Motorization in China at the dawn of the 21st century: Lessons from Beijing and Shanghai

Julien Allaire
LEPII-EPE /CNRS
FRANCE
Julien.allaire@upmf-grenoble.fr

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Abstract
During the 1990's, Chinese government has chosen to build up a national car industry and to promote automobile development. At that time automobile was collective, it was used as taxi or for enterprise staffs. But since 2001, personal cars has increased dramatically and the richest Chinese Metropolis have been quickly motorizing. That results in an important issue for energy consumption in transportation sector.

But, because of the density population and despite of high road construction rate, Chinese developing cities meet a serious lack of urban space for motorization. Authorities noticed that automobile couldn't answer to urban mobility needs. As public transport investment has been frozen during 1990's, more and more mass transit projects have been approved by the central government last years. From Metro to Bus Rapid Transit, every options are developed in the country. Public transport knows a revival in a country where it was particularly underdeveloped.

In this article, we will try to show the rapid changes of Chinese urban transport strategy due to dramatic increase of vehicle fleet in cities with high population density. We will look at the two models proposed by the country's two most developed metropolises: Beijing and Shanghai. Those two cities are both facing congestion but for different level of motorization. Beijing is the most motorized Chinese city, when Shanghai has kept a low motorisation level thanks to an auction system of registration plates. But both are meeting the space constraint with motorization.

Introduction

Over the past twenty-five years, China's cities have been transformed by the development that has been spawned by economic change. They have become both more populated and richer. At the same time they have spread outwards, vacating space in city centres and providing new areas for migrating populations and new economic activities. This transformation of the country's cities has meant an increase of daily travel distances, a phenomenon made possible by the development of mechanised forms of transport.

In the 1980s, the bicycle provided a transition towards the creation of a system based on the automobile. This development started out somewhat hesitantly in the 1990s with the introduction of non private vehicles such as taxis and company cars. Since the year 2000, the wealthier households in the most affluent towns and cities have begun acquiring vehicles, in line with the industrial policy of the Chinese authorities. Since the 1980s, the Chinese State has sought to provide the country with an automobile industry that can compete on the world market. Chinese leaders have decided to make this sector a mainstay of the country's economy. Its role is to ensure economic prosperity through exports, following the example of the Japanese and Korean economies. The domestic market is expected to provide the initial demand while the burgeoning industry is acquiring a competitive level of skills. With the help of foreign manufacturers, state-run companies have, since the end of the 1980s, produced vehicles to meet the needs generated by the social changes taking place. During the 1990s, the state was the main purchaser, since the country's total stock of vehicles was essentially composed of taxis and vehicles owned by state-run companies. Since this fictitious market between state compa-

nies did not produce the hoped-for industrial results, and faced with increasing demand, the government decided to liberalize the market, opening it up to individuals. When China joined the WTO in 2001 this was a decisive step that heralded an explosion of individual car sales.

The motorisation of Chinese households is an important issue for oil consumption and climate change. Currently, oil demand in the transportation sector is still low because of a low car ownership. But with economic growth, we can expect a rapid increase of oil imports because of the car fleet's development. Schipper *et al* (2000) propose different scenarios to illustrate the possible evolution of car use in China. In a "road ahead" scenario, the authors consider the oil demand will be around 2.4 million barrels per day (Mb/d) in 2020. In a "car collapse" scenario, the oil demand is forecast to be ten times less important mainly due to pollution and traffic constraints. In this article, we will try to show that, despite a "road ahead" policy of the central government, China is following the "car collapse" path because of urban form constraints.

Regarding the two richest cities, Beijing and Shanghai, we observe that rapid motorization is self-limitedby congestion. The country's two most developed metropolises propose two different models. The two cities have different urban heritages and, in an identical national context, have responded differently to motorization. To examine urban motorization in China, we only consider car growth. Strict legislations in Chinese large cities limit ownership of two-wheel vehicles.

Beijing has experienced rapid motorization in step with market development. Shanghai, following the Hong Kong model, has managed to control demand for automobiles. However, both cities are reacting in the same way to traffic congestion by rapidly building public transport networks. Scarcity of urban space during rapid urban development era is the first cause of mass transit infrastructures development. It is also one of the main reason of limited oil demand for urban mobility.

Two different urban heritages

Beijing, as the country's political capital, was developed in the 1950s along the lines of a Soviet model, with wide avenues that cross the city. During the Maoist period, the state invested in the construction of massive buildings in the city centre and along the main arteries that spread out from Tiananmen Square. Since that period, other roads have developed concentrically around this central point.

