system, roads pricing
instrument may have much more effect.

3.2.2 Parking charges

With the growing number of private cars, there is a corresponding demand of parking space. In recent years, the main concern of both citizens and government has been how to expand parking space in order to meet the growing demand instead of using parking toll to reduce the number of cars. In 2007, there were about 400,000 vehicles in urban areas, but only 130,000 parking space (Focus, 2008). This gap between cars and parking space impelled government to draw up ‘Municipal party committee office and Municipal government office’s implementation opinions about how to solve parking problems’ (Municipal party committee office, 2008).

In this document, the first principle is to meet people’s desire of parking through exploring parking resource, formalizing parking management, decreasing parking fees. Another principle is that under the premise of priority of walking people and non-motor vehicle. It also emphasized that to accelerate the establishment of public priority system: increasing the rate of trips by public transport, completing slow transit system.

One instrument to reduce the private cars in urban area in the document is planning parking lots at important transportation hubs. According to the plan there will be four large parking lots located in north, south, east and west of the urban districts. These parking plots are connected to the public transport system. Only in The west lake scenic area parking fee was encouraged as a market instrument to control the number of cars. In this area parking fees is suggested to be different between holidays and workdays, day and night in order to make traffic flow efficient. The high parking fee may have same effects as roads pricing in core centre districts. Since people have attractive alternatives, they have to endure high charge of parking fees.

Reducing parking space may be a useful way to reduce traffic congestion. At first, there may be much more vehicles on the streets, since there are not enough parking spaces and vehicles are not allowed
to stop on street, so some vehicles drive on the roads just in order to find parking space. But when they have more experiences about this situation, they would shift to other modes. The key point is that government must have a strong policy on reducing parking space, since there would be huge demand for more parking space from drivers when they can’t find parking spaces.

Market instruments may not have a good effect on reducing Hangzhou’s traffic congestions, since Hangzhou has no well-developed public transits system. People prefer to use vehicles even if there is a relatively high toll, such as roads pricing and parking fees, rather than choose public buses with poor qualities. Even if there is a toll high enough that some drivers have to shift to other modes and traffic flows are improved, these drivers’ trip qualities will drop significantly. In a word, market instruments for reducing traffic congestion should be implemented on the base of physical instruments.

3.3 Regulatory instruments

Regulatory instruments are used more frequently than market instruments to deal with traffic congestions in Hangzhou. They have more directly effects on reducing traffic congestion than market instruments. Banning motorcycle in six urban districts (not including Xiaoshan and Yuhang districts), and ramp metering on expressway are used in Hangzhou.

3.3.1 Banning motorcycles in urban areas

Motorcycles are forbidden in many cities in China. For example, in 2007, people in Guangzhou were not allowed to drive motorcycles in the urban districts any more, which covered 525 km² areas (Ma, 2009). Since 1991, government had restricted the numbers of license plates to new motorcycles and stopped to provide new license plates in 1998. Gradually, stricter measures were adopted to reduce the number of motorcycles in the urban districts. Finally, in 2007, motorcycles were forbidden in all urban districts.

One of the reasons for this decision was to improve traffic flows. And the measure did indeed have a huge, both positive and negative, influence on the traffic system. In 2007, 152,000 new private cars
were added to the local car fleet. In the years 2002-2006 the car fleet annually grew by between 70,000 and 100,000 new cars. This high rate of growth made people who formerly drove motorcycles to shift to private cars and people who formerly use other transit modes induced by improved roads system. The traffic volume of rail system in 2007 is 1.3 million persons, 72% more than in 2006. More than 60% of people who formerly chose motorcycles shifted to public transport system (Ma, 2009).

The banning of motorcycles in urban districts in Guangzhou have encouraged many people who formerly chose motorcycles shift to other kinds of modes, such as public transport, bicycles, and a minority to private cars. The question is whether this banning reduced traffic congestion? It may reduce traffic congestion to some degree at the beginning of banning. But the fast growth number of vehicles may have offset the positive impact on traffic congestion.

