URBAN TRANSPORT TRENDS AND POLICIES IN CHINA AND INDIA: IMPACTS OF RAPID ECONOMIC GROWTH

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ABSTRACT

This article provides a comparative overview of urban transport in the world's two most populous countries: China and India. Cities in both countries are suffering from severe and worsening transport problems: air pollution, noise, traffic injuries and fatalities, congestion, parking shortages, energy use, and lack of mobility for the poor. The urban transport problems in China and India results from continuing population growth, urbanization, suburban sprawl, rising incomes, and skyrocketing motor vehicle ownership and use. This article critically assesses government policies in each country and suggests a range of specific improvements. The authors advocate a slowdown in the massive roadway investment in recent years and a shift in emphasis to expanding and improving public transport, cycling, and walking facilities. While continued growth in motor vehicle use is inevitable, China and India should restrict motor vehicle use in congested city centers and increase taxes, fees, and charges to reflect the enormous social and environmental costs of motor vehicle use. At the same time, much stricter regulations should be imposed on manufacturers to produce cleaner, more energy-efficient, quieter, and safer cars, motorcycles, buses, and trucks. Mitigating the many social and environmental impacts of rising motorization is obviously important for the future well being of Chinese and Indian cities. It is also crucial to the future of the rest of the world.

INTRODUCTION

China and India are the world's most important developing countries. Together, they had more than 2.4 billion inhabitants in 2005, accounting for 37 percent of the world's total population (CIA, 2005). While their per-capita incomes are still quite low, they have risen considerably with rapid economic growth in recent decades. Between 1980 and 2005, real per-capita income (adjusted for inflation) more than doubled in India and more than quadrupled in China. One result of higher incomes has been skyrocketing ownership and use of motor vehicles in both countries. Since 1990, the total number of motor vehicles has roughly tripled in India and has increased 10-fold in China (Ministry of Road Transport and Highways, 2003; National Bureau of Statistics of China, 2005). That has led to alarming increases in traffic deaths and injuries, air pollution, noise, traffic congestion, and energy use (Gakenheimer, 1999; Vasconcellos, 2001; Pendakur, 2002; Gwilliam, 2003; Silcock, 2003).

Transport developments in China and India have important implications not only for these two countries but for the entire world. Because they encompass over half of the developing world's population, China and India are far more than just interesting examples. By their sheer mass, they are trendsetters for other developing countries. Moreover, what happens in China and India has enormous impact on the world as a whole, including the far more developed countries of Europe and North America. Current per-capita energy use in China and India is far lower than in Europe and North America. Nevertheless, total energy use in these two countries is high due to their large populations and will surely rise with future economic growth. Thus, worldwide concerns about energy shortages, air pollution, and climate change are focusing more and more on transport developments in China and India. If these two countries continue on the path toward rapid motorization, their increasing contributions to air pollution, greenhouse gases, and energy use will far offset the modest reductions achieved in more affluent, developed countries.

This article provides a comparative overview of urban transport developments in China and India. We begin with an examination of basic trends in economic growth, urbanization, and land use. Then we compare recent trends in motorization and travel behavior, highlighting variations between the two countries as well as among cities within each country. As suggested earlier, virtually all Chinese and Indian cities are beset by serious transport problems. In this article, we focus on four main categories of problems that have been worsening with increased motorization: traffic injuries and fatalities, environmental pollution, roadway congestion, and mobility problems of the poor. After analyzing the different nature and extent of these problems in each country, we critically examine the government policies in each country. On the basis of the shortcomings we identify in current policies, we propose alternative or revised policies that would more effectively solve the increasingly severe transport problems in Chinese and Indian cities.

OVERALL SIMILARITIES AND DIFFERENCES BETWEEN CHINA AND INDIA

While China and India have much in common, they also differ in some important ways. Table 1 provides an overview of the main similarities and differences between the two countries in terms of their urban transport situations.

The similarities between China and India are shared with many developing countries and are some of the very factors that characterize them as developing countries. The differences between China and India highlight the great variation among developing countries in their economic, political, and transport systems. We examine more closely the factors listed in table 1 in the following sections that deal with recent developments in urbanization, land use, travel behavior, transport problems, and government policies. Both the similarities and differences between China and India can help illuminate the nature of transport problems and policies in developing countries in general.

Table 1. SIMILARITIES AND DIFFERENCES BETWEEN INDIA AND CHINA

CATEGORY	SIMILARITIES	DIFFERENCES
Per-Capita Incomes	Both countries remain relatively poor compared to OECD countries, with per-capita incomes only about a tenth as high as in North America and Western Europe	Economic growth has been roughly twice as rapid in China as in India since 1980s. By 2005, China's per-capita income was almost 50% higher than India's.
Land use and Urban growth	Both countries are still primarily rural but are urbanizing rapidly, with especially rapid growth of the largest cities.	Indian cities are increasingly being surrounded by unplanned, haphazard suburban sprawl, while Chinese cities remain fairly compact, even as they grow outward to accommodate increasing populations
Non-motorized transport	Non-motorized transport has long been the most important means of travel for both Chinese and Indians, especially in smaller cities and rural areas.	China, for many decades was dominated by bicycles, with extensive cycling paths, lanes, signals, and parking provided in most cities. Bicycling has never been as important in Indian cities, and there has always been a lack of facilities for bicycling.
Motorization and transport systems	Weak transport infrastructure, particularly highway systems, but with more governmental investments on transport systems.	China has large governmental investment in new urban development and transport infrastructure, whereas India has a very limited government funding available for transport and other public infrastructure projects
Growth in cars	Governments in both countries have been increasingly accommodating growing car use through more road construction	Since 1990, the total number of motor vehicles has roughly tripled in India, but has increased 10-fold in China.
New highway projects	Both countries are experiencing dramatic increases in roadway congestion, noise, air pollution, and traffic accidents, as a result of increased car ownership and new highway projects.	Urban roadways, public transport, and highway infrastructure is far superior in Chinese cities than Indian cities.
Economic growth	Economic growth is concentrated.	China's growth has been fastest along the southeastern coast, while in India it is concentrated in the largest cities of several different regions.
Political System		China has a centralized and autocratic system whereas India is a democratic nation.

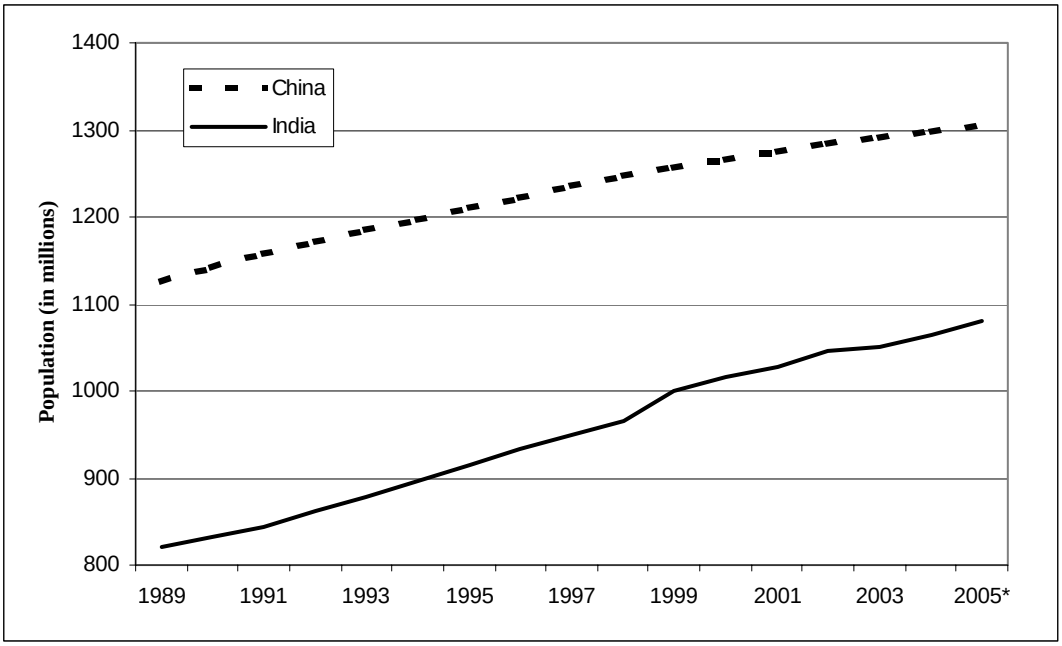
Urbanization and Economic Growth

Both China and India have experienced considerable population growth in recent years, but it has been much faster in India (see figure 1). Indeed, from 1989 to 2005, India's population grew at almost twice the average annual rate of China's (1.7% vs. 0.9%) (United Nations, 2004). The slower growth rate in China is due to strict family planning policies that generally limit a couple to only one child, but with some exceptions. In both countries, population growth has been concentrated in cities, especially in China, largely due to in-migration from economically depressed rural areas. Urban population rose in China from 178 million in 1978 to 524 million in 2003 (an average annual increase of 4.4%) (National Bureau of Statistics of China, 2004), and in India from 160 million in 1981 to 285 million in 2001 (an average annual increase of 2.9%) (Office of the Registrar General of India, 2001a; Padam and Singh, 2001). Thus, while overall population growth has been faster in India, urban population growth has been faster in China. In both countries, actual urban population growth probably exceeds these official statistics because there are additional, substantial transient populations in cities (often poor migrants from rural areas) who are not counted by the censuses in either country.

Figure 1. POPULATION GROWTH IN INDIA AND CHINA, 1989 - 2005

Source: National Bureau of Statistics of China, 2004; Office of the Registrar General of India, 2004

Note: '*' denotes 'estimated'

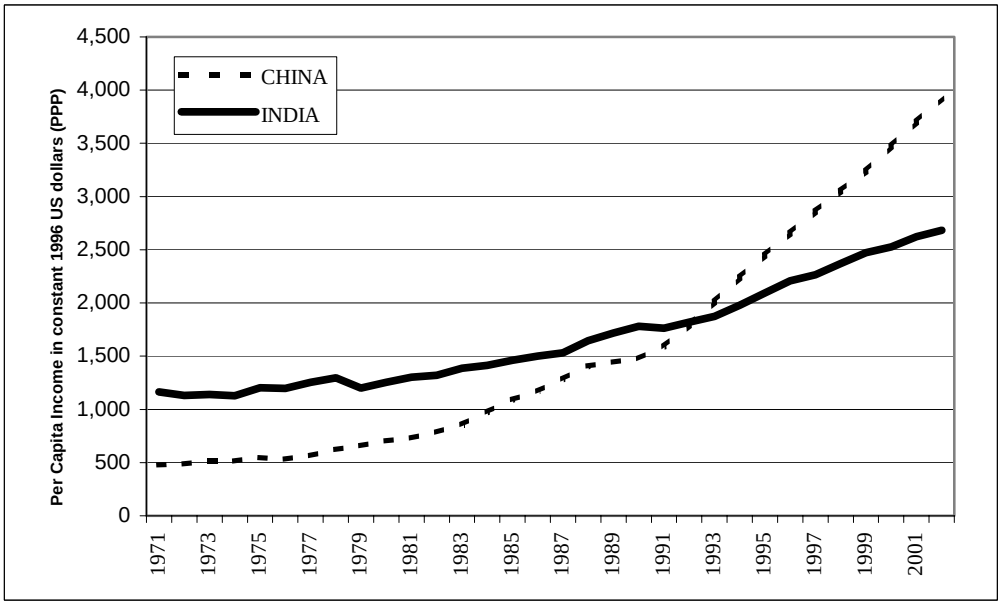


In both China and India, large cities have been the focus of both population and economic growth. Each country now has three megacities with populations over ten million: Beijing (11.5 million), Shanghai (10.4 million), and Chongqing (10.2 million) in China; and Mumbai (16.4 million), Kolkata (13.2 million), and Delhi (12.8 million) in India. China has five additional cities with populations over 5 million (Guangzhou, Tianjing, Xi'an, Chengdu, and Wuhan), and India has three such cities (Chennai, Hyderabad, and Bangalore). Overall, China has 174 cities with populations of over a million, and India has 35 cities that large (Office of Registrar General of India, 2001b; National Bureau of Statistics of China, 2004).

