

China's Urban Transportation System: Issues and Policies Facing Cities

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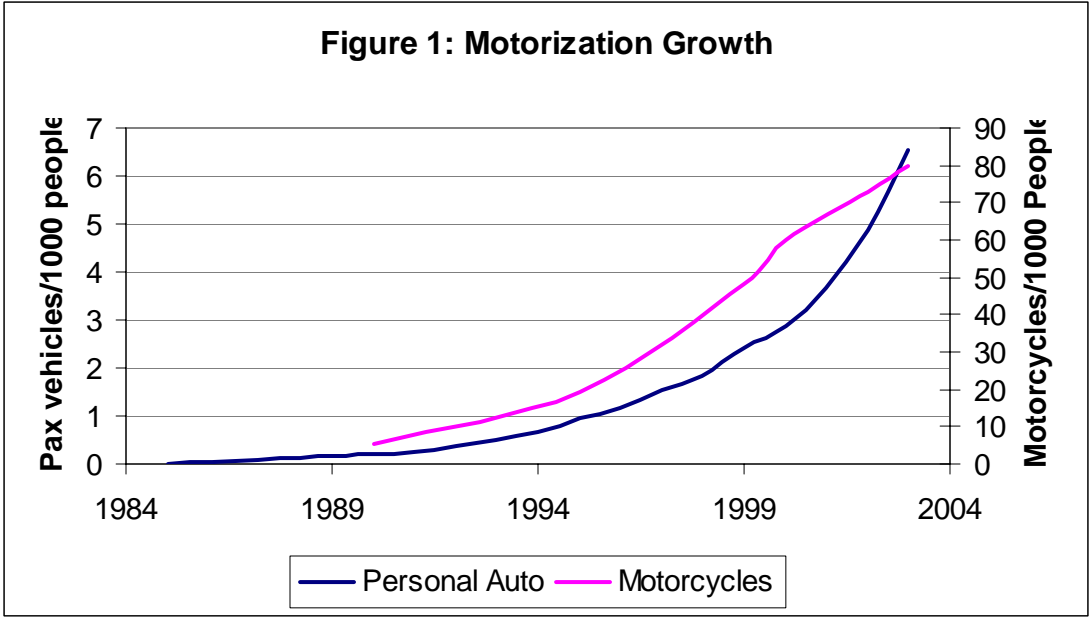
1. Introduction

China is the most populous country in the world. With a population of 1.3 billion, meeting the housing and transportation needs of this vast country are on the forefront of the political and academic agenda in China and throughout the world. China has experienced phenomenal economic and social growth and as a result the Chinese have desired more mobility and living space. The effects of these desires are beginning to be seen in new auto oriented ex-urban developments that have larger living spaces than the traditional urban centers and whose road infrastructure is developed to support high auto use. This results in spatially separated land uses and lower accessibility of goods and services, especially as road demand overruns supply and the transportation network becomes congested. Additionally, urban air pollution will continue to rise as transportation mode shifts from transit and non-motorized modes to the personal automobile. Some countries and cities throughout the world have established effective constraints against unsustainable levels of personal automobile use. A variety of measures have been used including: land use controls, competitive alternatives, user fees, high auto ownership fees, and rationing. These controls have been very effective in other developed Asian cities such as Singapore, Hong Kong, and Tokyo and many of these tools could be transferred to China. This paper will investigate the rising motorization rate in China and identify some cities that have taken approaches that could potentially alleviate some of the transportation problems in the cities. The first section will describe the main issues surrounding motorization in China. The second section will discuss some of the institutions involved in transportation decisions at the national and local level. The next section will discuss some transportation trends¹ in specific cities and identify different transportation policies that have been established in China. Finally, discussion and conclusions will be presented.

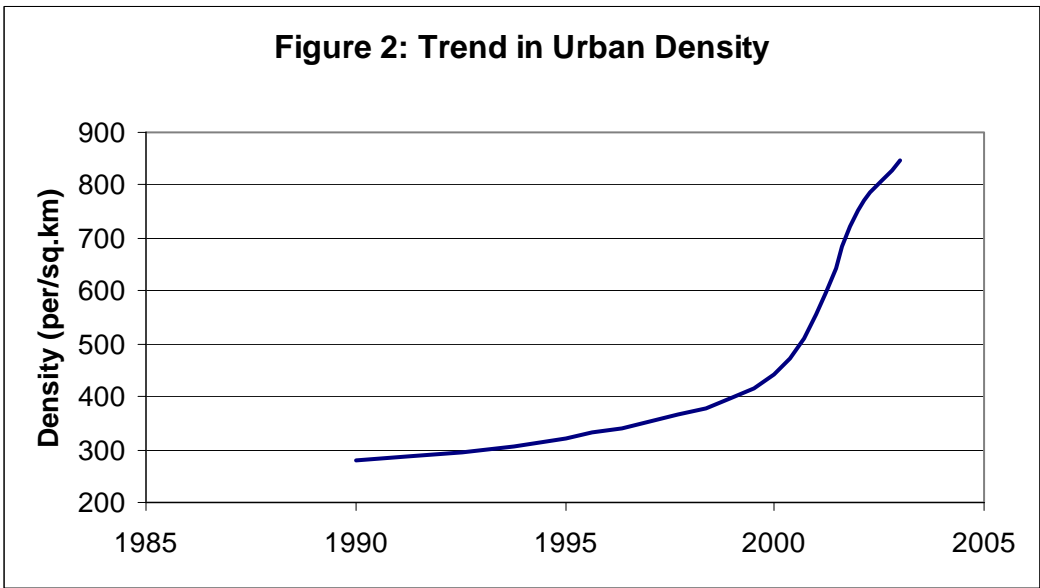
2. The Rising Motorization of China

China's motorization rate has grown in accordance with other rapidly developing countries, but because of China's high population, the impacts of motorization are potentially more severe. Figure 1 shows the exponential increase in personal automobile ownership rates. Currently, there are about seven personal automobiles per 1000 people, compared to over 700 vehicles per 1000 people in industrialized nations like the United States. This figure does not include privately owned trucks or publicly owned vehicles (including buses and trucks), which increases the number of automobiles to about 28 vehicles per 1000 people. If China were to achieve motorization rates comparable to those of developed countries, the environmental and economic consequences could be disastrous. By 2020, the total automobile fleet (not including motorcycles) is expected to grow by between three and seven times the current size depending on economic growth rates (NRC 2003).