In 2001, Hangzhou Planning Committee announced that license plates of motorcycle in urban areas (not including Xiaoshan and Yuhang districts) are not available any longer, and existing motorcycles are going to be sifted out gradually. Like in many other Chinese cities, there are now no motorcycles anymore in Hangzhou urban areas. The government gave no official explanation of why motorcycle should be sifted out in Hangzhou urban areas. But the main reasons for banning motorcycles could be listed as follows: Motorcycles are high pollution rate, have low security coefficient and they decreases the speed of traffic flow when combined with car flow. In addition riders of motorcycle often break traffic laws and motorcycles are used by many criminals committing a crime. Furthermore, many people think them not suitable for modern city’s image.

Because of motorcycle’s cheap price and mobility, motorcycles were chosen by many low-income people. Now city streets and expressway are only available for four-wheeled vehicles, which usually belong to rich people. What’s more important, motorcycle restriction separates countryside from urban areas, which makes the gap between city and countryside bigger, particularly when there is no convenient public transportation.

What if there motorcycle driving is allowed in Hangzhou’s urban districts? Definitely, there would be much more motorcycles in urban districts and many of them would came from countryside like the
Xiaoshan and Yuhang districts. But will it increase traffic congestion? According to Downs’ Law, if there are too many vehicles on roads, and the traffic is slower than other kinds of traffic modes, then some of the people using private cars would shift to other kinds of modes. So it may not increase the degree of traffic congestion. But as more people are on the roads in urban districts, the time of traffic congestion would be prolonged. Another problem is there will be more traffic accidents, as a result of the mixing of traffic modes.

In general, banning motorcycle in urban districts indeed eliminated this kind of transit, but without controlling the number of vehicles, traffic congestion will still exist in Hangzhou.

### 3.3.2 Ramp metering

Ramp metering instrument is used on Hangzhou’s expressways. This instrument only focused on traffic congestion happening on expressways. There is only one expressway named Shangtang Elevated Bridge in north-south direction, crossing Hangzhou urban districts. According to ZJOL (2010), there are three main problems causing congestions on this expressway: 1. three lanes merge into two lanes on the ramp, which decrease traffic flow; 2. The expressway reaches peak hours about 30-40 minutes earlier than normal streets in the same direction; 3. Two sites of the expressway were most congested: the ramp on the Qingcun road in north to south direction and ramp on the Wenhui road in south to north direction.

The ramp metering in Hangzhou have tried is close the ramp on the Qingcun road in north to south direction between 6:45am-7:45am every day, and control the ramp on the Wenhui road in south to north direction between 6:45am-7:30am. Also the closed time of N ring road ramps from west to north and east to north were shifted to an earlier time 6:45am instead of 7:15am (ZJOL, 2010).

The traffic flow on north part of Shangtang elevated road from Qingcun road have been increased to about 895 vehicles per hour, which is about 29.6% of total traffic flow. And the traffic flow on south part of Shangtang elevated road from N ring road have been increased to about 900 vehicles per hour,
which is about 29.4% of total number of vehicles.

In ‘Hangzhou Integrated Transport Planning’ (China National Technical Committee, 2011), there are a expressway roads net including five horizontal expressways and three vertical expressways in the next five years. According to triple convergence, if there is no vehicle controlling instruments, more vehicles are predicted to drive on those expressways. With this instrument, traffic flows on those expressways will be controlled at its maximum. This instrument is only designed for reducing traffic congestion on expressways, and it can achieve a good effect on reducing traffic congestion.

3.4 Conclusion

Hangzhou is in the process of urbanization with a rapid growth of both population and vehicles. Traffic congestion has become a problem in the social development. In order to manage the situation Hangzhou has used mainly physical instruments, regulatory instruments, and a few market instruments. The aim is to reduce Hangzhou’s traffic congestion without sacrificing the speed of economic development.

Image 16. Process of reducing traffic congestion

Physical instruments are most widely used to deal with traffic congestion. Without physical
instruments, the effects of reducing traffic congestion by other two kinds of instruments will cut down greatly and even slow the speed of economic development. But physical instruments alone can hardly reduce traffic congestion.