Figure 2. PER-CAPITA INCOMES IN INDIA AND CHINA, 1972 - 2002

Source: Organization for Economic Cooperation and Development (OECD)

Note: Per-capita Incomes for both China and India are expressed here in constant, inflation-adjusted 1996 US dollars, using purchasing power parity for currency conversion.



The rapid growth of both Chinese and Indian cities has dramatically increased demand for land and travel in urban areas, thus putting enormous pressure on transport and other kinds of public infrastructure. The sheer increase in urban population would be sufficient to generate serious transport problems. In addition, however, motorization rates have skyrocketed, thanks to large increases in average incomes, especially in China. As shown in figure 2, real per-capita income has increased about 8-fold in China between 1972 and 2002, compared to an increase of slightly more than 2-fold in India. While China's per-capita income was only 43% as high as India's in 1972, it exceeded India's per-capita income by 46% in 2002 (Organization for Economic Cooperation Development, 2002). As documented later in the article, income growth has stimulated large increases in private car and motorcycle ownership and use in both countries.

Trends in Land Use

As Chinese and Indian cities have grown in population, they have also spread outward to the suburbs at lower densities than previously. For example, the developed area of Chinese cities more than tripled from 1985 to 2003 (from 9,386 sq.km. to 28,308 sq.km.), while total urban population only doubled (National Bureau of Statistics of China, 2004). The population density of new suburban development is only about half as high as in older parts of the city. Low-income and middle-income households have been relocating to peripheral suburban areas because of the lack of affordable housing in the central cities. Employment has also decentralized. In the process of urban expansion, most factories were relocated to the suburbs. Moreover, local governments in China have been promoting new industrial and technology parks on the fringe of urban areas, thus pushing urban development further into rural areas.

Virtually the same type of decentralization can be found in India but to an even greater extent (Bertraud, 2002). That is partly due to deliberate government policies to decongest crowded city centers. Land use regulations strictly limit the ratio of floor areas to land areas in the city center, thus restricting the heights of buildings and density of development in the center (Bertraud, 2002; Padam and Singh, 2001). As Indian cities grow, that virtually forces new development to the suburban fringe. In addition, local governments in suburban jurisdictions have less stringent land use regulations than the cities and even advertise their more permissive policies to lure away economic development from the central cities. Similar to China, virtually every major Indian city has large technology parks on the fringe, thus further encouraging decentralization of both employment and population. While suburban developments around Chinese cities are to some degree planned and coordinated with the provision of basic public infrastructure, Indian suburbs are generally unplanned and rarely adequate public transport services (Ramachandran, 1989).

The decentralization of Chinese and Indian cities has greatly affected urban transport. In both countries, the expansion of cities has increased the length of trips for most urban residents, leading to more overall travel demand and thus more traffic on the roadways and public transport systems. Moreover, increased trip distances make walking and cycling less feasible than before, thus encouraging a shift from non-motorized to motorized modes.

Trends in Urban Transport

Neither China nor India has a national survey of travel behavior that canvasses the entire country. Travel surveys have been conducted for many of the largest cities, but they are not necessarily comparable, since they were conducted independently in each city by different firms using different methods. Moreover, since the available surveys focus on large cities, they are not representative of the country as a whole. Thus, the information that follows should be considered as rough approximations and not used for exact comparisons.

Modal split distributions

Generally, walking and cycling serve the highest percentage of trips in smaller cities and villages where incomes are lower, trip distances are shorter, and public transport is not available. In India, for example, the walk share of all trips falls from 37% in cities with 100,000 to 250,000 inhabitants to 28% in cities with over 5 million inhabitants. The bike share declines more sharply with increasing population size, from 26% to only 9% (Singh, 2005). As city size increases, trip length increases as well, and public transport services become more available. Higher incomes in larger cities make public transport more affordable and also enable purchase of private motorized vehicles.

Figures 3 and 4 show the most recent information on the distribution of trips by means of transport for

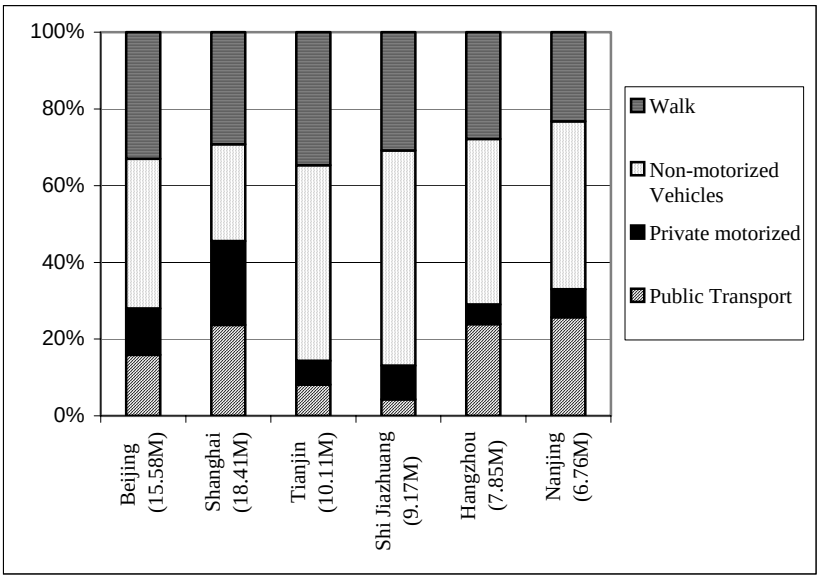
large Chinese and Indian cities. At least for these large cities, non-motorized transport accounts for a higher percentage of travel in China than in India. Among the megacities, for example, non-motorized transport accounts for over half of all trips in China but for only about a fourth in India. That difference is due to much more cycling in China. Even among the largest cities in each country, there can be considerable differences in travel behavior, but the reported differences between Delhi, Mumbai, and Kolkata seem unlikely. For example, the latest available surveys indicate a non-motorized mode share in Delhi (40%) that is twice as high as in Mumbai and Kolkata. Yet walking, cycling, and cycle rickshaws seem far more likely in Kolkata, with its very low incomes, and in Mumbai, which has a much more compact land use pattern than Delhi. As expected, however, the non-motorized share is much higher in smaller cities such as Kanpur (over 90%) and Lucknow (70%) (Pucher et al., 2005). There is less variation among Chinese cities. Even in China's two largest cities, Beijing and Shanghai, non-motorized transport accounts for 60% of trips. The non-motorized share ranges from about 70% to 80% for most of the smaller Chinese cities shown in figure 3. It is highest in Tianjin and Shi-Jia-Zhuang due to the extraordinary dominance of cycling in those two cities (51% and 56% of all trips by bike) (Urban Transit Center, 2003).

Public transport's share of travel usually rises with increasing population size. Using aggregated city-size categories, the Indian Ministry of Urban Development reported an increase in public transport share of trips from an average of only 16% in cities with 100,000 to 250,000 inhabitants to an average of 63% in cities with over 5 million inhabitants (Sreedharan, 2003; Singh, 2005). But there are considerable differences even with size categories. For example, public transport serves a much higher percentage of trips in Mumbai and Kolkata than in Delhi, perhaps because of the better road network and higher car ownership in Delhi. Mumbai and Kolkata also had more extensive rail systems than Delhi in 2000, at the time of the travel surveys. The recent opening and ongoing expansion of the Delhi metro will almost certainly raise the public transport share of travel there. In 2000, however, public transport's share of trips was roughly the same level in Delhi as in the intermediate size cities of Chennai, Bangalore, and Hyderabad. For the considerably smaller cities of Kanpur and Lucknow, regular bus services are minimal, typical of the situation of many smaller cities (Singh, 2005). Consequently, walking and non-motorized vehicles (mainly bicycles and cycle rickshaws) are far more important in those two cities, serving over two-thirds of all trips. In addition, Lucknow and many other smaller Indian cities rely on a mix of paratransit modes such as auto rickshaws, jeep taxis, and tempos (large auto rickshaws). The study by the Indian Ministry of Urban Development reported that such paratransit vehicles served an average of 30% of all trips in cities with 100,000 to 250,000 inhabitants, more than four times the 7% share in cities with more than 5 million inhabitants (Singh, 2005).

Figure 3. PERCENT DISTRIBUTION OF URBAN TRIPS BY MEANS OF TRAVEL FOR SELECTED CHINESE CITIES, 2000

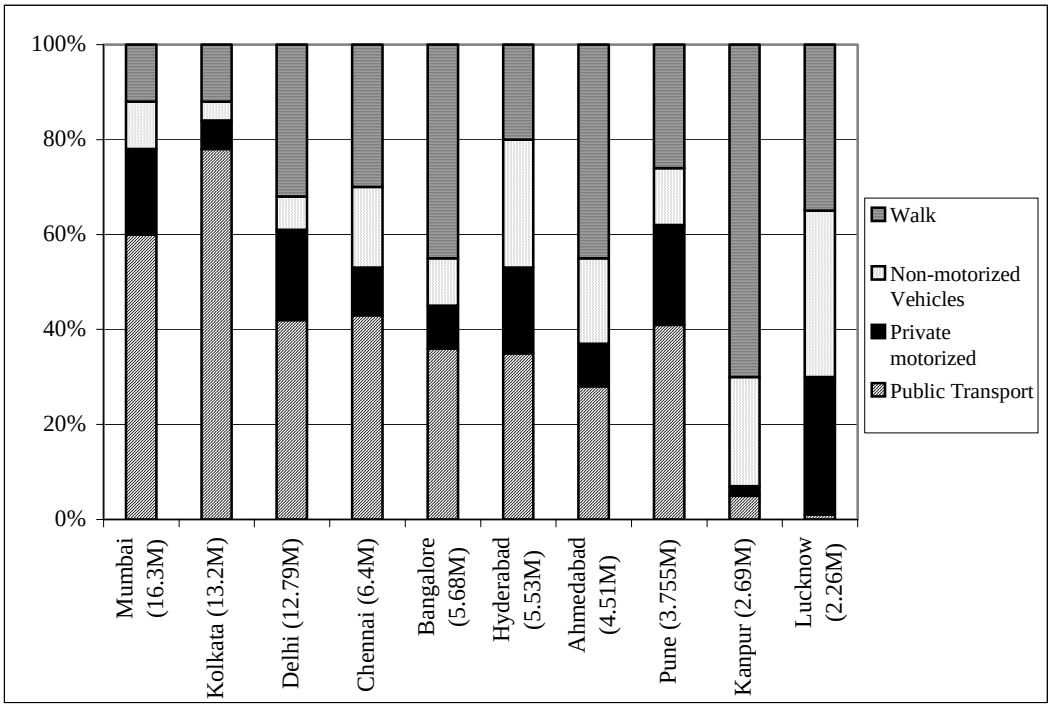
Source: China Academy of Urban Planning and Design, Beijing City Planning Institute, Shanghai City Comprehensive Transportation Planning Institute, Nanjing City Transportation Planning Institute