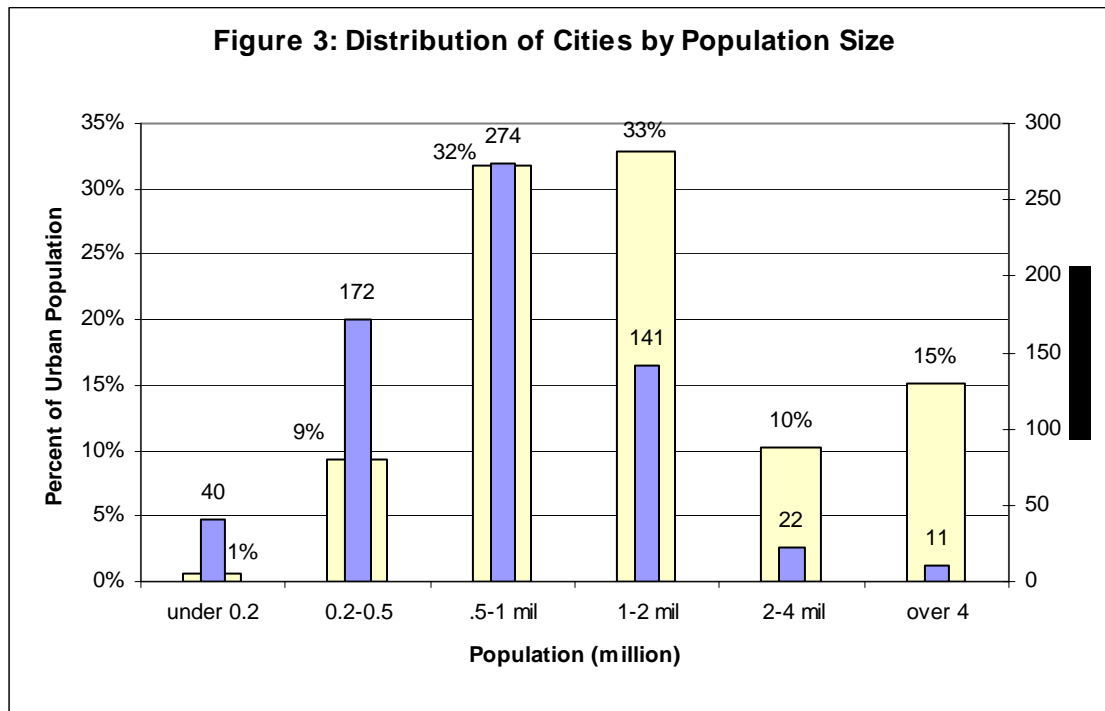
¹ Note: All figures and graphs are from data in the 2004 China Statistical Yearbook (NBS 2004) unless otherwise cited.



The population distribution of China is diverse, with the majority of the population (60%) living in rural areas. However, in the past several decades, the improved economic situation of the cities has caused a rapid urban in-migration. This trend has resulted in a nearly three-fold increase in urban development and density in the last decade as displayed in Figure 2. Much of this development is not necessarily representative of sustainable transit and pedestrian oriented growth. Although this new development is very dense, low land cost at the periphery cause developers to build spatially separated housing and commercial developments with few transit connections to the urban center (Gaukenheimer 1996).



The western provinces are the most sparsely populated with the largest urban population centers located in provinces along the eastern coast, in metropolises such as Shanghai, Beijing, and Guangzhou. These cities have been experiencing high motorization rates partially because of their higher incomes, but non-motorized modes still capture approximately 70% of the work trip commutes in these cities, while the personal automobile only accounts for 7% (Hu 2003). Much of the transportation and planning research has been centered on these cities, although they constitute a rather small portion of the entire population. Figure 3 shows the amount of cities of different sizes and the approximate total population of people living in cities of different size. Two thirds of the urban population resides in cities with populations between 0.5 and 2 million, indicating that much of the planning and transportation research related to China is focusing on problems that might not be relevant or applicable to the majority of the Chinese population. Economically, most of these cities are years or decades behind the more developed Chinese cities and have not developed many of the transportation problems Beijing, Shanghai and Guangzhou have. Focusing planning efforts in these cities could have much greater returns.



The Chinese economy has been growing at a phenomenal rate for the past decade and has doubled in size in the last nine years. In fact, the growth rate is so fast that the Chinese government is imposing several measures to try to control growth to keep it at a more sustainable level (Economist 2004). China's growth has largely been a result of investment in a few "pillar" industries. The highest growing pillar industries are: electronic manufacturing, automobiles, electric power, and steel. The eighth five-year plan (1991-1995) designated the automobile industry as one of the pillar industries of economic development. This policy statement encourages the growth of an indigenous auto industry that will be able to supply a large portion of its domestic demand and create

a strong export market. It calls for the consolidation of over one hundred companies into 3 or 4 large competitive companies. The auto industry accounts for 20% of Shanghai's gross regional product (Hook 2002). However, with China's entry into the World Trade Organization (WTO) in 2001, they must reduce tariffs on imported automobiles and can no longer protect their market. This has spurred development of the domestic automobile industry to a level that can compete with international competitors. One of the greatest challenges of cities in China is controlling automobile ownership growth, while fostering the national policy of growing the automobile industry.