Up till now Hangzhou has mainly focused on using physical instruments to reduce traffic congestion. When there is a thorough public transport system, market instruments and regulatory instruments will have much more effects on reducing Hangzhou’s traffic congestion.
4. Recommendations for Hangzhou’s transportation

In chapter three I discussed the instruments Hangzhou has adopted and compared it with instruments used in other cities. Combined with the theoretical instruments and principles discussed in chapter two and the background information of Hangzhou in the first chapter I will give some recommendations both in supply side and demand side for Hangzhou’s transport development in this chapter.

4.1 Supply side recommendations

Since the growth of population and the process of urbanization, Hangzhou will need to build more roads in future as they have done in the past two decades. In my opinion, because the source of lands for building roads is limited, and the rate of people who have vehicles is quite low, the growth rate of roads can’t catch up with the growth of vehicles. If roads are built for private cars, more vehicles will be induced by expanded roads capacity. The effect of traffic congestion by expanding roads is determined by the way the road capacity shared between private cars and public transportation. Therefore, new roads should put more priorities on public transport. Some of the new roads should be regulated as buses only right-of-ways not only for BRT system, but also for normal buses. Also more roads should be built for pedestrians and cyclists.

The rate of people who trip by public transport is at present quite low, compared with other cities, in Hangzhou. Most people travelling on foot or bicycle in Hangzhou are relatively poor, and only a small percentage use private cars. With growing incomes many middle-class families will choose private cars if there is no good and efficient public transport system. Therefore more investments in public transportation are needed. The BRT system should be expanded with more separated buses only right-of-ways. Since public buses system is the biggest public transit mode so far and BRT only has two lines and the metro system is under construction, efforts should be made to develop the bus system.
Public buses should be given more traffic lights priorities and road priorities in order to serve people more efficiently. The development of public transport should be put in the most important place, since all other market instruments and regulatory instruments are based on a good public transport system. Without good public transport system, traffic congestion can’t be reduced easily.

As a well-known tourist city, Hangzhou also wants to be a liveable city. Public bicycle is a good try, since it is environmentally friendly and can be seen as a healthy way of life. There are several aspects of public bicycle system that can be improved. The first one is to combine more tourism info sites and small shops with bicycle rental sites particularly in landscape areas and bus stations. And the incomes of those sites and shops could be used as the cost of bicycle maintenance. In addition, the bicycle company should get more support from government to set more bicycle rental sites all over the urban districts of Hangzhou. Many people cannot rent a bicycle or return it during peak hour areas, because of the limitation of sites space. So more bicycle rental sites can make it become more convenient to use bicycle system. Also, the borrowing system need to be improved, because people are disappointed when they find out that it does not work and they spend much more time on it.

In general, there should be a better integrated public transport system rather than several different kinds of public transits running separately. One-card would be a good try used in different kinds of public transits in Hangzhou, which could make it more convenient in all kinds of public transits. Transfer stations facilities should be improved. More people living outside of Hangzhou centre districts would park their private cars at transfer station then take public transits to urban districts, and people living in centre districts would prefer to transfer between different transport modes. All this small improvements could make public transport more attractive for people and give them more choices.

4.2 Demand side recommendations

Supply side instruments alone are not enough to solve the traffic congestion problem. Supply side instruments give people more choices when they travelling which may cause the result that fewer people choose using private cars. However, those instruments do not focus on key point of traffic
congestion: the private cars. So demand side recommendations mainly focus on how to control the number of cars.

Road pricing should be used on Hangzhou’s core urban district. Payments are needed when private cars enter these districts, but free for public buses. Some drivers will not pass these districts by cars or choose other kinds of modes when they do not consider it affordable to use private cars. It can be used at peak hours, then people can change their travel time and there will be less congested during peak hours. In other words, prices should be differentiated based on the traffic volume in order to stimulate people to change the travel habits. Also road pricing could be used 24-hours if the effect of charging only during peak hours is too small. Technically, with the help of smart card vehicles can be charged without stop at any ramps when they enter pricing districts.

Parking fee is another useful instrument for Hangzhou. Similar to road pricing, when people think it’s not affordable for them to park at urban district, they would not travelling by vehicles. So there should be enough high parking fees and a few parking lots in order to get people to choose other transport means.