Note: Public Transport includes Buses, Metro rail, Taxis and Private Motorized includes Autos, Motorcycles, Others and employer provided cars and buses



China's two largest cities Beijing and Shanghai both have about a fourth of their trips by public transport. Construction and expansion of metro systems in these cities explains much of the increase in public transport use and market share in recent years. From 1999 to 2004, for example, public transport share in Shanghai rose from 15% to 24% (see figure 3) (Urban Transit Center, 2003). Most surprising is the very low 8% share in Tianjin. The low public transport share there is probably due to the extraordinary dominance of cycling in Tianjin (51% of all trips), which is the center of China's bicycle industry. Shi-Jia-Zhuang's public transport share is only 3%, perhaps also due to the low incomes, compact city center, and dominance of cycling there (56% of trips) (Urban Transit Center, 2003). The intermediate size cities of Nanjing and Hangzhou, both have about the same public transport market share as Beijing and Shanghai. Clearly, size alone does not explain the relative importance of public transport compared to other modes. Some of the surprising irregularities in figures 3 and 4 might not be due to real differences but rather to data problems and inconsistencies among Chinese and Indian cities in their travel surveys.

Figure 4. PERCENT DISTRIBUTION OF URBAN TRIPS BY MEANS OF TRAVEL FOR SELECTED INDIAN CITIES, 2002
Sources: Pendakur 2002 and World Bank 2002



Among China's largest cities, private car use is much higher in Beijing and Shanghai than in other cities—about 15% of all trips, compared to 5%-8% in the other cities in Figure 3 (Beijing City Planning Institute, 2001). The greater car use in Beijing and Shanghai is due to higher incomes there, and also the concentration of government offices and firm headquarters. Many cars are, in fact, provided by firms and government agencies for their high-ranking employees. For China as a whole, there were about 10 cars per 1,000 people in 2003 (National Bureau of Statistics of China, 2004). By comparison, the rate of car ownership was almost 9 times higher in Beijing (86 per 1,000 inhabitants) (Bureau of Statistics of Beijing, 2004) and almost 3 times higher in Shanghai (27 cars per 1,000 inhabitants) (Bureau of Statistics of Shanghai, 2004). Delhi has the highest level of car ownership and use in India for similar reasons, with 75 cars per 1,000 inhabitants compared to an average of only 7 for India as a whole (Ministry of Heavy Industries and Public Enterprises, 2004). Car ownership and use declines in intermediate size cities with lower incomes, and is even lower in small cities and villages, accounting for only 3% of trips in cities with populations between 100,000 and 250,000.

Travel trends

A few cities provide statistics on trends in travel over time, and most such information suggests declines in walking and cycling and rapid increases in the use of private cars and motorcycles. In Shanghai, for example, the combined modal share of walking and cycling fell from 72% in 1986 to 54% in 2004 (Shanghai City Comprehensive Transportation Planning Institute, 2005). In Beijing, the combined walking and cycling share fell from 66% in 1986 to 41% in 2000 (Beijing City Planning Institute, 2001). In

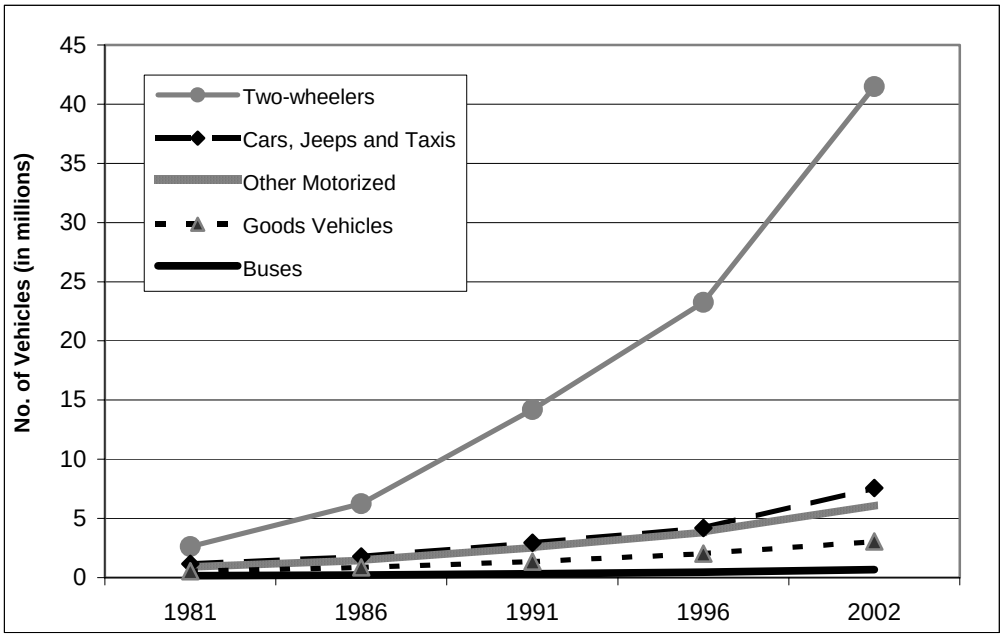
Nanjing, it fell from 75% in 1986 to 65% in 2002 (Nanjing City Transportation Planning Institute, 2003). And finally, in Shi-Jia-Zhuang, it fell from 92% in 1986 to 86% in 2000(Urban Transit Center, 2003). The falling non-motorized share of trips is due to increasing trip distances in expanding cities as well as increased ownership and use of private cars and motorcycles with rising incomes.

Public transport use has risen in almost all Chinese cities, due both to rising populations and the longer trips caused by the expansion of urban areas. For all Chinese cities in aggregate, total public transport trips rose by 67% from 1996 to 2004 (from 25.6 billion to 42.6 billion) (National Bureau of Statistics of China, 2005). The increase was slower, however, in Shanghai (22%) and Beijing (46%), perhaps due to the much greater increase in car ownership and use there than in other Chinese cities. In addition, those two cities already had much higher levels of public transport use than other cities; thus, the percentage increase in usage in Beijing and Shanghai was relative to a much higher base level.

Expansion of public transport

In response to rapidly increasing demand, most Chinese cities have invested heavily in both bus and rail systems. Six cities already have metro systems (Beijing, Shanghai, Guangzhou, Tianjing, Shenzhen, and Nanjing), and the 406 route km of metro in those cities are currently being expanded by another 256 route km (Zhou, 2005). Ten additional cities are planning the construction of new metro systems. Seven Chinese cities already have light rail systems (Beijing, Shanghai, Tianjing, Chongqing, Wuhan, Dalian, and Changchun), and nine other cities are planning light rail systems. While the recent emphasis has been on rail systems, most public transport in Chinese cities is by bus. Indeed, the number of buses in China increased 6-fold between 1985 and 2003, from only 45,100 to 264,300 (National Bureau of Statistics of China, 2004). From 1995 to 2003, the number of buses quadrupled in Beijing, tripled in Tianjing, and doubled in Shanghai (National Bureau of Statistics of China, 2004). Thus, the supply of both rail and bus services has greatly expanded to meet growing demands.

Figure 5. GROWTH OF INDIA'S MOTOR VEHICLE FLEET BY TYPE OF VEHICLE, 1981 – 2002 (IN MILLIONS)
Source: Ministry of Road Transport and Highways, 1999, 2000, 2003
Note: 'others' includes tractors, trailers, motorized three-wheelers such as auto rickshaws and other miscellaneous vehicles that are not separately classified.

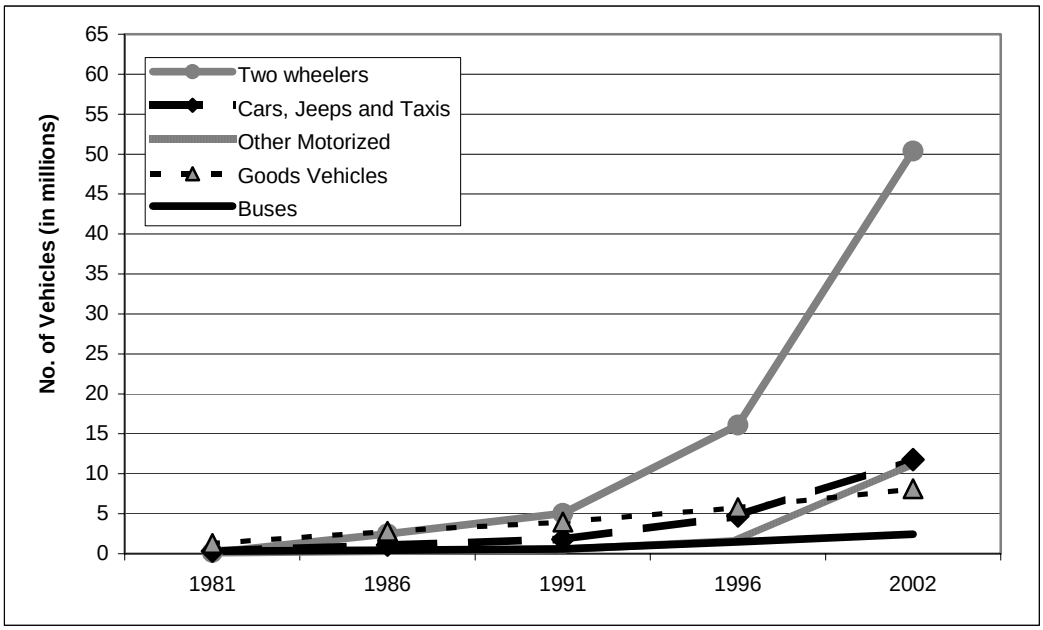


Unfortunately, public transport services have lagged far behind in Indian cities, both in quality and quantity. There has not been nearly enough investment in new vehicles and infrastructure because no level of government has sufficient funds available. In contrast to China, India has only two cities with metro systems (Kolkata and Delhi) and only one city with a tramway (Kolkata). Mumbai, Kolkata, Chennai, and Delhi have suburban rail systems, but some trains are dangerously overcrowded. In Mumbai, for example, peak-hour trains are filled to more than twice their maximum design capacity, with so-called "super dense crush loads" of 14-16 passengers per square meter of floor space. (Varshneya et. al., 2002; Indian Railways, 2003) That forces some passengers to hang out of doors or windows, or ride

between cars (Acharya, 2000). Similarly, many buses are overcrowded, sometimes forcing passengers to sit on roofs or to hang perilously from the sides. The slow bus speeds in very congested traffic further diminish service quality, and divert passengers to other modes, especially motorcycles, which can maneuver more easily between vehicles.