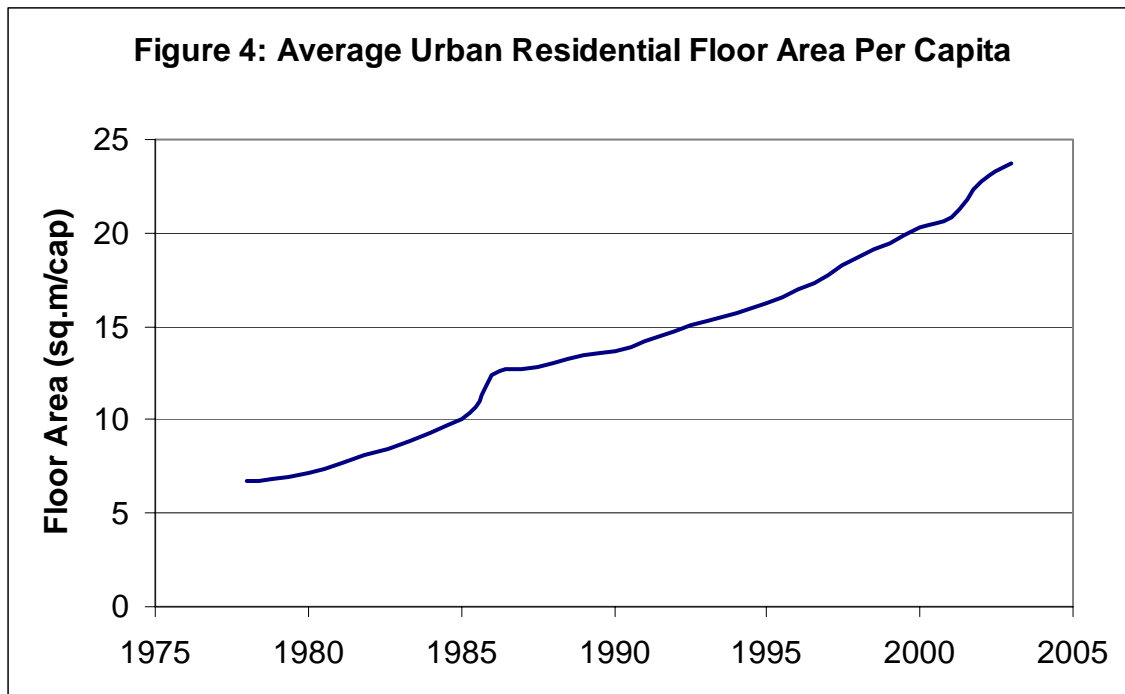
Costs and Benefits of Motorization

The cost and benefit implications for Chinese motorization are enormous. Motorization is a major economic growth strategy. The government has adopted a strategy of developing an automobile manufacturing industry. Automobiles can also provide indirect economic benefits of decreased travel time, improved accessibility to goods and services, and new found mobility that will cause people to travel more and achieve a more mobile lifestyle that they would not have otherwise been able to experience.

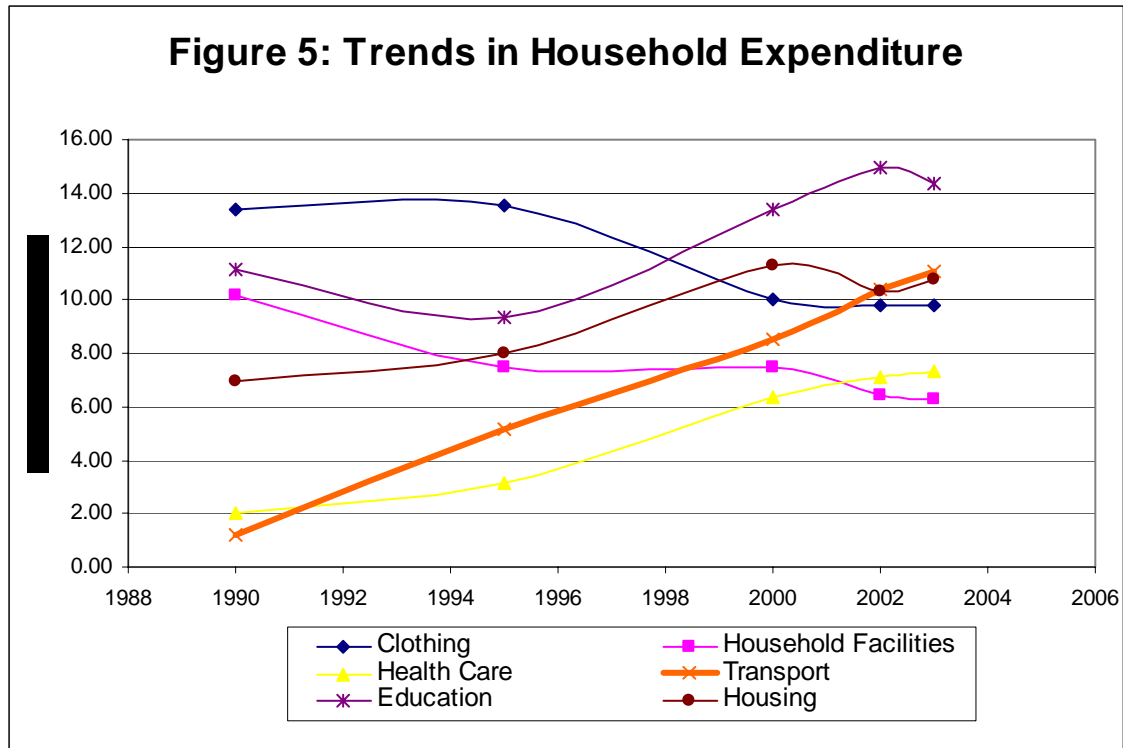
The potential costs are enormous. The United States has the highest motorization rate in the world and perhaps the most mature automobile industry. However, the US has also experienced very high costs associated with our level of motorization. The most obvious and potentially most severe cost is the air pollution and greenhouse gas emissions associated with the automobile. The US emits 26% of the global greenhouse gases but only constitutes 5% of the world's population. China's policy goal is to achieve Euro II emissions standards by 2005 (about a decade behind Europe) and be internationally compliant with Euro IV standards by 2010. This is a very ambitious goal, but it is necessary if Chinese automakers want to compete in the international market and improve the air quality in their own country. With the three to seven-fold growth rate anticipated in the next 15 years, CO₂ emissions will likely quadruple, CO, and hydrocarbons will likely triple, and NO_x and particulate matter will likely stay the same. This assumes an aggressive emissions regulation strategy and a modest economic growth rate (NRC 2003). The US EPA has identified all of these emissions as having serious health effects at high concentrations. From a global perspective, China's motorization could have adverse effects on the global climate. Currently, the transportation sector accounts for 17% of the greenhouse emissions, but this proportion could increase significantly if the motorization trends continue. China is also the second highest consumer of oil in the world (behind the United States). If China motorizes as rapidly as expected, the increase demand could cause the global price of fuel to skyrocket.

Another major issue associated with increased motorization is changes in land use. As incomes increase, people desire more living space, which reduces density and encourages expansion at the urban fringe. Figure 4 shows the growth of residential floor space per capita, which is a force toward lower density. This requires more auto oriented transportation infrastructure as well as more land for development. In Shanghai, approximately 10% of the land area is devoted to transportation infrastructure (compared to 20-25% in Europe) (Shen 1997). Because of the built environment, most of the new

transportation infrastructure is expanding at the periphery, encouraging auto oriented developments. An increasingly open housing market, where people choose where to live is also creating a spatial jobs-housing imbalance that did not previously exist, when industry provided housing for its employees adjacent to their plants. This greatly increases the cost of transportation for Chinese households as indicated by Figure 5. The proportion of a households income spent on transportation has increases ten fold in less than 15 years. Another major consideration is the conservation of agricultural land. China currently has a very low amount of agricultural land per capita (World Bank 2001) and cannot afford to lose more through urban expansion (Franke 1997).