Besides those market instruments, ramp metering should be used on expressways net. In the next decade, the expressways net will be finished. Since ramp metering control specific number of vehicles driving on roads, traffic flows could move at a high speed.

4.3 Conclusion

To meet the goal of reducing traffic congestion in Hangzhou, the instruments I have discussed should be adopted. Supply side instruments or physical instruments should be improved in the first step, such as public transit. All the other instruments used should be based on these instruments. Since instruments like road pricing, parking fees could not reach their aims without good public transits.

Also when there is a good public transport system, which is accessible for majority of people in urban districts, demand side instrument should be adopted, since demand side instruments both market
instrument or regulatory instruments directly put pressure on private vehicles.

How big impact the suggested instruments may have on the traffic situation is undefined. Building of BRT system net may take five to ten years, and a metro way system will take even longer time. During this period, traffic congestion probably will not reduce, even if there are more buses only way for normal buses. And traffic congestions may still exist, also when the BRT and metro are finished, since the accessibility of public transport is lower than private cars, especially in rural areas of Xiaoshan and Yuhang districts. Many of people in these two districts will go to Hangzhou city centre by private cars when vehicles are affordable for them, but there is no convenient public transit they can choose. Also for people living in urban districts, many of them may still prefer to private cars. But with the applying of roads pricing and parking fees, some of people may shift to public transports. In a situation in which public transports reach their top limit, these demand side instruments will be less efficient, since it is no longer possible for drivers to shift to overload public transits.

It is difficult to predict whether these instruments will solve the traffic problem or just temporarily reduce it. When people get richer, fees of road pricing and parking fee may not be an economic problem for them. Then there will probably again be traffic congestions. And traffic congestion may be eased temporarily again when government further raise fees of road pricing. But people's salaries continue to grow. So it is hard to know whether traffic congestion is solved forever or just temporarily.

There are some difficulties when Hangzhou tries to implement these instruments. Lots of subsidies are needed to improve public transport facilities. How much Hangzou can spend on those physical investments is undefined. How to integrated different kinds of transport is another important question, since there are different interest groups among different transit departments. Furthermore, it is difficult to persuade people to choose public transport instead of private cars inwardly. So when parking fee and road pricing are affordable for people, many of them may probably choose private cars.
References


Hangzhou Planning Committee, 2001. Notification of Arrangement opinions of growth vehicles in Hangzhou urban districts. Available at:


Wang, J., 2010. More 250,000 vehicles added this year in Hangzhou, ranking 6th in China. Available at:


Image references


Image 2. Made by author.

Image 4. Electric bicycles. Available at:


Image 5. Traffic congestion in Hangzhou. Available at:


Image 6. Comparison among the cars, buses, and tram system. Available at:


Image 7. Public transport facility. Available at:


Image 9. Buses only right-of-way. Available at:


Image 10. BRT lanes net planning 2015 in Hangzhou. Available at:

<http://www.hzplanning.gov.cn/DesktopModules/GHJ.PlanningNotice/ShowImageWeb.htm?noback=no&image=%u002F%u0077%u0069%u006E%u0074%u0061%u0063%u0068%u0072%u0065%u006E%u0061%u003C%u002F%u0077%u0069%u006E%u0074%u0061%u0063%u0068%u0072%u0065%u006E%u0061%u003E80&file=U0120412.jpg> [Accessed 12 May 2011].

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Image 11. BRT lanes net planning 2020 in Hangzhou. Available at: <http://www.hzplanning.gov.cn/DesktopModules/GHJ.PlanningNotice/ShowImageWeb.htm?noba ck=no&image=%u002F%u0077%u0069%u0073%u0074%u0061%u0072%u0066%u0069%u0066%u0061%u0063%u0069%u0074%u002F%u0065%u0073%u006B%u0074%u006F%u0070%u006D%u0065%u0073%u002F%u0070%u006F%u0062%u006C%u0069%u0074%u002F%u0032%u0030%u0031%u0030%u0031%u0032%u0038%u0031%u0035%u0030%u0032%u0038%u002E%u006A%u0070%u0070%u0067> [Accessed 12 May 2011].