Shanghai's heritage shows far less influence from the Maoist era. Because of its "capitalist past", the city was to a certain extent looked down upon. Its configuration did not greatly change between 1950 and 1990, remaining close to that of a colonial town of the pre-Second World War period. In 1980, it was a very densely populated city with very little public space. The lack of infrastructure was even more marked in Shanghai than elsewhere. Its historical subdivision into concessions by foreign occupation forces had made it difficult to implement a city-wide transport plan.

With the reforms begun by Deng Xiaoping at the end of the 1970s, Chinese cities underwent considerable transformation. The Chinese Communist party decided to use market mechanisms to raise the necessary funds to improve the living conditions of the city's inhabitants. The party also allowed the development of a manufacturing industry for export purposes. The southern cities were first of all designated as development zones, but very rapidly both Beijing and Shanghai started to attract foreign investment.

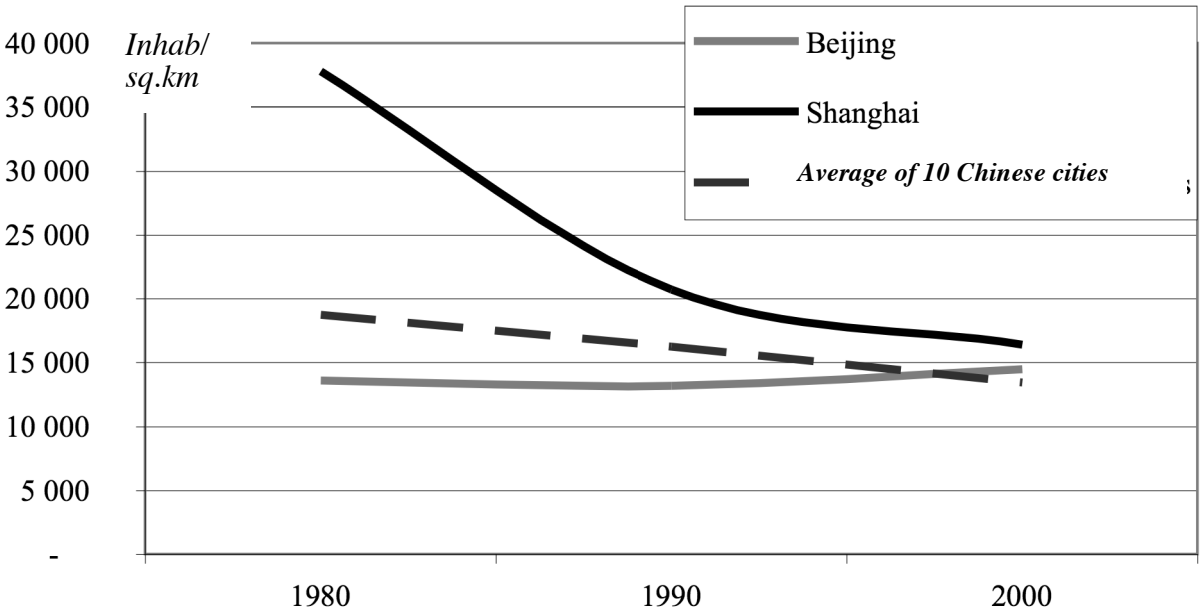
The country's two largest metropolises then experienced a spectacular construction boom. Shanghai was rehabilitated and became a showcase for Chinese capitalism. Its development was particularly rapid. By the end of the 1980s, Shanghai's population was close to 5 million and there was hardly a single building over five storeys high, apart from the colonial buildings dating from the late 19th and early 20th century. Today, the city has become a mass of skyscrapers. Until 1990s, the Pudong district, covering an area bigger than the historic city, was still used for farming before becoming the business centre for the metropolis. With its sights set on being able to compete with Hong Kong, Shanghai became mainland China's first financial centre and the country's leading commercial port. Beijing on the other hand has maintained a more administrative role, with its development favouring a certain continuity with the past. The Chinese capital has experienced less rapid growth and this growth has taken place over a wider area than in the case of Shanghai. Urban renewal has taken place according to the national plan, in other words traditional industries have been shifted to outlying areas of cities to make way in the centre for housing, services, infrastructures and the installation of modern industries in free trade zones generally served by ring roads.

This process has led to a decrease in the population density of Chinese cities. Figure 1 shows this trend for the largest cities in the country based on data compiled by Demographia.com. According to statistics, the average density of cities has fallen by a third in twenty years and is now below the threshold of 15,000 inhabitants/sq.km.

These statistics must be interpreted with caution, since they depend on both the population data and the urbanized areas considered. Population data underestimate the floating population in metropolises, which is put at a third of the official population (Kenworthy & Hu, 2002). Similarly, the urbanized land areas considered depend on the available statistics. Table 1 presents data for the year 2000, showing population, area and population density for both the municipalities and the urbanized areas of Beijing and Shanghai. By considering the area within the boundaries of the municipalities, both rural and urban zones are taken into account, while considering an area that is strictly urban means ignoring part of the urbanized area.