Additional costs include accidents and injuries associated with motorization. Currently, the fatality rate (deaths per mile of travel) is 30 times that of the United States, with over 100,000 deaths per year since 2001, many of which are pedestrians and bicyclists (NRC 2003, Hook 2002b). Additionally equity issues must be considered, specifically the dislocation of the poor. Even with the high projected growth rates in automobile ownership, most Chinese will not own vehicles, so alternative modes must be supplied that can serve the increasing spatial separation between origins and destinations. The cost of the required infrastructure will be enormous and the government will likely have to provide more subsidies to the transportation sector, potentially restricting its investment in other sectors.



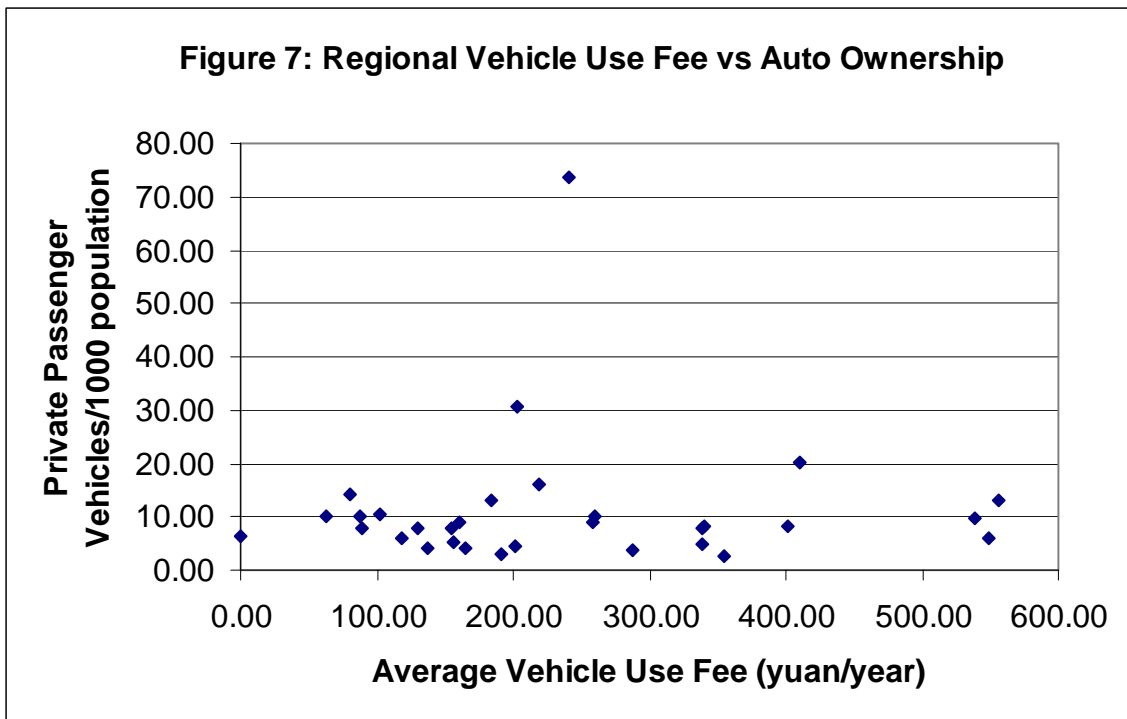
Causes of Motorization

The primary impetus for the motorization of China has been the rapid growth of the economy. With a rise in the economic growth of a country comes a desire and means to become more motorized. Motorization rates are associated with a country’s gross domestic product (GDP). Countries with low GDP (below \$800) generally have a high proportion of trucks and buses in their vehicle fleets. As GDP increases up to about \$10,000, the share of personal automobiles increases drastically until a saturation level is reached (NRC 2003). China’s GDP has been increasing by more than 8% annually for over a decade. A large proportion of upper income people can now afford the luxury of the automobile.

Kenworthy et. al. (1999) argue that, while GDP plays an important role, there are many other factors that likely influence motorization rates. By comparing cities with similar GDP and very different transportation energy use, they conclude that land use is a primary factor influencing energy use and thus motorization. Additionally demand management schemes can limit the adverse effect of motorization in China. Currently China’s regulatory structure is weak and inconsistent. Some cities have effectively provided competitive transit alternatives and limited outward expansion (Joos 2000). Others have fully embraced the automobile, pushing many other modes to the side (Hook 2002b).

Transportation Finance

The Chinese government currently funds transportation infrastructure from a variety of sources. The central government administers a consumption tax on fuel and a vehicle purchase tax. The local government charge vehicle use taxes, which include annual flat rate maintenance fees and tolls to maintain and build roadways. These fees are not aimed at urban roads, that are the most heavily used, but intercity roads. As a result, these taxes seem to be ineffective at steering auto ownership, although they may steer auto use. Figure 7 shows the relationship between auto ownership in different major cities in China and the corresponding locally imposed vehicle use fees per year. A regression fit shows essentially a horizontal line, or an R-square of near zero. Although some cities have much higher auto use fees, there is no significant relationship between auto ownership. In 1998 there was a movement to impose a national fuel tax to be administered by the central government. This tax fuel would replace maintenance fees and tolls, but would cost drivers twice what they were paying in fees and tolls. Presumably, it would steer driver behavior toward less travel and more fuel efficient vehicles. This reform has been delayed because of recent high fuel prices and it would hurt auto owners who are already suffering high gas prices and controversy over imposing a high cost on farmers who do not use the infrastructure (Zhang W.B. 2003, China Daily 2005). Much of the urban roads and infrastructure is built by the Ministry of Construction, using funds exacted from leasing new land and land use rights. (Li 1996). China is also very actively financing transportation infrastructure using public-private partnerships. Build-Operate-Transfer schemes are being encouraged as a way to share risk and develop capitally intensive infrastructure in areas of high latent demand (Wang et al. 1999, Zhang et al. 2001).