In spite of funding shortages, metro systems in Delhi and Kolkata are being expanded, and suburban rail systems in major cities are being improved through the addition of more trains and some new cars as well as by route expansion and doubling of trackage on some stretches to separate local from express traffic. Nevertheless, the improvements are not sufficient to meet rising demands for suburban rail travel, which has almost tripled since 1980. The problems are even worse for bus services, which carry over 90% of public transport passengers in India (Singh, 2005; Pucher et al., 2005). Many buses in India are badly designed, old, in poor repair, and overcrowded during peak hours. Governments at every level have neglected bus services, failing to provide them with traffic priority and separate rights of way on city roads and denying them sufficient funds to modernize the bus fleet. (Gakenheimer and Zegres, 2003). While there have been considerable improvements in rail services, bus services continue to deteriorate, thus forcing many passengers to choose faster motorized modes such as cars and motorcycles.

Figure 6. GROWTH OF CHINA'S MOTOR VEHICLE FLEET BY TYPE OF VEHICLE, 1981 – 2002 (IN MILLIONS)
Source: National Bureau of Statistics of China, 2004
Note: Motor vehicle is consisted of automobiles, freight vehicles (tractors) and other motor vehicles. Passenger vehicles include bus, car and jeep etc.



Rapid motorization

Surely the most dramatic transport development in China and India has been the striking growth in private motorized travel, especially by car and motorcycle. The best available indicator of that trend over time is the level of ownership of such vehicles. Figures 5 and 6 show the increase in the stock of motor vehicles by type of vehicle. In both China and India, the fastest growth has been in motorcycles and motorscooters. From 1981 to 2002, the total number of motorized two-wheelers rose from less than 3 million to 42 million in India—a 14-fold increase—and from only 200,000 to over 50 million in China—a 250-fold increase (Indian Ministry of Road Transport and Highways, 2003; National Bureau of Statistics of China, 2004). Figure 7 compares the growth in motorized two-wheelers in the two countries, and indicates that China overtook India around 2000, probably due to the much faster economic growth in China. There is considerable variation within China, however, in levels of motorcycle use, which are far higher in southern China than in northern China. For example, motorcycles account for less than 2% of all trips in Beijing, Tianjin, and Hangzhou, 3% of trips in Nanjing, and 5% in Shanghai, but over 10% in Fuzhou and Guangzhou. Medium-size cities in southern China have especially high levels of motorcycle use—for example, 36% in Quanzhou, 19% in Zhuhai, 51% in Shunde, and 22% in Jinde Zhen. (Urban Transit Center, 2003).

As is evident in figures 5 and 6, motorized two-wheelers now account for the vast majority of motor vehicles in both countries. While these two-wheelers provide an increasing proportion of the middle class with affordable, flexible, and relatively quick transport, they pose serious problems for traffic safety. Indeed, due to the high fatality rates and air pollution caused by motorcycles, many Chinese cities have recently banned motorcycles altogether or at least restricted their use to some extent (Jin, 2004). Those restrictions will probably dampen future growth of motorcycle use in China.

Figure 7. RISING MOTORCYCLE OWNERSHIP IN INDIA AND CHINA (1976 – 2002)
Source: National Bureau of Statistics of China, 2003; Indian Ministry of Road Transport and Highways, 2003

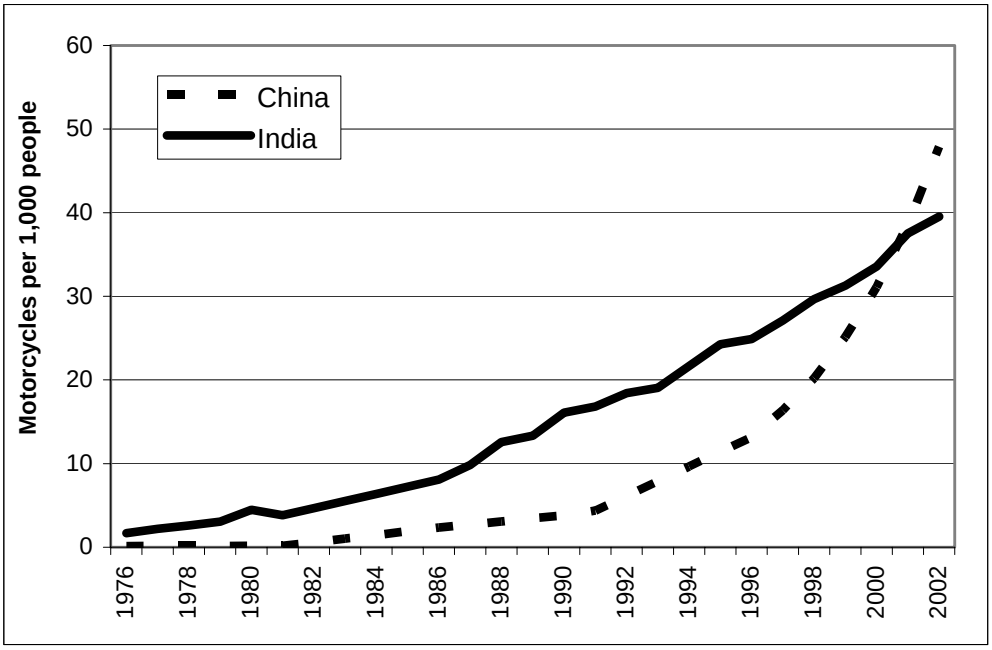
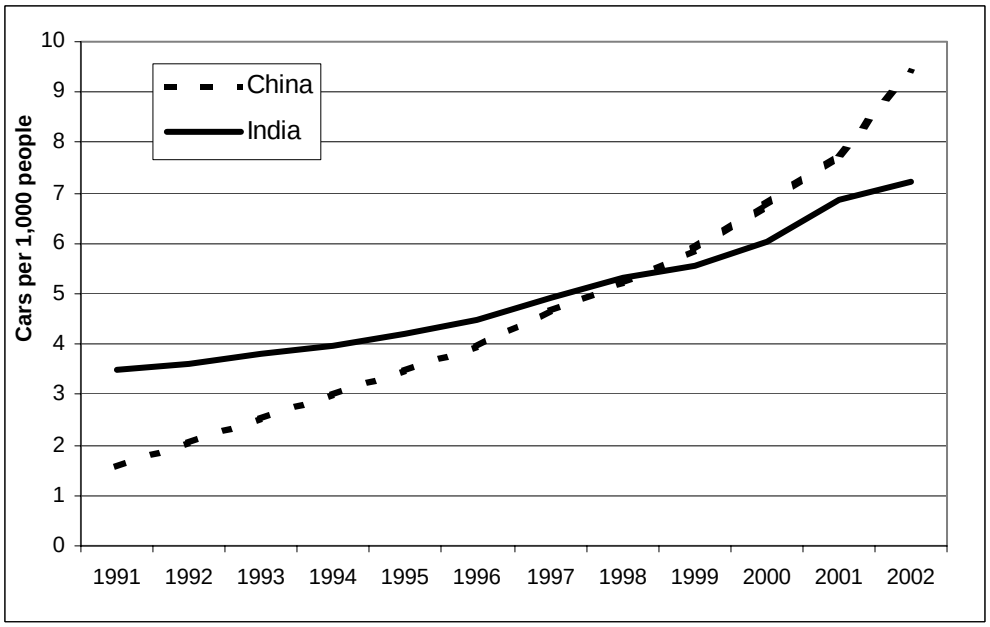


Figure 8. RISING CAR OWNERSHIP IN INDIA AND CHINA, 1991 – 2002
Source: National Bureau of Statistics of China, 2003; Indian Ministry of Road Transport and Highways, 2004



Although motorcycles and motor scooters account for most of the recent growth in motor vehicle ownership, worldwide attention has focused on the rapid growth in private car ownership over the past two decades, as shown in figure 8. From 1991 to 2003, the number of cars per 1,000 population in China rose from less than 2 to almost 10—a five-fold increase in only 12 years. During the same period, the number of cars per 1,000 population in India more than doubled, rising from about 3 to more than 7 (National Bureau of Statistics of China, 2003; Ministry of Road Transport and Highways, 2004). Figure 8 shows clearly the much faster rate of growth in China, which overtook India in per-capita car ownership

in 1998, just about the same time that per-capita income in China also overtook that in India.

As suggested earlier, these national aggregate statistics hide huge variation in car ownership among regions and cities. For example, while China's national average in 2003 was only 10 cars per 1,000 population, the corresponding car ownership rates were 86 for Beijing, 27 for Shanghai, 20 for Tianjin, and 16 for Nanjin (National Bureau of Statistics of China, 2004; Bureau of Statistics of Tianjin, 2004; Nanjing City Transportation Planning Institute, 2004). Surely, they are even lower for small towns and villages. Similarly for India, Delhi has 75 cars per 1,000 inhabitants, ten times higher than the national average of 7 (Ministry of Heavy Industries and Public Enterprises, 2004). Car ownership was once concentrated among the political and economic elite in India and China, but it has been increasingly spreading to the middle classes as well, since the car is a hugely popular consumer item and prestige symbol in both countries. As noted later in this article, rising ownership and use of cars and motorcycles has been causing severe social, environmental, and economic problems for the rapidly growing cities in India and China. In the two sections that follow below, we first examine the nature and extent of those problems and then describe and critique the government policies with respect to each of these problem areas.

URBAN TRANSPORT PROBLEMS

Although Chinese and Indian cities suffer from a long list of transport problems, we focus here on only four of the most important problems: traffic deaths and injuries, environmental pollution, congestion, and lack of adequate mobility. To varying degrees, all four problems have become more serious in recent years due to rapid population growth, the spreading out of cities into lower-density suburbs, and skyrocketing motorization.