Table 1 shows that the municipality of Shanghai is more populated than that of Beijing, but much smaller in area, making it three times more densely populated. However, this observation does not hold for the centre of the metropolis: as shown in Figure 1, the population density of Shanghai was almost halved during the 1980s. In the 1990s, it continued to decrease at a more modest rate. In Beijing, population density has remained stable for the last twenty years in the area under consideration. However, population densities can be seen to have evened out between the central districts and the more peripheral districts (Wang F. & Zhou Y., 1999)[1]. The city centre districts have seen

1. This study shows population densities for the districts of Beijing from 1982 to 1990, based on data from the third and fourth national population censuses.



Note: The 10 Chinese cities included in the average are: Beijing, Chongqing, Guangzhou, Harbin, Nanjing, Shanghai, Shenyang, Tianjin, Wuhan, Xian.

Source: Demographia

Figure 1: Changes in population density of Chinese cities from 1980 to 2000

Table 1: Urban data for 2000

		Municipality	Urbanized area
		China Statistical Yearbook	Demographia.com
Beijing	Population	13,820,000	7,500,000
	Area (sq.km)	16,800	518
	Density (inhab/ sq.km)	823	14,479
Shanghai	Population	16,740,000	9,000,000
	Area (sq.km)	6,341	549
	Density(inhab/ sq.km)	2,640	16,393

a sharp drop in population density: five districts had more than 50,000 inhabitants/sq.km in 1982, but by 1990 there was only one left in this category. All the districts with more than 35,000 inhabitants/sq.km have seen their densities decrease. At the same time, population density has increased in the peripheral districts, particularly those nearer the centre. In 1982, five sub-districts of the municipality of Beijing, situated at more than 5 km from the centre, had over 20,000 inhabitants/sq.km, while in 1990 there were a dozen with this population density.

Demographic growth has thus been absorbed by these megalopolises through the urbanisation of surrounding areas and the reconstruction of the old city centres. This phenomenon has been made possible by increased mobility, largely centred on road transport.

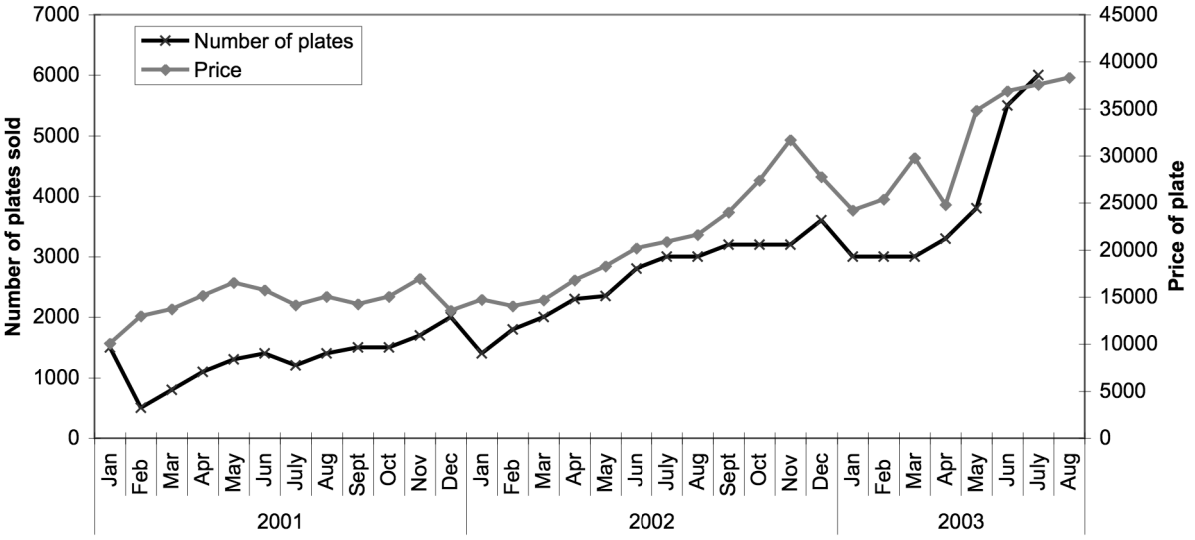
Industrial policy toward urban development: submission from Beijing, resistance from Shanghai

From the mid-1980s, the Chinese leaders had expressed an interest in road transport. The country was then almost without any vehicles. The central authorities chose to develop the automobile industry not only to meet the increasing demand for the movement of goods and people associated with economic growth, but also to develop an automobile industry that would represent a cornerstone of industrial policy. While the fleet of utility vehicles began to develop in the 1980s, in 1994 the government showed its determination to develop the industry through the market for private cars[2].