Institutional Structure

China's early transportation development was focused on connecting all parts of a very divided nation. Policy makers were focused on opening communication lines between all provinces and major cities. As a result, the highway planning department was placed under the Ministry of Communication. Likewise, the Ministry of Railways is responsible for intercity passenger and freight rail travel. These Ministries are the most founded and strongest institutionally because of their longer history and importance during China's early development.

At an urban level, China established a planning policy of social and spatial integration. This resulted in very mixed income communities with short distances between work and home. However, little infrastructure was developed and it was mostly built for non-motorized modes. With rapid motorization and spatial separation, China's institutional structure is unable to manage regional interaction. Chinese institutes of planning are generally the responsibility of the construction bureau, and there are no higher level urban planning institutions. Transportation planning is a completely different institution under the planning commission, construction bureau, public security and finance. Figure 8 is an organizational chart showing the different layers of government and authority related to urban transportation planning and infrastructure development. In order to overcome regional transportation problems, interagency coordination must be developed as well as system and regional level planning. Shanghai was the first to consider a Metropolitan Transport Institute to manage transportation at a regional level. Some of the major issues confronting Chinese institutions are:

- 1) Traffic and vehicle registration management: parking policy, registration limits
- 2) Pricing policy: transit, auto purchase, registration, parking, vehicle operating cost
- 3) Financial Regime: Determine finances transport-users, land owners, developers, and/or public agencies
- 4) Link Land Use policy to transportation
- 5) Institutional development: Develop larger inter-institutional planning agencies (Gakenheimer 1996).

There have been several criticisms of Chinese transportation institutions and strategies. Zhang et al. (2003) identified five problems with the Chinese institutions and their strategies to control the negative externalities of auto use:

- 1) They rely heavily on supply-side approaches such as road capacity expansion
- 2) They encourage individual transportation, particularly the ownership of private cars
- 3) They have inadequate emission control
- 4) They lack of integrated command-and-control and market-based instruments
- 5) They lack of coordination mechanisms among the key government agencies involved in the formulation and implementation of transportation

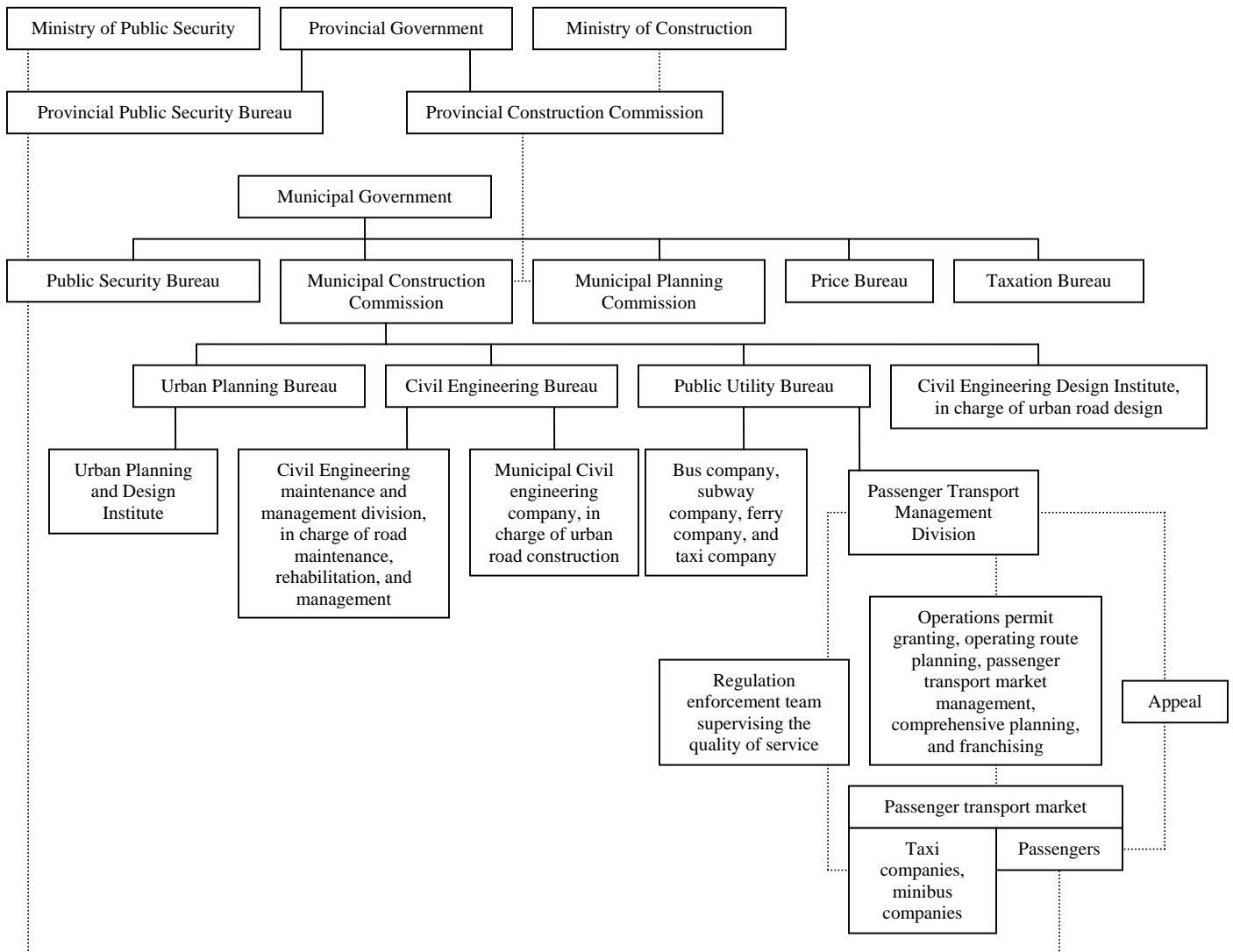


Figure 8: Institutional Arrangement for Urban Transport Administration and Operation (Wu et al. 1996)

China's transportation institutions are based on systems that are becoming obsolete as the country urbanizes, cities become spatially separated, and the desire for personal mobility drives the modal options of the Chinese people. Regional planning is essential to the development of efficient and sustainable cities. Additionally, linkages between land use and transportation must be considered when making transportation planning decisions and these agencies must be coordinated.