Traffic safety

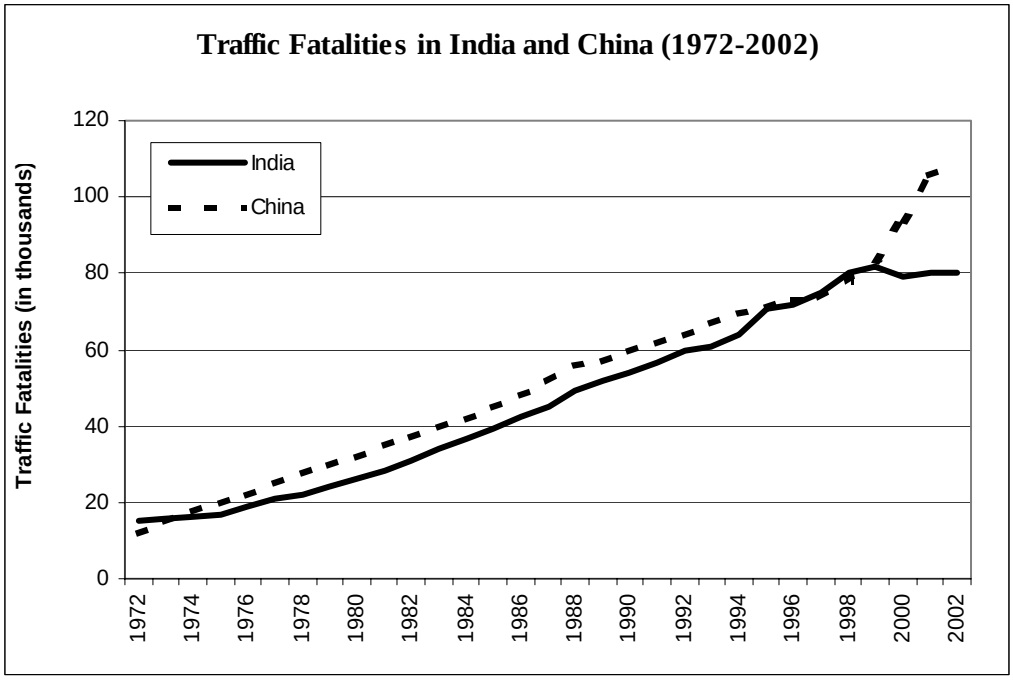
As figure 9 clearly indicates, there has been an alarming increase in traffic fatalities in both China and India over the past three decades. Even controlling for population growth, the traffic fatality rate per million inhabitants has roughly quintupled in China and tripled in India. China reports almost 105,000 traffic fatalities in 2003, compared to 80,000 in India. (National Bureau of Statistics of China, 2004; Ministry of Road Transport and Highways, 2003)

The available statistics indicate that the number of traffic injuries far exceeds the number of fatalities, although injury data are far less reliable and less comparable between countries. In China, there were almost 500,000 traffic injuries reported in official statistics for 2003, about five times the number of fatalities (National Bureau of Statistics of China, 2004). In India, government statistics report 342,000 traffic injuries, but academic studies criticize this as a severe underestimate and indicate much higher levels: 1.2 million serious injuries and 5.6 million minor injuries in 2002 (Mohan, 2004). While there is considerable debate in all countries about the exact number of traffic injuries, the main point here is that the full extent of the traffic safety problem is far greater than the number of fatalities indicates. All studies agree that injuries are many times more numerous than fatalities, and can cause social and economic problems that rival those of death.

Clearly, the sharp rise in motorization is one of the main reasons for the alarming increase in traffic fatalities. Studies show that the likelihood of death in traffic crashes increases sharply with increased speed, and motor vehicles can obviously travel much faster than non-motorized modes. In both countries, the rising danger posed by increased motorization is compounded by inadequate road supply, unsafe vehicles and driving behavior, sharing of roads by motorized and non-motorized vehicles, overcrowding of vehicles, and inadequate or non-existent traffic signals, signs, and traffic management. On virtually all of these dimensions, the situation is worse in Indian cities. In particular, roads in India are both worse and in shorter supply than in China. Indeed, many Indian cities are plagued by roads that are narrow, crowded, unpaved, and obstructed by stationary uses such as street vendors, parked vehicles, and resting animals. Moreover, most Indian cities lack even the most basic infrastructure for pedestrians and cyclists, while most Chinese cities have long provided extensive cycling paths and lanes as well as sidewalks. That provides a greater degree of separation for slower-moving, non-motorized traffic in Chinese cities. That helps avoid many collisions, but it also speeds up motorized traffic, which might help explain the higher percentage of fatal traffic accidents in Chinese cities. Perhaps for the same reason, traffic fatalities in China have risen especially fast in recent years, while those in India have leveled off.

Whatever the safety problem encountered by car occupants, it is far exceeded by the much more dangerous situation facing motorcyclists, bicyclists, and pedestrians. Walking is especially dangerous in Indian cities, where over half of all traffic fatalities are pedestrians (World Bank, 2002). That is twice as high as the pedestrian share of traffic fatalities in China (25%) and is probably attributable to the almost complete lack of sidewalks, pedestrian crossings, and pedestrian traffic signals in Indian cities. Bicyclist fatalities are higher in China than in India (18% vs. 8% of traffic fatalities), but that is almost certainly due to much higher levels of cycling in Chinese cities. Motorcyclist fatalities account for roughly the same 20% share of total traffic fatalities in both countries, roughly five times higher than their share of total trips (National Bureau of Statistics of China, 2004). The combination of speed, open exposure, and dangerous driving makes the motorcycle the most dangerous way of getting around in both countries. Nevertheless, the relatively low cost of this flexible and fast means of travel appears to make motorcycles almost irresistible for many in the middle class.

Figure 9. TRAFFIC FATALITIES IN INDIA AND CHINA (1972-2002)
Source: *National Bureau of* Statistics, 2004 (China); Ministry of Road Transport and Highways, 2003 (India)



ENVIRONMENTAL POLLUTION

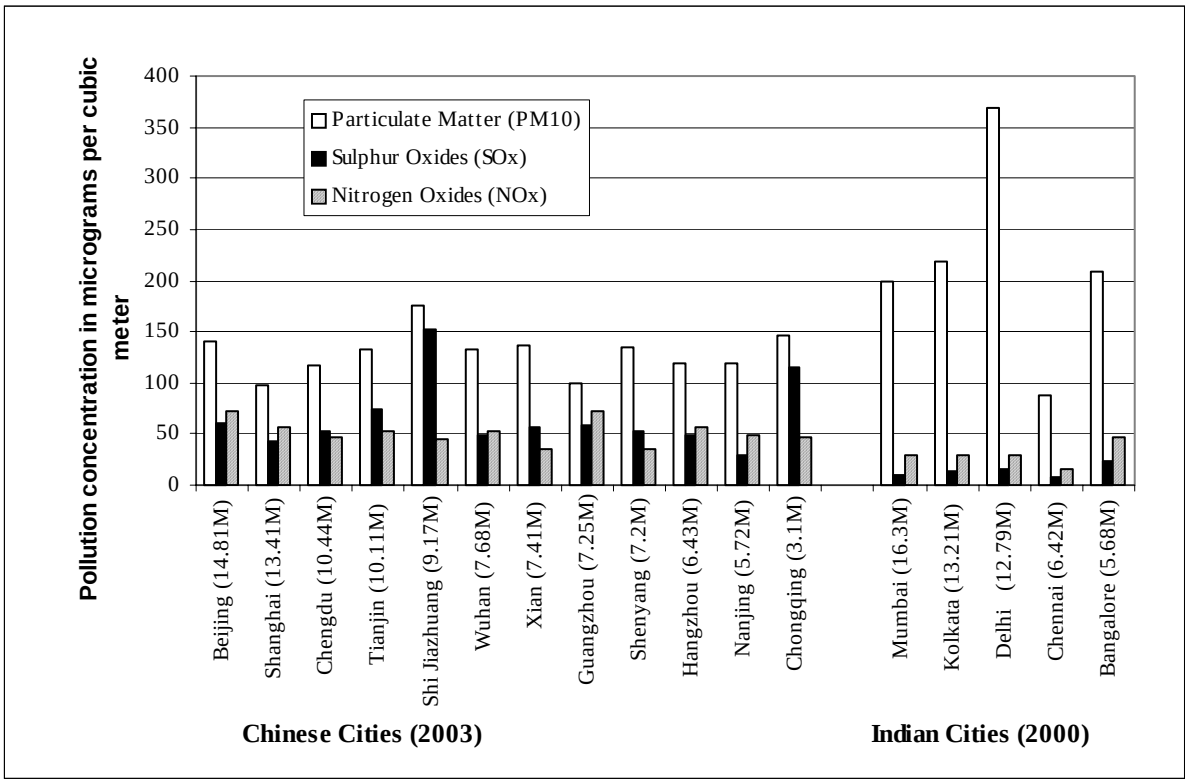
Noise, air, and water pollution are all serious problems in both Indian and Chinese cities, and transport sources contribute to all three kinds. The most reliable and comparable statistics are for air pollution. As shown in figure 10, concentrations of suspended particulate matter are much higher in large Indian cities than in large Chinese cities, while concentrations of sulfur oxides (SOx) and nitric oxides (NOx) are much higher in Chinese cities. (Bose, 1998; Vasconcellos, 2001; Padam and Singh, 2001; Ministry of Petroleum and Natural Gas, 2002; Sibel and Sachdeva, 2001) Even the lower concentrations of suspended particulate matter in Chinese cities exceed the WHO's air quality standard, but the Indian levels are 3 to 4 times higher than the WHO standard, indicating a truly alarming public health hazard. (World Health Organization, 2000; Kandlikar and Ramachandran, 2000)

Concentrations of SOx and NOx in most Indian cities are well below the WHO standards, suggesting only moderate to low health dangers from those two kinds of pollution. In China, however, SOx concentrations exceed the WHO standards in most cities, especially those in northern and western China (due to coal burning power plants there). NOx concentrations exceed WHO standards in about half of China's large cities. Air pollution is obviously a serious problem in both Chinese and Indian cities.

To some extent, the differences between China and India in pollution concentrations are due to non-transport sources of air pollution. The higher levels of SOx pollution in China are mainly due to coal burning power plants there, especially in northern and western China. The higher levels of suspended particulates measured in Indian cities may be partly due to more dust in the air, both from the dry surrounding countryside in northern India and from the many unpaved roads throughout India. In addition, wood and charcoal are still used in India by the poor for cooking and heating, emitting yet more

suspended particulates into the air.

Figure 10. AIR POLLUTION IN CHINESE AND INDIAN CITIES
Source: National Bureau of Statistics of China, 2004; Indian Ministry of Petroleum and Natural Gas, 2002



Whatever the contributions of non-transport sources of pollution, the rapid motorization of both countries in recent years has unquestionably worsened overall air quality. In both countries, fuel standards and exhaust emission standards are lower than European and American levels. Consequently, even new cars, buses, and trucks are more polluting than in Europe and North America. On-the-road degradation of pollution control equipment is more severe in China and India as well, since vehicle inspection systems are either non-existent or less stringent than in Europe. Perhaps most important, many of the motor vehicles on the road in China and India are old and thus more polluting than newer models. An additional problem in India is the large number of old motorcycles, scooters, auto rickshaws, and tempos, many of which still rely on highly inefficient, poorly maintained, and very polluting 2-stroke engines (Tata Energy Research Institute, 1997). Since many auto rickshaw drivers illegally adulterate their gasoline fuel with up to 30% kerosene and 10% lubricating oil, the pollution they generate is yet further increased (Kandlikar and Ramachandran, 2000). And in both India and China, diesel buses are much dirtier than in Europe, emitting high levels of suspended particulates.

While noise pollution has been increasing with rising motorization, it does not appear to be a very serious problem in China and India except in the largest cities. According to official Chinese statistics, only about a fifth of Chinese cities suffer serious noise pollution from roadways, which Chinese authorities define as 70dB or higher. Nevertheless, in a survey of 31 large Chinese cities, the State Environmental Protection Agency found roadway noise levels ranging from 67.5 to 70.6dB, which is certainly loud even if not dangerous for health (National Bureau of Statistics of China, 2004). Moreover, the largest cities report the highest values: 69.7 in Beijing and 70.4 in Shanghai (National Bureau of Statistics of China, 2004).