To satisfy the objectives set, the State Planning Commission had clearly stated its policy regarding the car in the city: "No local department or institution can employ administrative or economic measures to prevent the legal acquisition or use of automobiles. Measures must be adopted to support and protect individual use through facilities and regulations concerning the registering of vehicles, parking spaces, service stations, driving schools, etc." (see J-F Doulet, 2001).

However, these policies did not necessarily correspond to the point of view of all the ministries. In fact, the issue brought

2. The national objective was to produce 1.2 million cars per year by 2000, and 3.5 million by 2010, with 90 % of production to be sold on the domestic market (Zhou *et al.*, 2001).



Source: Pan Hai Xiao (2005)

Figure 2: Number of license plates and purchase price from January 2001 to August 2003 in Shanghai

into conflict the pro-automobile Ministry of Machine-Building Industry, the Ministry of Construction, which preferred public transport, and the Ministry of Public Security which wanted to limit the number of vehicle registrations per year.

Two years later, when the Municipality of Beijing attempted to exploit an inter-ministerial loophole by proposing the introduction of license plate quotas, the central government called it to order (J-F Doulet, 2001). According to the advocates of motorization, Beijing had so many public institutions, public corporations and companies that it would have been difficult to try and restrict car ownership. In addition, restricting individual car ownership would have led to problems between those able to obtain a vehicle through their companies and the rest of the population. Finally, the impact of such a decision by Beijing would have had a domino effect on the other large cities of China. At the end of the 1990s, the central government preferred to deal with this question at the national level by eliminating a large number of local taxes relating to the purchase and use of automobiles. Only Shanghai managed to maintain a system of rigorous restrictions on the purchase of cars.

Despite being the most developed metropolis in mainland China, Shanghai has not seen its roads invaded by the automobile to the same extent as Beijing. Because of its very dense population and lack of available infrastructure, the city has maintained an auction system for car registration rights, defying the central government in Beijing. The system, modelled on the one used in Singapore, has strongly discouraged car purchase through pricing. From 1986 to 1999, license plates were sold at auctions with a base price of 160,000 yuan[3] (US$ 19,300).

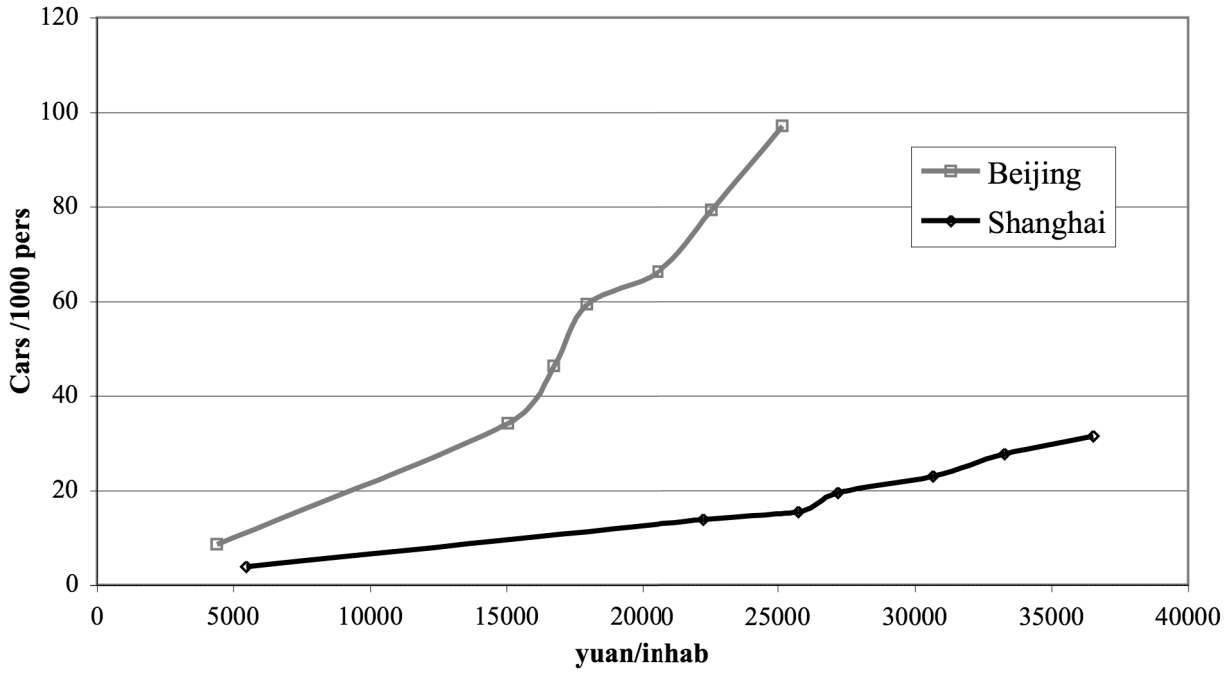
The Municipality of Shanghai has been ordered several times to discontinue the auction system as it is hindering the development of the automobile industry. The situation is particularly atypical because automobile production represents around 20 % of GDP in Shanghai, thanks to the presence of Volkswagen and General Motors. Under pressure from the central government, the city had to do away with these very high taxes and reduced the base price for license plates to 20,000 yuan (US$ 2,400). In 2000, there were twice as many automobiles in Beijing as in Shanghai. Since January 2000, auctions have taken place without any base price. From 1986 to 1999, 11,293 license plates were sold for private cars; in 2000, 14,000 new registrations were logged (Wang H., 2002). Currently, more than 40,000 yuan (US$ 4,800) is needed to obtain a license plate in Shanghai (Figure 2), which is equivalent to over half the price of the least expensive cars on the market. But demand is increasing rapidly[4].