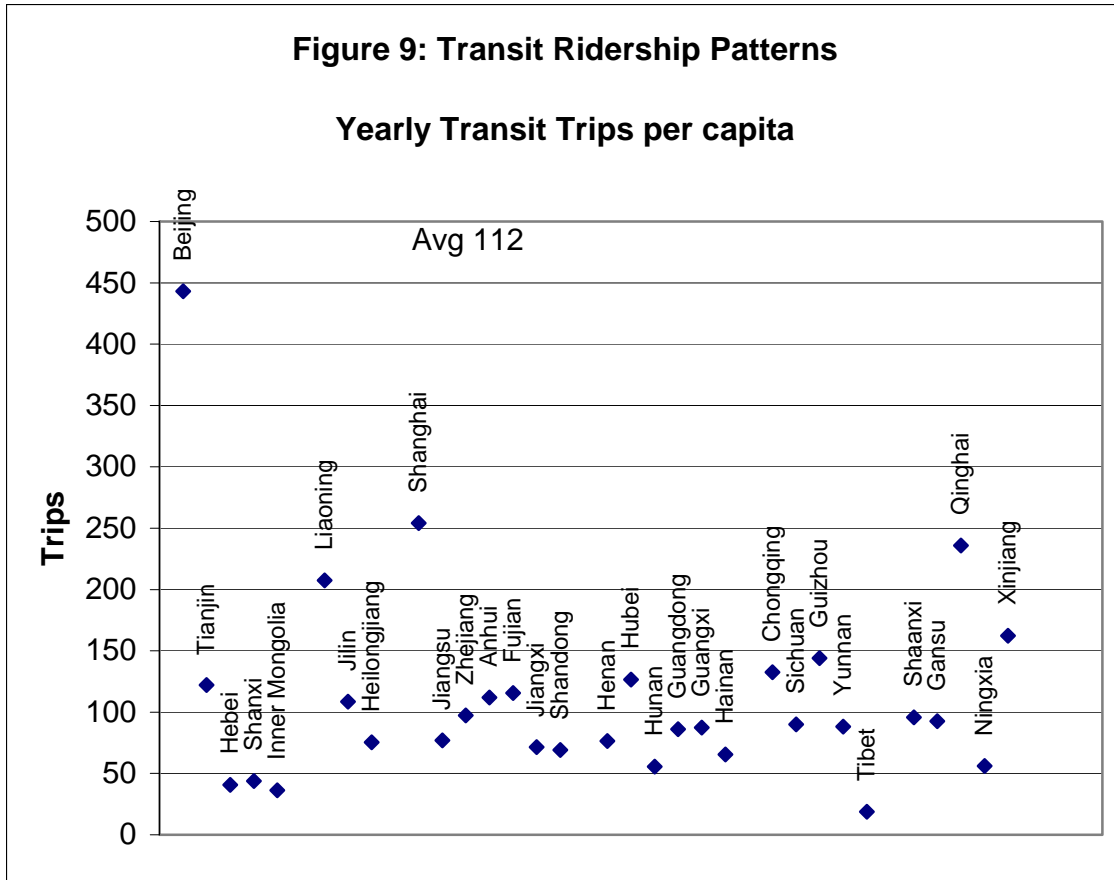
4. Comparative Analysis of Transportation Policy in Cities and Regions

Many cities in China have taken different approaches to confront their transportation challenges. All cities seem to identify that uncontrolled growth of auto ownership and use will result in economically debilitating congestion and pollution. As a result, different cities have adopted different strategies to control congestion and auto use. Most research has investigated the transportation systems in Beijing and Shanghai, the economic engines of China. These two cities have high economic productivity and incomes (relative to other cities in China), and as a result have very high auto ownership rates compared with other cities in China. They also have two major event that are spurring major infrastructure improvements, the 2008 Olympics in Beijing and the 2010 World Expo in Shanghai. Other cities in China have had little international attention, with a couple of exceptions.

One of the policy approaches is to use the existing roadway network in the most efficient matter. From a capacity perspective cars are the least efficient users of road space. Compared to a single car, a roadway lane can carry 4-5 times more bicyclists, 8-10 times more pedestrians and 15-20 times more transit riders (Shen 1997). Despite these numbers, cities are beginning to restrict or discourage bicycle use. Lu et al. (1997) state that bicycles are poor users of road space, citing that bicycles account for only 20% of the person-km traveled in Shanghai, but use 40% of the road space; transit accounts for 40% of the person-km, using 20% of the road space and “other modes” (cars) account for the remaining 20% of the person-km on 40% of the road space. Because of these numbers, planners have decided to restrict bicyclists in the city center of Shanghai, giving the roads fully to cars and buses. This policy, combined with improved public transportation is expected to reduce bicycle traffic to 20% of its current level. Because bicycles are perceived as a less desirable mode and because they create challenging conflicts with auto traffic, there has been a concerted effort to shift bicyclists to transit modes. Many cities have begun to see reductions in bicycle mode share and increases in transit and auto mode share as they have invested heavily in transit and roadway infrastructure.

Transit

Chinese cities have identified high capacity transit as the solution to many of their urban transportation needs. In 1995 China established an urban public transportation policy that focused on investing in bus and urban rail projects. As trips become longer and activity centers become more spatially separated, modes must be developed that can compete with the automobile and provide mobility to populations that previously relied on non-motorized modes. Figure 9 shows the total number of transit trips per capita for cities in different regions. As expected, cities with well developed public transportation systems, such as Beijing and Shanghai have high transit use. Identifying transportation and land use policy that encourage transit use might be an effective way to serve the public. However, many of these transit trips are a result of public policy to decrease bicycle use, not decrease auto trips. As a result, cities with high transit ridership might not be achieving sustainable transportation goals, as roads and transit can be a force toward



decentralization, disadvantaging non-motorized modes and increasing the cost of transportation.

Because of the increasing congestion on roadways and the decreasing effectiveness of mixed flow bus service, Chinese cities have been investigating improved exclusive right-of-way transit solutions including heavy rail, light rail and bus rapid transit (BRT). Kunming, in cooperation with the Swiss transportation planners, developed China's first BRT demonstration project to reverse decentralizing auto oriented development strategies (Joos 2000). This project was seen to be a great success and since then, many Chinese cities have developed or plan to develop BRT systems (Figure 12).