Traffic Congestion

In both China and India, traffic congestion is probably the most visible, most pervasive, and most immediate transport problem plaguing their cities on a daily basis. It affects all modes of transport and all socioeconomic groups. Most estimates as well as anecdotal impressions suggest rapidly worsening congestion. In Mumbai, for example, average roadway speeds for motor vehicles fell by half from 1962 to 1993, from 38 km/hr to only 15-20 km/hr (Gakenheimer, 2002). In Delhi, the average vehicular speed fell from 20-27 km/hr in 1997 to only 15 km/hr in 2002 (Times of India, 2002). Moreover, the periods of

peak congestion in Delhi now last five hours, from 8:30 to 10:30 in the morning and from 4:30 to 7:30 in the evening. In Chennai, the average speed is 13 km/hr, and in Kolkata, it ranges from 10-15 km/hr but falls to only 7 km/hr in the center (Times of India, 2003). Roadway speeds have also fallen in Chinese cities. Average motor vehicle speed in central Beijing fell from 45 km/hr in 1994 to only 12 km/hr in 2003. Buses have been especially slowed down by congestion, with average operating speed falling from 17 km/hr in 1994 to only 9 km/hr in 2003 (Yang et al., 2004). During peak hours over 70% of roads in central Beijing are considered oversaturated with traffic. In Shanghai, the average motor vehicle travel speed on roads in the central area ranges from 9 to 18 km/hr. During peak hours, more than half of the roads and intersections in Shanghai's central area are considered oversaturated, and 20% of Beijing's inner roads are completely gridlocked, with traffic speed of less than 5 km/hr (Yang et al., 2004; Shanghai City Comprehensive Transportation Planning Institute, 2005).

Traffic congestion is frustrating and time consuming for travelers. With both Indian and Chinese cities spreading outward, average trip distances have been increasing. Combined with slower travel speeds, suburban sprawl has greatly increased average travel time. In India, the trip to and from work now requires up to three hours a day for suburban residents of the largest cities (Gakenheimer, 2002). Chinese cities have not experienced as much suburban sprawl as Indian cities, but average travel times have surely increased there as well. In 2003, for example, over 40% of work trips in Beijing took over an hour; only 6% of workers needed less than 20 minutes for the trip to work (Yang et.al., 2004). The stop-and-go traffic flow caused by congestion also wastes energy and increases pollution. Moreover, roadway congestion increases the likelihood of crashes, although the slower speeds reduce the percentage of crashes with fatalities. Congestion within vehicles unquestionably impairs safety, especially on trains and buses. In India, some passengers fall off overcrowded public transport vehicles during peak hours, since many are forced to ride on the roofs or hang onto the sides of trains and buses. Bicycles, motorcycles, and auto rickshaws can also become dangerous when occupied by too many riders, which happens often in Indian cities. The overcrowding of pedestrians, cyclists, and street vendors on the shoulders of roads creates additional safety problems, since they often spill over onto the roadway itself. (Pucher et al., 2005) That is especially problematic in India, where most roads have neither sidewalks nor bike lanes. Uncontrolled on-street parking further exacerbates congestion and safety problems by narrowing further the already restricted right of way for moving traffic.

Perhaps the most obvious cause of congestion is the rapid increase in travel demand, especially of motorized travel, compared to the much slower growth in transport infrastructure. For example, the average annual rate of growth in travel demand has been 5% in Mumbai, 10% in Delhi, and 7% in Chennai (World Bank, 2002). In virtually no Indian city has the growth in roadway supply reached even one percent a year, let alone the much higher rates of growth in travel demand noted above.

While Chinese cities have invested huge amounts of money in new roadway infrastructure, it still has not kept pace with the even faster growing travel demand, especially in the largest cities. A special problem in China is that almost all new roadway construction has focused on urban arterials and motorways while almost entirely ignoring the need to upgrade local roads. For example, Beijing and Shanghai now have quite extensive expressway networks of high quality, but their local roads remain narrow and chronically congested. Thus, traffic on the newly constructed arterials cannot be distributed effectively to local roads. One important factor in China is that the most affluent households with the most cars live in the congested city centers. Thus, car use is highest where there is the least space for it. Inner-city travel demand is also high due to the monocentric land-use patterns of Chinese cities, with high concentrations of employment in the core.

Both Chinese and Indian cities have far less overall roadway supply than American or European cities. For example, the average roadway density was 3.16 km/km^2 in Beijing and 4.42 km/km^2 in Shanghai in 2003, less than half the roadway density in L.A. (9.0 km/km^2) and London (10.70km/km^2) (Bureau of Statistics of Beijing, 2004; Bureau of Statistics of Shanghai, 2004; Ingram and Liu, 1997). Measuring roadway supply instead as a percentage of total land area devoted to roads, Indian cities report quite a range of values: for example, 21% in Delhi but only 11% in Mumbai and 5% in Kolkata (Pucher et al., 2004). Delhi appears to be quite an exception, however. As the national capital, it has the best road network of any Indian city, thanks to large central government subsidies.

Another important source of congestion is the diverse mix of transport modes forced to share the limited roadway space. Especially in India, slow non-motorized modes such as bicycles, hand-pulled and cycle-drawn rickshaws, pedestrians, and animal-drawn carts obviously slow down faster transport modes such as cars, trucks, buses, auto rickshaws, and motorcycles. Such a wide diversity of roadway users also causes safety problems, since the modes have very different sizes, maneuverability, capacities, speeds, and other operating characteristics, thus generating a range of conflicts. The

situation is not so extreme in China, since extensive rights of way are provided for cyclists and pedestrians on the main roads. Even in China, however, cyclists are so numerous that they compete with motor vehicles for roadway space, especially at intersections, where cyclists necessarily must cross the paths of motor vehicles. That causes both congestion and collisions. Moreover, most of the older, narrow local roads in Chinese cities lack separate rights of way for pedestrians and cyclists. As in Indian cities, that forces them to share the road with motor vehicles.

The overall roadway situation is considerably worse in India than in China. As already noted, Chinese cities generally provide far more extensive and better facilities for pedestrians and cyclists. Most roads in Indian cities are narrow, with only one lane in each direction. They usually lack sidewalks, thus forcing pedestrians to walk on the shoulder or the roadway itself. Many roads are in a dismal state of disrepair, often riddled with potholes, uneven, and unpaved. There is a general lack of modern traffic signals and signage, and even where they exist, travelers often ignore them, thanks to a lack of enforcement by police.

The situation in China is not nearly as chaotic. Traffic signals and signs as well as traffic management overall at least exist in most Chinese cities, and they are currently being upgraded in most cities. As in India, however, drivers often ignore traffic regulations. Chinese taxi drivers, in particular, are notorious for running red lights and stop signs and weaving in and out of traffic to save time. That causes both congestion and safety problems.

Impacts on the Urban Poor

The problem of urban poverty is older and more serious in India than in China. In 2000, for example, about a fourth of India's urban population fell under the official poverty line (Ministry of Finance, 2002), which is very low indeed, since it represents the absolute minimum income required to prevent a family from starving (World Bank, 2005). By comparison, only about 6% of China's urban population fell under the official Chinese government's poverty line in 2005, which averages about US $225 per capita per year ($900 in purchasing power parity) but varies from one region to another due to differences in the cost of living. (Ministry of Civil Affairs of China, 2005) The full extent of urban poverty in China is uncertain due to the unreliability of official statistics and their inconsistency over time. It is clear, however, that the number of urban poor has been rapidly increasing in Chinese cities, especially since 1990, due to rising unemployment and massive migration from rural areas. In 2005, there were about 45 million urban poor in China, including an estimated 23 million poor rural migrants. In India, the number of urban poor rose from 65 million in 1978 to 67 million in 2000, but the portion of the urban population under the central government's official poverty line fell sharply—from about half to a fourth. (Indian Ministry of Finance, 2004)

The actual extent of urban poverty in each country is highly questionable, since there are different poverty definitions and measurement methods even within a country, varying by region and over time. Some Indian economists, for example, find the official government's poverty line far too low (Deaton and Kozel, 2005). They suggest an urban poverty rate of 46%, almost twice the government's estimate. At any rate, it seems clear that the percentage of the urban population that is poor is much higher in India than in China—at least four times as high—although the number of urban poor is increasing faster in China.

The poor are doubly disadvantaged by the evolving land use patterns and transport systems in Chinese and Indian cities. Since they can least afford any form of motorized transport, it becomes more and more difficult for them to cover the growing trip distances within rapidly expanding cities. Although public transport fares vary from city to city even within each country, it is estimated that average round trip bus fares in Chinese and Indian cities would require 30%-40% of a poor resident's daily wage (Peng, 2004). Thus, bus fares are unaffordable for most urban poor, and rail transit fares are even more expensive. (Mohan, 2001; Whitelegg and Williams, 2000; Badami et al., 2004).

Many of the poor are forced to live on the urban periphery, where trips are especially long and time-consuming. Moreover, as several studies indicate, the poor in developing countries suffer greatly from the increased traffic dangers, noise, and air pollution caused by rising motor vehicle use (Vasconcellos, 2001). That is perhaps most evident in the area of traffic safety. With pedestrians and cyclists accounting for over 40% of all traffic fatalities in China and over 50% in India, the very travel modes that the poor most depend on are far more dangerous than riding in private cars or public transport. As more street space is devoted to accommodating motor vehicles, less remains for the non-motorized modes on which the poor depend. That reduces the speed, safety, and convenience of the non-motorized modes, and in effect, curtails further the already limited mobility of the urban poor.

POLICY ANALYSIS AND RECOMMENDATIONS

The preceding sections have documented the already severe and worsening transport problems in Chinese and Indian cities. To some extent, transport problems are intensifying due to rapid urban growth, rising motorization, growing inequality, and relatively low per-capita incomes overall. Yet government policies at all levels have clearly exacerbated these problems instead of dealing with them effectively. We examine in this concluding section a range of government policies and critically assess their deficiencies as well as propose improvements that would increase both the effectiveness and equity of urban transport.

Government Support for Increased Motor Vehicle Ownership and Use

In China and India, recent policies have generally focused on promoting increased motorization to stimulate economic development and to cater to the popularity of private transport among the more affluent classes. (Vasconcellos, 2001; Tiwari, 2001; Low and Banerjee-Guha, 2003; Badami et al., 2004) It is the official policy of both countries to promote their motor vehicle manufacturing industries as the most important way to ensure continued rapid economic growth. Central and provincial governments offer a range of tax breaks, subsidies, and regulatory concessions that enhance the industry's profitability. In addition, governments at all levels have concentrated on the expansion of roadway capacity to accommodate the increased volumes of private motorized travel, especially by car and truck. Finally, taxes and fees for car purchases, registration, parking, licensing, and petrol are generally quite low, thus facilitating the affordability of cars. All three policies clearly favor motorized travel over non-motorized travel, making more and cheaper cars available, providing more extensive rights of way to use them on, and making car use itself relatively cheap by minimizing taxes and fees.

In China as a whole, the urban roadway network more than doubled in length between 1990 and 2003, from 95,000 km to 208,000 km (National Bureau of Statistics of China, 2004). China's network of high-speed motorways only began in the early 1990s, but by 2004, they reached 34,300 km in length, the second most extensive system of motorways in the world after the USA. China's largest cities, Beijing and Shanghai, have been at the forefront of roadway expansion. The roadway network in Beijing's metropolitan area expanded in length by 24% between 1996 and 2003, from 11,682 km to 14,452 km. By comparison, the length of roads in the urban portion of the Beijing metropolitan area increased by only 3% (from 3,665 km to 3,786 km), suggesting that much new construction has been in suburban areas, beyond the three ring beltways (Beijing Transportation Commission, 2004). The 3% growth in length greatly understates the extent of roadway expansion, however, since the total area of the same inner roadway network grew by 65% over the same period (from 38.1 to 61.5 sq. km). Thus, much of the roadway expansion in central Beijing has come in the form of road widening. Perhaps most striking, there was almost a five-fold expansion in Beijing's expressway network, from 114 km in 1996 to 501 km in 2003. The roadway expansion in Beijing has already cost over $5 billion (US). For the coming years, Beijing is planning to spend another $4 billion (US) on 390 km of additional expressways and over a thousand km of additional arterial roads (Beijing Transportation Commission, 2004). Beijing's investment in new, expanded, and improved roads has been averaging four times the investment in public transport, suggesting an imbalance in priorities that is encouraging a further modal shift toward the private car.