Figure 3 shows the rates of motorization for the two Chinese metropolises according to their level of wealth. It may be observed that Beijing and Shanghai are following two very different trajectories, in line with the trends defined by A. Armstrong-Wright (1986) and completed by T. Kidokoro (1992). Their studies showed that the relationship between the level of GDP per inhabitant and motorization followed a concave curve in the large cities of the world, except for cities with systems for taxing the purchase and registration of vehicles. There is therefore a linear relationship between economic development and motorization in these cities.

The motorization of the two Chinese cities can be seen as part of this international trend. Shanghai is following the model of Hong Kong, Singapore, Seoul and New York, whereas Beijing is following the classic path of metropolises undergoing rapid motorization without restrictive measures. Figure 3 shows the two possible ways in which motorization can develop, the unbridled form as seen in Beijing or the more controlled form as witnessed in Shanghai. However, it will be more difficult for

3. At that time, 160,000 yuan represent more than 10 times the per capita annual income of urban residents in Shanghai.

4. Obviously there is a certain amount of tax evasion, with numerous individuals purchasing their cars in neighbouring Jiangsu or Zhejiang. To restrict this practice, the authorities have prohibited cars not registered in Shanghai from using urban motorways during the day.



Data: China Statistical Yearbook, miscellaneous years

Figure 3: Number of passenger vehicles per 1000 inhabitants from 1996 to 2003

other Chinese cities to introduce the controls on motorization that Shanghai has been able to use. China's most affluent metropolis has for a long time had a special relationship with the central authorities and its urban heritage has justified restrictions on motorization in order to avoid total saturation.

The constant threat of saturation

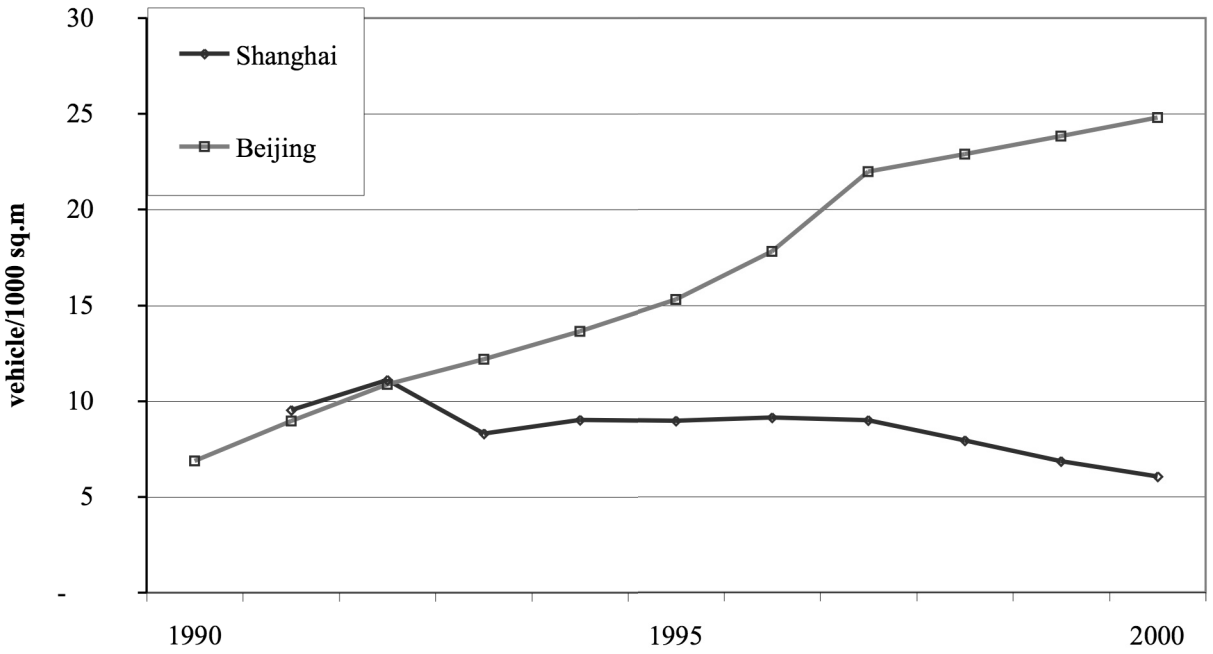
In the 1990s, the annual growth rate for road construction in Beijing was 3 % whereas the number of vehicles on the roads increased by 12 % and the number of passenger cars by 25 % (Lin Gan, 2001). In 1986, Beijing had 270,000 automobiles and a total area of urban roads covering some 21.5 million m². By 2000, there were six times more automobiles (1.6 million) in circulation in the capital and, even though 80 % of investment in transport was destined for road infrastructures, the total road area had only just doubled. At that time, there were 25 vehicles per 1,000 sq.m of road (Figure 4). Road construction has since intensified. However that infrastructure development has still not been able to meet the explosion of automobile sales since the year 2000. The rate of motorization in 2002 reached 94 vehicles per 1,000 inhabitants in Beijing. In 2003, at the time of the SARS syndrome, people wanted to avoid public transport to reduce the risk of infection and 400,000 new cars appeared on the roads of the capital, representing more than 20 % of national sales in that year.