These systems are complementary to larger public transportation plans. The central government allows metro systems to be developed only in cities with populations greater than three million. Consequently, all 15 cities with populations greater than three million have developed preliminary plans to develop metro systems (Zhang, W.B. 2003). Shanghai and Beijing have the most comprehensive public transportation plans, in anticipation of the Olympics and the World Expo. Beijing plans to greatly increasing its mixed traffic bus service, construct 100 km of BRT lines, and expand its metro system to 300 km by 2008. Shanghai plans to build 380 km of metro rail, 130 km of light rail, and 70 km of BRT. Additionally, Shanghai recently completed a 30 km Maglev train from the financial center to Pudong Airport (Lu et al. 1996, Zhang, W.B. 2003, Chang 2005).

Highways

China's highway systems are underdeveloped in most cities because the cities were not developed for auto uses. At the end of 2003, only 11% of the China's urban areas are devoted to roads, compared to 20-30% for most industrialized nations. Most Chinese cities have developed a ring road structure to provide circulation, mobility and access to all parts of the city. Highway construction has been intense in many urban areas, mostly on the periphery in an attempt to keep up with the rising demand for mobility and to curb severe congestion. In the case of Beijing, they built 1789 km of new roads between 1998 and 2003, including a 155 km expressway. They plan to invest \$250 million dollars per year for transportation infrastructure in preparation for the Olympics. Shanghai also has ambitious expressway building plans, extending its 60 km expressway system to 650 km (Zhang W.B. 2003).

Auto Ownership

As stated earlier, China has adopted a policy to encourage the development of an indigenous auto manufacturing industry. The conflict of planners is to develop sustainable cities and encourage responsible auto use while still promoting auto ownership. China's personal auto ownership is approximately seven vehicles per 1000 people, but there are major differences between cities. Figure 10 displays the auto ownership of regions in China. Beijing has four to five times higher personal auto ownership rates than Shanghai, which are cities of comparable in size, average income and importance. Beijing's large population of taxis and company cars could inflate its statistic. Figure 11 shows the relationship between average wage and car ownership in China. There is clearly a positive correlation, but not as strong as one might expect. There are definite outliers (Beijing and Tibet). Cities like Shanghai and Guangzhou (in Guangdong) have low auto ownership rates compared to cities like Beijing and Tianjin. This is an indication that auto ownership restraints, public transit efficiency, or urban form play an important role in the amount of autos purchased in these regions.²

Transportation Policies/Technologies

Different cities are given some independence of decision making, as long as those policy decisions are consistent with the Central Government's social and economic goals. Many Chinese cities have developed innovative transportation policies and identified technological improvements that are will presumably improve the efficiency of their transportation systems. Many of these policies and technologies are demonstration

² Note that auto ownership and auto use (veh-km traveled) are two different things and both have different sustainability implications. Because of the availability of data, auto ownership will serve as an indicator of use.

Figure 10: Per Capita Auto Ownership by Region

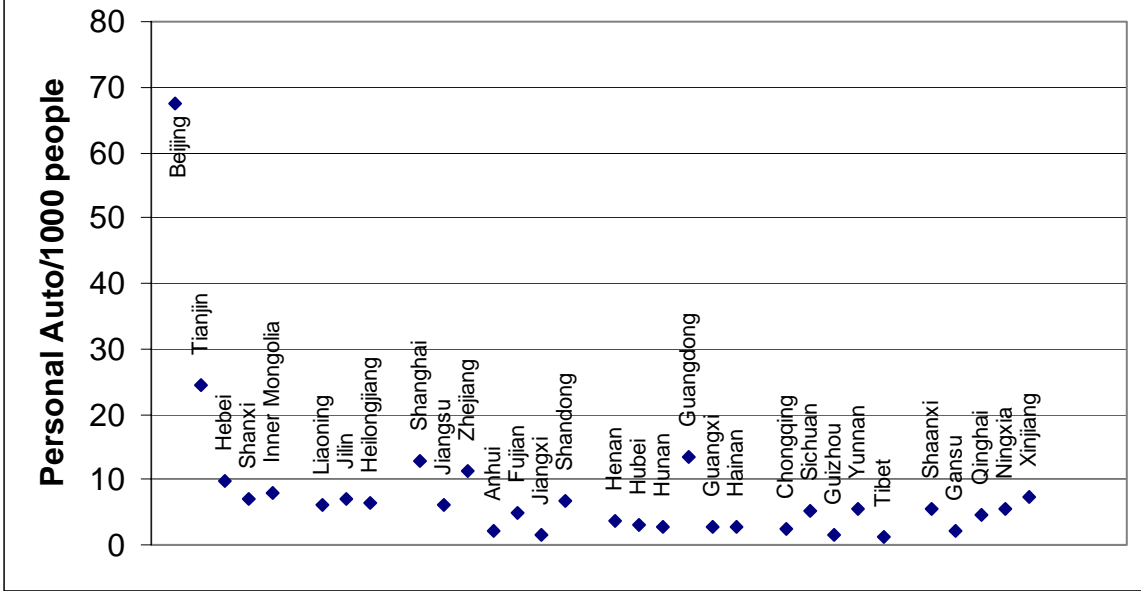
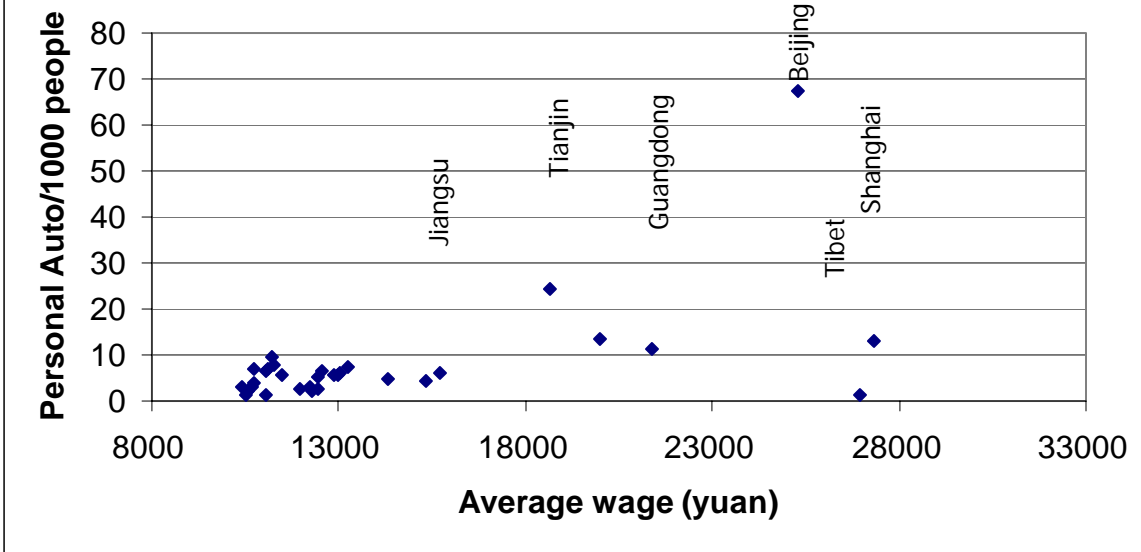


