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Urban Transport Trends and Policies in China and India: Impacts of Rapid Economic Growth

JOHN PUCHER***, ZHONG-REN PENG†, NEHA MITTAL*, YI ZHU† and NISHA KORATTYSWAROOPAM*

**Rutgers University, New Brunswick, NJ, USA; **University of Sydney, Sydney, Australia; †University of Wisconsin-Milwaukee, Milwaukee, WI, USA*

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ABSTRACT *This paper 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 a lack of mobility for the poor. The urban transport crisis in China and India results from continuing population growth, urbanization, suburban sprawl, rising incomes, and skyrocketing motor vehicle ownership and use. This paper critically assesses government policies in each country and suggests a range of specific improvements. It advocates 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 centres 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 for the future of the rest of the world. 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 non-renewable resources.*

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% of the world's total population (Central Intelligence Agency (CIA), 2005). While the countries' 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

Correspondence Address: John Pucher, Bloustein School of Planning and Public Policy, Rutgers University, 33 Livingston Avenue, New Brunswick, NJ 08901, USA. Email: pucher@rci.rutgers.edu

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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 tenfold 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 also for the world. 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 increasingly on transport developments in China and India. If these 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 paper provides a comparative overview of urban transport developments in China and India. It begins with an examination of basic trends in economic growth, urbanization, and land use. It then compares recent trends in motorization and travel behaviour, highlighting variations between the two countries as well as among cities within each country. As suggested above, virtually all Chinese and Indian cities are beset by serious transport problems. In this paper the focus is on four main categories of problems that have been worsening with increased motorization: traffic injuries and fatalities, environmental pollution, roadway congestion, and the mobility problems of the poor. After an analysis of the different nature and extent of these problems in each country, the respective government policies are critically examined. On the basis of the shortcomings identified in current policies, alternative or revised policies are proposed that would address more effectively 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 variation among developing countries in their economic, political, and transport systems. The following sections examine more closely the factors listed in Table 1 that deal with recent developments in urbanization, land use, travel behaviour, 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.

Urbanization and Economic Growth

Both China and India have experienced considerable population growth in recent years, but it has been much faster in India (Figure 1). Indeed, from 1989 to 2005,

Table 1. Similarities and differences between India and China

Category	Similarities	Differences
Per-capita income	Both countries remain relatively poor compared with Organization for Economic Co-operation and Development (OECD) countries, with per-capita incomes only about one-tenth as high as in North America and Western Europe.	Economic growth has been roughly twice as rapid in China as in India since the 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 and well planned, 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.	For many decades, China was dominated by bicycles, with extensive cycle paths, lanes, signals, and parking provided in most cities. Cycling has never been as important in Indian cities, and there has always been a lack of facilities for cycling.
Government transport investments	Weak transport infrastructure for many decades, but with increased government investment in recent years, especially in roadways.	China has been investing huge amounts in new urban development and transport infrastucture in recent years, both for roads and rail, while India has much more limited government funding available and has invested much less and more recently than China in its transport infrastructure.
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 tenfold 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 south-eastern 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 democracy.

India's population grew at almost twice the average annual rate of China's (1.7 versus 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

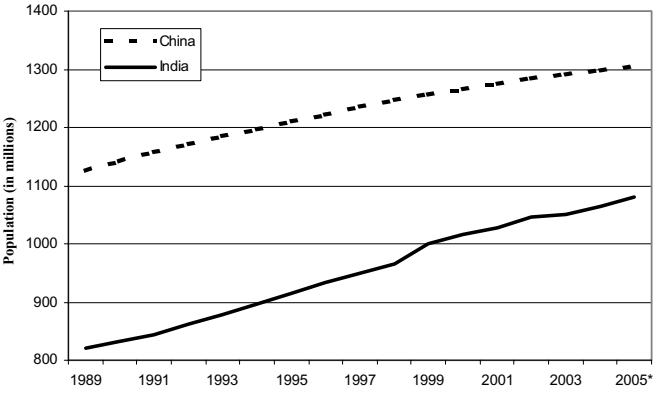

Figure 1. Population growth in India and China, 1989–2005. *Estimated. *Sources:* National Bureau of Statistics of China (2004), Office of the Registrar General of India (2004)

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) that are not counted by the censuses in either country.