Congestion has become a chronic problem in the Chinese capital (Zhuo Jian, 2004). In 1997, the traffic speed during the rush hour was estimated at between 13 and 19 km/h (He K. & Chang C., 2000). Today, it is often less than 10 km/h. A total of 34.3 % of Beijing residents take 60 to 80 minutes every day to get to work and 6.5 % have journeys of more than 100 minutes (Zhuo J., 2004). The city's traffic jams have created a real daily ordeal for the Beijing population and are seriously degrading air quality. Even though the Chinese capital already has 6 ring roads, it is a constant struggle for the city's infrastructure to keep pace with the growing number of cars.

In Shanghai the story is slightly different. Thanks to measures to control car ownership, it has been possible to build infrastructures before saturation has occurred. During 1990s, the ratio vehicle on road surface decrease from 10 to 5, thanks to an extensive road network built around elevated motorways. They provide a larger area for traffic while at the same time limiting the space required on the ground. However, this does not mean there are no traffic jams; roads in the centre of the agglomeration are congested for 8 hours every day. However, traffic moves faster during the rush hour than in other large cities. In 1997, the average rush hour traffic speed was more than 20 km/h (He K. & Chang C., 2000).

Because of their respective urban forms, the metropolises of Beijing and Shanghai suffer congestion at different levels of motorization. Shanghai has a high population density and its roads become saturated much more quickly than those of Beijing, justifying the city's policy to restrict car ownership. However, at the moment Beijing has far more traffic jams. In 2000, the capital has one half less road surface than Shanghai, but twice the number of vehicles. This means that there are four times more cars per unit area of road in Beijing than in Shanghai.

Auction system seems to be an effective way of addressing the problem of congestion. But the central government has not changed its national policy and is continuing to put pressure on the Municipality of Shanghai to modify its policy. In Beijing, the mayor has opened an internet forum to enable the city's population to discuss the issue of urban congestion. The municipality has also set up an Urban Transport Commission with responsibility for drawing up proposals for tackling the



Data: Zhang & Hu (2002) & Statistical Yearbooks

Figure 4: Ratio number of vehicles on road surface in Beijing and Shanghai

problem. In his report on the debate over taxing car use or ownership, Zhuo J. (2004) points out in particular the refusal of the population of Beijing to approve a system comparable to that of Shanghai. However, those participating in the internet debate seem to feel that an urban toll would be a satisfactory solution. The possibility of an urban toll to replace the auction system in Shanghai is also under study. Increasing the cost of car use seems to be the preferred approach to relieving congestion. According to Chinese authorities, car purchase should not be taxed. Finally, it should be noted that the price of petrol has increased over the last few years but taxes cannot be increased at too fast a rate for fear of penalising transport companies. Prices in China are still low compared with Europe and Japan.