The roadway expansion in Shanghai is also impressive. From 1991 to 2004, the total length of roads more than doubled (from 4,818 km to 11,825 km), and the total area of roads increased five-fold (from 3,760 sq. km to 20,558 sq. km) (Zhou, 1999**;** Shanghai City Comprehensive Transportation Planning Institute, 2005**).** Thus, similar to Beijing, many roads are being widened.

India lags far behind China in roadway expansion. Indeed, in the 50 years from India's independence from Great Britain in 1947 until 1997, the extent of the entire National Highway network increased by only 40%. Only 556 km of 4-6 lane roads were built, or about 11 km per year. (Ministry of Road Transport and Highway, 2006a) In the mid 1990s, however, the central government greatly increased its commitment to improve the overall roadway system. In 1995, the Indian Parliament passed the National Highway Act and created the National Highway Authority of India. That initiated an ambitious program of roadway expansion and modernization. From 1997 to 2005, the extent of Indian National Highways grew from 34,298 km to 65,569 km, a 90% increase in only 8 years. That increased roadway investment has been financed by the new Central Road Fund, which receives revenues from increased petrol and diesel taxes dedicated to roadway improvements.

Most of the roadway expansion in India since 1997 has been between major cities, such as the massive new Golden Quadrilateral (GQ) motorway system (5,846 km long) that is shaped like a diamond and

connects Kolkata, Delhi, Mumbai, and Chennai. The GQ was started in 2002 and will be finished by August 2006. Another major project is the planned North-South-East-West corridor (NSEW). Although its planned extent is 7,300 km, only 812 km had been upgraded to four lanes by mid 2006. There are also special new efforts to improve highway connections between major ports and large cities or to the GQ or NSEW highway networks under construction. Finally, the Indian Government recently initiated an ambitious project to pave and widen much of its already existing but mostly substandard National Highway Network. (Ministry of Road Transport and Highways, 2006b)

Even with these massive new roadway expansion efforts, India's roadway network lags far behind that in China in terms of quality and carrying capacity. Most Indian roads are narrow and about half are unpaved. The National Highways constitute only about 2% of the total road length and State Highways constitute another 4%. Only those National and State Highways are 2 lanes or wider. The remaining 94% are narrow district roads and rural roads (Ministry of Road Transport and Highways, 2006b). Moreover, India's current motorway system is only a seventh as extensive as China's. In urban areas, even major arterials are often only two lanes wide, and most local roads in residential areas have only one lane.

Since India's new and improved roadways are mostly between cities, their main impact is on intercity and interstate travel. Nevertheless, the highways often pass directly through the centers of cities, so they also have an important impact on urban travel. Separate statistics on urban roadways are less comprehensive and less up to date than those for national roads, but they suggest far less dramatic expansion than for intercity and interstate roads. For example, the total length of urban roads increased by only about 6% from 1998 to 2002. Moreover, high-speed limited access expressways are mostly lacking in India, in sharp contrast to China.

As in China, however, the overall length of roadways is not a sufficient index of roadway expansion. Especially in urban areas, much investment in India has been devoted to selected improvements in roadway quality and intersections. For example, hundreds of flyovers (overpasses) have been built in Indian cities to avoid the congestion and crashes caused by conflicting streams of traffic.

Altogether, the Indian Government has budgeted about $10 billion for recent and planned future highway improvements. (Ministry of Road Transport and Highway, 2006b) India's investment in expanded and improved roadways has come much later than in China, but it is a huge financial commitment relative to India's GDP. Since it represents the overwhelming majority of urban transport investments, the massive new investment in roadways clearly signals a government policy focus on accommodating vastly increased motor vehicle ownership while largely neglecting even greater public transport needs.

Clearly, the affluent are the main beneficiaries of roadway expansion and subsidized car production and use. Moreover, the poor have often been displaced by urban roadway expansion and forced to live on the suburban periphery, where they are even less accessible to jobs, schools, doctors, shopping, and other services. Thus, there appears to be a serious inequity in the current focus on roadway expansion and increased motorization. But there is also another distortion. Clearly, the supply-based focus on roadway expansion encourages more car ownership and use, which in turn causes more congestion, noise, air pollution, energy use, and traffic crashes. As documented in decades of research, roadway expansion also encourages suburban sprawl, increased trip distances, and increased dependence on the private car as the only feasible means to getting around. In the long term, roadway expansion generates more and more traffic, so that any congestion relief is temporary (Downs, 1962). Obviously, some amount of roadway expansion is warranted, especially in developing countries, where rising incomes naturally generate more car ownership and use. Unfortunately, the many new and expanded roads built in China's crowded cities have disrupted many inner city neighborhoods and exacerbated both social and environmental problems.

Excessive Focus on Expensive Rail Systems and Neglect of Bus Services

Chinese cities have made impressive new investments in urban public transport, spending massive sums of money to build, expand, and improve their metro and light rail systems. Since 2002, investment in rail transit has been averaging about US $1 billion a year in Beijing and US $1.7 billion a year in Shanghai (As noted earlier in this paper, six Chinese cities already have metro systems—most of which are expanding—and ten cities are planning new metro systems. Seven cities already have light rail systems, and nine more cities are planning them. In addition, there is the high speed Maglev line (up to 430 km/hr) that connects Shanghai's Airport with its city center.).

There can be little doubt that high-capacity rail transit is essential for moving large numbers of passengers through the high-density corridors that increasingly characterize China's rapidly growing

cities. In some cases, however, high profile rail projects have been chosen over buses because rail symbolizes modern, advanced technology and offers politicians tangible, highly visible achievements to impress their constituencies and the rest of the world. The Maglev airport connection in Shanghai is the most blatant example of this. At a construction cost of US $1.2 billion, this 33 km line has been a big money loser since it opened for regular service in 2004. It only runs about a fifth full and requires large operating subsidies in spite of a high fare (about US $6 one-way) (Dong Fang Daily, 2004). Clearly, the Maglev line was built primarily as a prestige project for Shanghai, since it is the world's first commercial magnetic levitation train. It has no usefulness for daily travel in Shanghai, and its central terminus is not even integrated with the city's metro lines. In February 2006, the Central Government approved a 170km extension of the Maglev line to Hangzhou, at a projected cost of US $4 billion (Xinhua Press, 2006). That would probably enhance the practical usefulness of the line, but it very high cost is still a problem.

In addition to the high public cost of building new rail systems, the fares on rail systems are generally too high for any poor person to afford. For example, the average monthly cost of one daily round trip on the metro and light rail systems in Beijing and Shanghai roughly equals the total family income that qualifies for the poverty level and thus government assistance. Metro and light rail fares are about three times higher than bus fares. Thus, whatever the other benefits of rail transit, it seems unlikely to be of direct benefit to the poor, who simply cannot afford it, unless the government can provide subsidized, low-cost tickets especially for the poor.

Although bus services have been greatly expanded in many Chinese cities over the past two decades, some cities are now planning to sharply reduce bus services and substitute new rail lines for them. Shanghai, for example, is planning to reduce its bus services in central city in the coming years, since the focus is on expanding the metro system (Bureau of Transportation of Shanghai, 2005). The remaining bus services are declining in quality and attractiveness because buses get caught in the worsening traffic congestion on Chinese city streets. With average bus speeds in Beijing only 9-10 km/hr, bus passengers are now shifting to either rail transit or to private motorized transport such as the motorbike or car.

Clearly, one of the most pressing needs in Chinese cities is to speed up bus services by implementing exclusive bus lanes, signal priority at intersections, unified fare structures and ticking systems between routes, and level boarding platforms at key stops in the bus network. In 1999 Kunming became the first Chinese city to construct a roadway with special bus lanes, and they are currently being upgraded further to provide an express bus service comparable to bus rapid transit. Many other Chinese cities are currently in the process of constructing or planning bus rapid transit systems. Beijing and Jinan are already building BRT, and at least 12 other Chinese cities are planning BRT. Beijing will construct 6 routes of BRT with total length of 100km in the next few years. By 2020, the total length of BRT in Beijing is expected to reach 300km, which would make it the world's largest BRT system (Chang, 2005). Because BRT is generally thought to be cost-effective and much faster to build than rail transit, Beijing chose BRT to provide essential supplemental transport capacity needed for the 2008 Summer Olympics. (Lean and Bertini, 2003)

While China's new BRT systems will provide a necessary complement to rail transit, there remains a crucial need to improve regular bus services in Chinese cities. The vast majority of China's public transport passengers travel by buses that are providing slower, less reliable, and less convenient service due to rising traffic congestion on the roads. More funding and effort must be devoted to improving these regular bus services, both by modernizing vehicles and by providing more separation from other roadway traffic, for example by exclusive bus lanes, special turn lanes, and signal priority at intersections. There are pressing needs for improved transfer facilities, better planning and scheduling, as well as unified public transport fare structure and ticketing system. These improvements would facilitate transfers from one bus route to another, and also from buses to the rail system, especially in cities where bus routes are managed by different bus companies.

India has only recently begun investing in new public transport systems such as the metro system in Delhi, which is now 65 km long and expanding (Delhi Metro Rail Corporation, 2003). The Government of Delhi has tentative plans to construct over 100 km of BRT over the coming five years, but funding is not yet certain. Many other Indian cities have been evaluating alternative public transport improvements, but so far, little has actually been achieved. For example, at least five cities are considering BRT systems, but none have even begun construction. Kolkata's 9 km extension of its 16 km metro system seems rather feeble compared to the immense transport needs of this rapidly growing megacity (Metro Railway Kolkata, 2003). Bangalore has approved funding for a new metro system, but construction has not yet begun (Transportation Research and Injury Prevention Programme, 2004). The only other noteworthy rail investments in India are the selective improvements to existing suburban rail systems in Mumbai,

Chennai and Hyderabad. Hyderabad and a few other Indian cities have started implementing real-time information systems for monitoring bus locations, optimizing bus routing, coordinating traffic signals, and providing waiting passengers with arrival and departure information at key bus stops and rail stations. (CMC, 2005; Kumar et al., 2005) The progress has been slow, however, and is limited to only a few cities.