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 10 million[1]: Beijing (12.4 million), Shanghai (15.4 million), and Chongqing (15.2 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, Tianjin, Xi'an, Chengdu, and Wuhan), and India has three such cities (Chennai, Hyderabad, and Bangalore). Overall, China has 174 cities with populations of over 1 million, and India has 35 cities that large (Office of the Registrar General of India, 2001b; National Bureau of Statistics of China, 2004).

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 the 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 eightfold in China between 1972 and 2002 compared with an increase of slightly more than twofold 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 Co-operation and Development, 2002). As documented below, 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

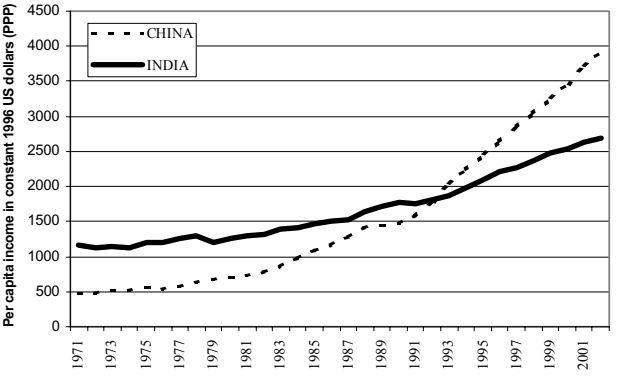

Figure 2. Per-capita incomes in India and China, 1972–2002, expressed in constant, inflation-adjusted 1996 US$, using purchasing power parity for currency conversion. *Source:* Organization for Economic Co-operation and Development (2002)

developed area of Chinese cities more than tripled from 1985 to 2003 (from 9386 to 28 308 km^2), while total urban population only doubled (National Bureau of Statistics of China, 2004). Although new Chinese suburbs are generally less dense than the older parts of cities, they are much denser, better planned, and better coordinated with public transport than the low-density, car-dependent sprawl characteristic of North American suburbs (Kenworthy and Hu, 2002). Many low- and middle-income households in China have been moving to peripheral suburban areas because of the lack of affordable housing in the central cities and the government's explicit programmes to redevelop inner-city areas. 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 centres. Land-use regulations strictly limit the ratio of floor areas to land areas in the city centre, thus restricting the heights of buildings and density of development in the centre (Padam and Singh, 2001; Bertraud, 2002). 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 have 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 behaviour 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 100 000–250 000 inhabitants to 28% in cities with over 5 million inhabitants. The bicycle 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

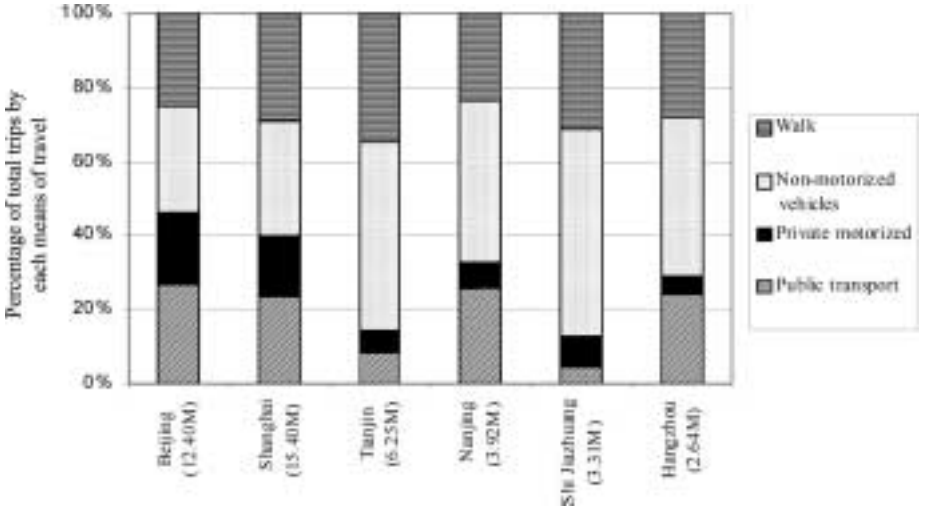

Figure 3. Percentage distribution of urban trips by means of travel for selected Chinese cities, 2000. Public transport includes buses, metro rail, taxis, and private motorized vehicles including autos, motorcycles, others, and employer-provided cars and buses. The modal split for Beijing was adjusted based on the official report of a 2000 household trip survey in Beijing. Population figures for all cities are from 2003. *Source:* Ministry of Construction of China (2003), Beijing City Planning Institute (2001), Shanghai City Comprehensive Transportation Planning Institute (SCCTPI) (2005), and Nanjing City Transportation Planning Institute (2003)