The rise in public transport

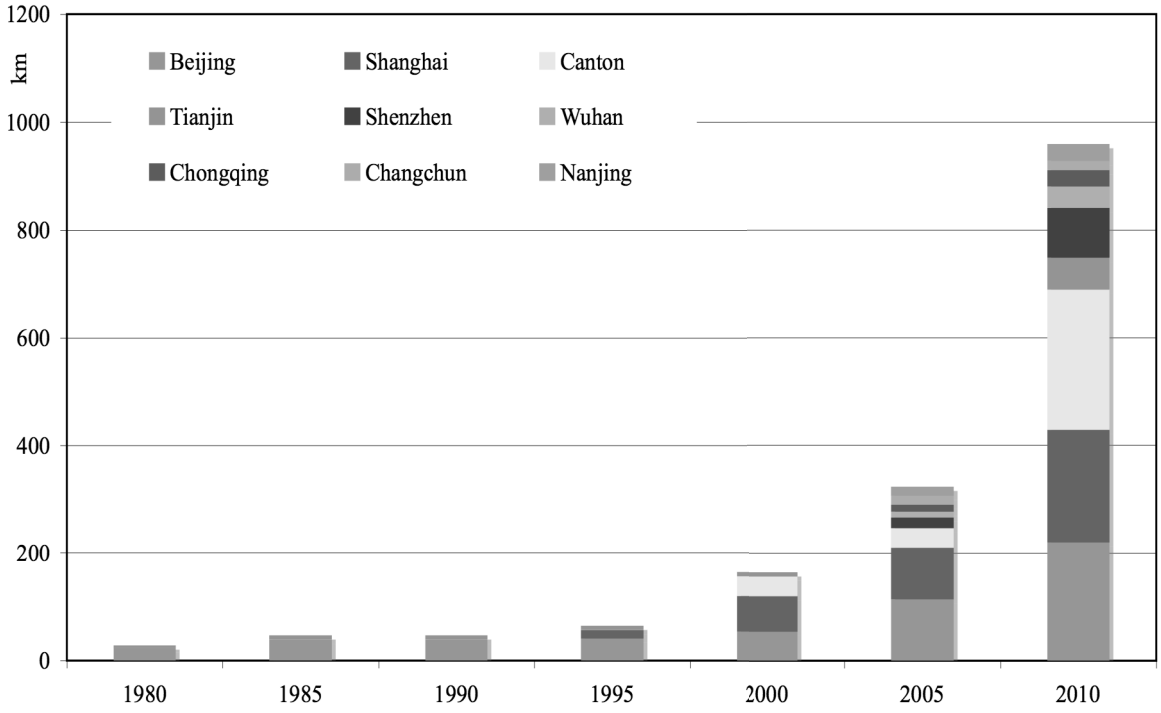
The host cities of the Beijing Olympic Games in 2008 and the Shanghai World Expo in 2010 will have to meet the mobility needs of huge numbers of visitors. The Olympic Games could attract between 4 and 10 million spectators to Beijing over a 16-day period, while Shanghai expects to receive 75 million visitors over 6 months in 2010 (Bovy P., 2004). Faced with the prospect of automobile saturation, the two metropolises have taken the opportunity provided by these events to launch vast programmes to construct urban rail infrastructures. The city of Beijing has planned major development programmes for its public transport networks. Five new lines will be added to the city's underground rail system between 2002 and 2008, tripling the length of track from 50 km to 150 km. But projects will not stop with the advent of the Olympics. At the International Academic Conference on Underground Space, which took place in November 2006, the Beijing Urban Planning Commission and the Beijing Urban Planning and Designing Research Institute jointly announced a construction project for six new lines by 2020, which would bring the total track of the metropolitan network to 561 km, making it the biggest underground rail network in the world[5].

In Shanghai, investment in the underground rail network has increased by 41 % during the 9th five-year plan. The urban rail system is destined to become one of the main transport modes in the metropolis, accounting for a modal share of 50 % by 2020, when it is expected to carry 12 million passengers per day. The Master Plan provides for the construction of more than 460 km of underground and surface track over a 25-year period (People's Government of Shanghai Municipality, 2002).

Even though rail infrastructure development is particularly justified in Beijing and Shanghai because of the major events of 2008 and 2010, such development is not limited to these two cities. There has been a change in national policy in recent years and numerous cities now have construction projects under way (Figure 5). The Chinese leaders recognised that the country was underdeveloped in this sector and began to react at the beginning of the 2000s.