Figure 11: Auto Ownership vs Wage



projects supported by outside agencies to identify their feasibility and effect on sustainability metrics. Depending on their success, these demonstration projects can be expanded to other cities in China. Figure 12 is an incomplete matrix^{3 4 5} of policies and technologies that different Chinese cities have instituted. From the table, cities are clearly embracing grade separated transit technology. Many of the major cities in China have developed or are developing plans to invest heavily in BRT, Light Rail Transit (LRT), Subway, or some combination of all of those technologies. Additionally, cities are implementing Intelligent Transportation System (ITS) strategies that will improve the operation and efficiency of their road and transit systems. Several cities have developed demand management schemes to control auto use; particularly, restrictions on road use by using license plate schemes, restriction of informal transit, restrictions on trucks and farm vehicles, and motorcycle restrictions. Many of these restrictions are enforced using the ring road system of many Chinese cities, not allowing certain vehicles into ring roads during certain hours of the day. Some of the more drastic plans include the relocation of massive trip generators such as factories and ports in order to reduce demand on the local road network. These policies are primarily developed on a local and municipal level and vary between municipalities.

Case-based comparisons offer an opportunity to sort through factors leading to different policy strategies in different Chinese cities – such as fiscal constraints, political rationales, unforeseen opportunities, or local technological capacities. Given the difficulties in obtaining statistical data below the city level in China, cross-case comparisons provide an avenue for ferreting out the influences of different factors in the decision to pursue different policy and technological strategies in coming to grips with the mounting transport problems faced in urban China.

³ This matrix was developed by compiling work from Cervero (2005), Chang (2005), Wang et al. (2004), International Mayors Forum (2004), Zhang W.B. (2003), Subways.net (2005).

⁴ MOST ITS projects include: Urban traffic monitoring and control, Rapid accident response and traffic management systems, System integration for ITS urban applications, Deployment of comprehensive ITS systems on 1-2 inter-provincial highways within 3-5 years, Comprehensive highway management systems, Inter provincial passenger transportation systems, Special projects for Beijing Olympics, ATMS, Intelligent parking guidance, Intelligent public transportation management systems, and a Comprehensive Information Platform

⁵ The eco-city management and planning programme: develop best practice strategies in coordination with German counterparts to develop sustainable communities. Eco-city master plans developed and implemented.

Figure 12: Policy and Technology Matrix of Chinese Cities

	Policy							Operations Technology				Transit Technology					
	Bicycle Bans (core areas, major roads)	Registration Quotas	Motorcycle/Moped Bans/Restrictions	Relocated Activity Centers: ports, major markets	Licensing Scheme	Freight or Truck bans/restrictions in city	Informal Transit Bans	Co-city management and planning programme (Deutsche Gesellschaft fuer Technische Zusammenarbeit(GTZ).	Ministry of Science and Technology (MOST) ITS Demo Cities	Operations: Bikes: separate left turn lanes; signal phases	ATMS/ATIS	Clean Fuel/CNG	BRT/Exclusive ROW	LRT-Trolley	Subway	Maglev	
Anshan																	
Beijing	x		x		x	x	x			x	x		x	x	x		Existing
Changchun													x				Planned
Chengdu													x		x		
Changzhou											x						
Chongqing													x	x	x		x
Dalian				x									x				x
Guangshou																	
Guangzhou	x		x										x	x			
Hanzhou													x				
Harbin													x	x			
Jinan										x			x				
Kunming			x			x	x		x				x				
Leshan											x						
Nanjing															x		
Qingdao											x			x			
Shanghai	x	x			x	x							x	x	x	x	
Shenyang													x	x	x		
Shenzhen										x				x			x
Shijiazhuang													x				
Suzhou													x		x		
Tianjin											x						
Tienjing													x				
Wuhan				x							x			x			
Wuxi																	x
Xi'an													x		x		
Yangzhou																	
Zhongshan											x						

5. Conclusion

As Chinese cities become less pedestrian and bicycle oriented, cities must invest in modes that the majority of the non-car owning population can use to access more spatially separated land uses. There are benefits and costs with this strategy. As regional transit is developed, the car-less population has much higher mobility and presumably more access to different jobs, goods, and services. However, as cities decentralize as a result of transit and road improvements, the accessibility of the city to non-motorized modes is diminished greatly, forcing people to use public transit or autos for trips that they would have otherwise walked or bicycled to. This strategy increases the energy and pollution consequences of travel by shifting benign non-motorized transport to expensive

(and polluting) public transit or heavily polluting and congestion causing personal transportation.

The conundrum faced by today's transportation planners in China is to develop a transportation system that encourages auto ownership (which will help build China's auto industry) and promote sustainable cities that have low pollution levels and high accessibility and mobility to goods and services. Chinese cities have very limited space for road infrastructure so many cities have attempted to balance the use of the road with very efficient users of capacity (bus transit) with very inefficient users of capacity (personal automobiles). Bicycles and pedestrians, which are the majority of the road users have received secondary treatment as their mode is considered inferior and does not operate well with motorized transportation. While some of these approaches have good intentions of increased throughput and improved safety, they discourage the most sustainable and well founded mode of transportation in China. As a result, bike use has decreased in cities with these policies. If China is to maintain its economic growth and development, it must control its motorization rates, but more importantly, it personal automobile use, otherwise, the cities will be debilitated by congestion. There are several strategies that cities are using with varied success. Some strategies include improving the efficiency of their road network by using ITS strategies; others include implementing demand management schemes that ration road space. China has also implemented drastic approaches of reorganizing cities and relocating major trip generators to more strategic locations. As China's urban institutions mature and with the help of international agencies, China is making steps toward building a sustainable urban transportation network. The goal is to balance the economic benefits of motorization with the economic costs of congestion, pollution, accidents, and transportation costs.

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