Complementing regular public transport services such as suburban rail, metro, light rail, and buses, a range of paratransit services provide essential transport in both Chinese and Indian cities. Taxis, for example, can be found in virtually all cities and provide an important travel option for those who can afford them. Privately owned and operated auto rickshaws, cycle rickshaws, tempos, minivans, and minibuses provide most of the public transport services in small and medium-sized Indian cities, since regular public transport services are either scarce, low quality, or too expensive. Even in large Indian cities, such paratransit services can be seen everywhere, often serving routes where regular buses do not run. Taxis are the most important type of paratransit in Chinese cities, and they have been rapidly increasing in number in recent years. Minibuses are also quite common in most cities, providing convenient transport options in suburban areas poorly served by regular public transport. Shanghai and Guangzhou do not have any such minibus services, but Beijing, Nanjing, Changsha, and Xi'An have minibus services in their suburban areas, and some large cities such as Shenzheng and Chongqin as well as many small and medium-size cities have extensive minibus services in all parts of the urban area (Peng, 2005).

While these paratransit services provide essential transport, they also cause some important problems. Especially in India, many paratransit vehicles are unsafe, both due to their dilapidated condition and the notoriously unsafe driving behavior of the operators, who often swerve in and out of traffic, competing with each other to pick up passengers waiting at the curbside. They are also a major source of noise, air pollution, and traffic congestion. Paratransit is not quite so problematic in Chinese cities, partly due to stricter regulations and greater traffic separation. Nevertheless, taxi drivers in China are also notorious for unsafe driving behavior, and the large number of taxis contributes to the severe traffic congestion on urban roads. Thus, while paratransit services can provide flexible, convenient, and affordable transport, they must be carefully regulated by local government to minimize their adverse social and environmental impacts. Perhaps most important, police must enforce laws against unsafe driving practices.

Neglect of non-motorized transport

Although walking and cycling account for about half of all trips in Chinese and Indian urban areas, they do not receive nearly the funding, infrastructure provision, legal rights, or traffic priority they deserve. That is especially true in India, where sidewalks are either non-existent or so cluttered with other uses that pedestrians are usually forced to walk in the roadway. Separate bike lanes and paths are not available for cyclists in any Indian city except the planned city of Chandigarh (Chhabra, 2002). Thus, pedestrians and cyclists in India are exposed to extraordinary traffic dangers, forced to share crowded rights of way with a wide range of both motorized and non-motorized transport. While that has always been the case in India, the sharp increase in motorized travel, especially car and truck use, has greatly raised the danger for pedestrians and cyclists, who now account for almost three-fourths of India's traffic fatalities. With each passing year, the need for separate pedestrian and cyclist facilities grows. Yet Indian governments at every level have instead given priority to roadway expansion and modernization, with virtually no concern at all for the consequences of rising motor vehicle travel for cyclists and pedestrians.

The situation is less serious in China, but it is getting worse. For decades, roads in many Chinese cities generally have provided some sort of separate facilities for walking and cycling. In sharp contrast to India, it is not uncommon to see sidewalks, crosswalks, bike paths, bike lanes, and special traffic signals for pedestrians and cyclists. While pedestrians and cyclists account for a higher percentage of total travel in China than in India, their percentage of total traffic fatalities is considerably lower in China (43% vs. 64%). Surely, the more extensive pedestrian and cycling facilities in China account for the greater safety there. Nevertheless, those facilities are not nearly sufficient in quantity to handle the large volumes of walking and cycling trips, and their quality in terms of engineering design lags far behind the superb facilities in northern European cities.

Since about 2000, many Chinese cities have begun restricting cycling on key arterials and central city streets. The large volume of relatively slow moving bikes in every Chinese city is viewed as a major source of roadway congestion, since bikes get in the way of faster moving motorized vehicles, especially at intersections. The cities of Shanghai and Nanjing have even established official goals of reducing the bike share of trips to about a fourth or fifth of all trips, half their current share. Many cities throughout China have begun to restrict or prohibit bicycles on busy roads during peak travel times, especially in the

central city. Moreover, several cities have cancelled previous plans for new bike paths and bicycle streets (Peng, 2005). Even those separate cycling facilities that are being built are mainly intended to get bikes off the roads and out of the way of motor vehicles. Clearly, the general direction of transport policy in China is to curb bicycling in order to free up more roadway space for cars, trucks, and buses, which are viewed as being more modern, faster, and increasingly necessary to cover the growing trip distances in China's expanding cities.

Instead of restricting bike use, Chinese cities should be focusing on the expansion and improvement of separate cycling facilities and improved intersection design and traffic signalization. That would increase cycling safety while reducing the conflicts between bikes and motor vehicles. It would cost a small fraction of the massive amounts being spent on expanded roadway and public transport systems. Indeed, the expansion and improvement of facilities for bicyclist and pedestrian facilities should be a top priority in both Chinese and Indian cities, since non-motorized travel there is so important. Unfortunately, the political and economic priorities in both countries strongly favor increased motor vehicle use and reduced non-motorized travel, which is viewed as backward, slow, inefficient, and inconsistent with a progressive, modern transport system. Perhaps equally important, walking and cycling are so efficient and resource-saving that they do not generate large profits for private companies or rapid economic growth, as measured by purely monetary indices such as gross domestic product. Thus, throughout the world, these most sustainable of all transport modes continue to be either neglected or outright discouraged, as is currently the case in both India and China.

Decentralization and suburban sprawl

Cities in both India and China have been rapidly decentralizing into their surrounding areas. To some extent, this is the natural result of rapid population growth and the need to develop suburban areas to accommodate new housing and commercial developments. Indian cities, however, have accelerated the trend toward suburbanization by restricting central city densities and permitting less stringent building standards in suburban areas. In most Indian cities, there is no systematic, regional land use planning. That is partly due to the fragmented local government structure within each metropolitan area. Suburban jurisdictions, in particular, compete with each other and the central city for new economic development by offering lax land use regulations. Neither provincial nor local governments coordinate new developments with the provision of roads and public transport. The consequence has been rapidly rising trip distances, increasing reliance on private cars to get around, worsening traffic congestion, and mobility problems for the poor who can not afford to live in the more accessible central city areas.

Chinese cities are also decentralizing, but to a lesser extent than Indian cities, and there is much greater government control over the location and nature of suburban developments. Land use planning is facilitated by the public ownership of all land, which the state leases to private individuals, firms, and developers for specific uses. New developments in outlying areas are far more likely to be planned in China than in India, as well as better coordinated with provision of roadways and public transport. Moreover, in sharp contrast to India, the Chinese central government establishes national land use policy guidelines. For example, the central government recently banned most new low-density housing development in the suburbs to slow down suburban sprawl in the coming years. The Land Administration Law, as amended in 1998 and 2004, specifically requires that 80% of cultivated land must be preserved as farmland and may not be used for new suburban development. That sort of centralized, autocratic land use policy is hardly conceivable in India's highly democratic, federative, and fragmented government structure.

Although the central government in China sets overall land use policies, local governments are responsible for actually making and carrying out land use plans. They are supposed to conform to central government laws and regulations, but they often diverge from the officially approved policies (Qian, 2002). Local governments have a strong incentive to permit substantial new suburban development, since they earn about a fifth of their revenues by leasing land to private developers. That helps explain the widespread establishment of high-tech zones and economic development zones on the outskirts of Chinese cities in the 1990s. The central government seems to be aware of the problem and is tightening its laws and regulation while increasing its surveillance of local government land use plans to ensure better compliance. That suggests at least some hope for less sprawled suburban development in China's future. In contrast, all indications are that India's cities will continue to decentralize in a haphazard, unplanned manner that further exacerbates its transport and environmental problems.

CONCLUSIONS

As suggested in the introduction to this article, China and India share many common developments in

their urban transport situations. They both suffer from most of the same problems such as congestion, air pollution, noise, traffic dangers, and deteriorating mobility for the poor. In both countries those problems have been exacerbated by rapid population growth, suburbanization, and sharp increases in motor vehicle ownership and use. Governments in both countries have strongly supported increased motorization to stimulate their economies, to modernize their transport systems, and to meet the growing demand for cars and motorcycles among the middle and upper classes. It seems highly unlikely that the strong trend toward increased motorization can be stopped, let alone reversed, although perhaps it can be slowed down.

The important policy question now is how to mitigate the negative social and environmental costs of increased motor vehicle use. As shown by the experience in the formerly socialist countries of Central and Eastern Europe, rapid increases in motor vehicle use must be accompanied by strong government policies to limit their negative impacts (Pucher and Buehler, 2005). Initially, in the early 1990s, the sudden jump in car ownership and use in the formerly socialist countries of Europe led to alarming increases in traffic fatalities, air pollution, noise, parking problems, and congestion. Over time, however, democratically elected governments were able to gradually develop policies to control the negative aspects of car use while still permitting much higher levels of car ownership than under Communism. The same sorts of policies to regulate motor vehicle use are possible and necessary in India and China. Moreover, Western European countries have a long history of permitting high levels of car ownership but sharply restricting and taxing car use, providing high quality public transport services, ensuring safe and convenient walking and cycling facilities, and integrating land use with transport.

On the basis of that European success, we propose a series of measures that should be considered for adoption in Chinese and Indian cities:

- Stricter testing of motorists to obtain driver's licenses.
- Stricter enforcement of traffic laws and regulations both for motorists and non-motorists to ensure safer driving, walking, and cycling.
- Stricter emissions and fuel-efficiency standards for all motor vehicles, including not only cars but also motorcycles, buses, and trucks, preferably by adopting Euro III standards.
- More and better designed facilities for pedestrians and cyclists to separate them from motor vehicles, thus increasing their safety while also reducing their interference with traffic flows, especially at intersections.
- Investment in expanded and improved public transport should be the top priority, while new roadway investment should be slowed down a bit and focus on roadway resurfacing and modernization, safety improvements, and the provision of key missing links in the road network.
- Grade-separated metro and light rail systems should be expanded where expected passenger volumes are very high. They should be fully integrated with bus rapid transit and regular bus systems, both in terms of their routing and scheduling as well as their fare structures and ticketing.
- Bus rapid transit systems should be implemented as a cost-effective and quick way to provide high-speed service in key corridors, and these should be given priority over new rail systems except where expected travel volumes are very high or roadway space cannot be made available.
- Separate bus lanes on all expressways, arterials, and primary roads throughout metropolitan areas and bus signal priority at key intersections.
- Improved coordination of land use and transport planning through transit-oriented development such as in Singapore, Hong Kong, Tokyo, and dozens of European cities.
- Increasing the cost of private car and motorcycle use through higher driver license and vehicle registration fees, higher petrol taxes, higher parking charges, and roadway tolls.
- Improved planning controls on new suburban developments through stricter land-use regulations perhaps combined with urban growth boundaries, greenbelts, development impact fees, transit-oriented new towns, and protected agriculture land and green spaces. New development should only be permitted when it is well coordinated with pedestrian, bicycling, and public transport

services.

- Shanghai already has limitations on the number of new car registrations per year, somewhat similar to Singapore, and that sort of policy would useful to slow down the very sharp and problematic rise in motor vehicle use and thus give governments and planner more time to mitigate the negative impacts of rising motor vehicle use.

Mitigating the many social and environmental impacts of rising motorization is obviously important for the future well-being of Chinese and Indian cities. It is also crucial to the future of the rest of the world as well. Unless the problems of motorization in China and India can be effectively dealt with, the world faces sharp increases in Greenhouse gases, accelerating climate change, and rapid depletion of a range of nonrenewable resources (He et al, 2005). It is in the interest of all the world's citizens to help solve the urban transport problems in China and India, and that might entail both financial and technical assistance as well as free transfers of western technology (Walsh, 2006).

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