At the beginning of the 1980s, Beijing was the only city that had an underground rail network, the first line having been built in 1969. Only three cities already had a light rail or tram system: Dalian, Changchun and Anshan. Elsewhere, public transport was provided essentially by buses, trolleybuses and minibuses, but was particularly underdeveloped (Kenworthy & Hu, 2002). Urban rail systems (and particularly the underground) were being talked about in the 1980s. Chinese cities with populations of several million wanted to invest in this type of public transport to meet the mobility needs of their inhabitants. Certain local governments, recognising the importance of public transport for the sustainable development of cities,

5. Beijing to Build World's Longest Metro, China Daily, 20 November 2006



Note: The underground rail projects represented here are shown only for those cities that already have an underground rail system under construction.

Data: Urbanrail.net

Figure 5: Underground and light rail lines built or under construction (1980-2010)

proposed underground rail projects to the central government, which has to approve projects at two different stages of the implementation process.

There is no procedure that provides for investment by the State in underground or light rail projects. The State may, however, offer preferential treatment to certain cities by authorizing them to borrow abroad. A substantial proportion of funds is expected to come from the development of the surrounding land (Allport R, 1995). At the beginning of the 1990s, the State attempted to combat hyperinflation by imposing austerity measures to reduce public spending. Most of the investment projects for the construction of underground or light rail networks were frozen by the central government in 1995. The projects for Qingdao, Nanjing, Shenyang and Tianjin were cancelled and proposals submitted by 17 other cities were rejected (Chang T. D., 2000). At this time, cities were not yet seriously affected by congestion and pollution problems. Macroeconomic restraints, as observed in other economic sectors such as that of energy, were hampering long-term investment. In addition, some projects appeared rather unrealistic from a financial point of view, the system layouts were poorly planned and there were no plans for integration with bus networks.

At the end of the 1990s, many cities submitted new projects to the national commission responsible for supporting the construction of underground, tram and light rail systems. Since then, the central authorities have given their approval for these projects. Between 2006 and 2015, investment in underground rail networks is expected to reach US$ 75 billion. According to experts, 1,200 to 1,500 km of urban rail track should be built in the next 10 to 20 years.

Another type of public transport currently developing in China to combat traffic congestion is BRT (Bus Rapid Transit). Bus lines with specially reserved lanes and optimized management systems are being introduced in China, as in numerous other countries in the world, based on the South American model. In 1999, Kunming, the capital of Yunnan province, inaugurated a BRT line thanks to a partnership with Zurich, Switzerland (Feiner J. *et al.*, 2001; Lin W. & Tang C., 2001). Beijing also started to operate a line in 2004, with 18 stops over a distance of 16 km. By 2008, 100 km of BRT will complement the city's 300 km of urban rail track. Numerous projects are also under study in a dozen other Chinese cities, including Shanghai (250 km), Tianjin (145 km), Xian (48 km), Chongqing (15 km), Hangzhou, Chengdu and Shijiazhuang. Some are already under construction (Chang, J., 2005).

Average speeds on BRT lines can be as high as those on underground rail lines for a much lower construction cost. In Beijing, the BRT line cost around US$ 4 million per kilometre, while the cost per kilometre of underground track is 15 to 40 times higher. However, BRT must on principle be allocated a part of the road system, and in congested cities it is still difficult reduce the space destined for the car in favour of rapid transit systems. In the current period of heavy investment, the underground is therefore preferred to BRT in the largest cities. However, BRT would seem to be particularly appropriate for medium-sized cities with fewer investment possibilities. In the future, if investment capacity in large cities declines, then BRT could be seen in a more favourable light.

Conclusion

The rapid economic growth in developing countries means an increase of household motorization. This phenomenon induces a raise of oil demand and worrying trends of greenhouse gases emissions. For twenty-five years, China has been experiencing a considerable development and authorities have chosen to develop the car market to support economic growth. But at the end of the 1990s, the national industrial policy in favour of the automobile had to cope with the urban forms of Chinese cities. Despite the rapid urban development and lower population densities in city centres, cities have not been able to provide sufficient space for the car. At the beginning of the 2000s, after observing the woeful lack of space available for the automobile, the central government recognised the importance of public transport for urban mobility in Chinese cities, something that they had denied in the 1990s.

Beijing and Shanghai are spearheading this new drive to improve urban mobility in China. The fact that these cities are soon to host major international events has underlined the urgent need for infrastructure construction. However, these two cities will have to adapt once again in different ways as they prepare for these events. Beijing may have to prohibit automobile traffic during the Olympic Games to deal with congestion, while Shanghai, with its more limited motorization thanks to its license plate auction system, should be able to host the World Expo of 2010 without having to resort to such restrictive measures.

The stakes of urban mobility energy consumption in the world's most populated country are huge. The Beijing model can be considered as a foretaste of the "car collapse" scenario for the whole urban China in the next decade. Shanghai, in the 1990s, has avoided this scenario by discouraging car property. Obviously, this is a more sustainable model but the Chinese authorities refuse to recognise its advantages.

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