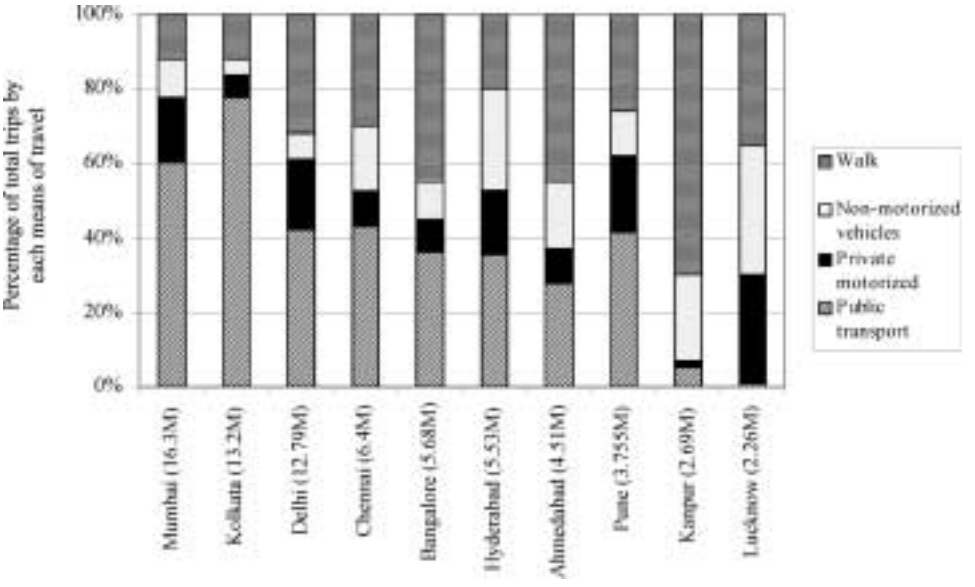

Figure 4. Percentage distribution of urban trips by means of travel for selected Indian Cities, 2002. *Sources:* Pendakur (2002) for Mumbai, Delhi, Bangalore, Ahmedabad and Kanpur; and World Bank (2002) for Kolkata, Chennai, Hyderabad, Pune and Lucknow

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 one-quarter 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 behaviour, 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—due to a much higher walking share. Yet, one would expect the share of walking trips to be higher in Kolkata, with its very low incomes, and in Mumbai, which has a much more compact land-use pattern than Delhi. The counterintuitive result suggests that walk trips might have been counted differently in the three cities, highlighting the dangers of comparing surveys for different cities and countries. 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 40–55% 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 bicycle) (Ministry of Construction of China, 2003). Since the methodology for defining and counting non-motorized trips, in particular, can vary between countries and cities, the modal split distributions in Figures 3 and 4 must be viewed with caution. Nevertheless, the available travel surveys generally indicate a significantly higher non-motorized trip share in China than in India.

Public transport's share of travel usually rises with increasing population size. Using aggregated city-size categories, the Indian Ministry of Urban Development

(2001) reported an increase in public transport share of trips from an average of only 16% in cities with 100 000–250 000 inhabitants to an average of 63% in cities with over 5 million inhabitants (Sreedharan, 2003; Singh, 2005). But there are considerable differences even within 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 probably 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). A study by the Indian Ministry of Urban Development (2001) reported that such paratransit vehicles served an average of 30% of all trips in cities with 100 000–250 000 inhabitants, more than four times the 7% share in cities with more than 5 million inhabitants (Singh, 2005).

China's two largest cities, Beijing and Shanghai, both have about one-quarter of their trips by public transport. Population growth, suburban expansion, and the construction of metro systems in these cities explain 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% (Ministry of Construction of China, 2003). Most surprising is the 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 centre of China's bicycle industry. The intermediate size cities of Nanjing and Hangzhou both have about the same public transport market share as Beijing and Shanghai. Shi-Jia-Zhuang's public transport share is only 3%, perhaps due to the lower incomes, compact city centre, and dominance of cycling there (56% of trips) (Ministry of Construction of China, 2003). Clearly, size alone does not explain the relative importance of public transport compared with 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.

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 (SCCTPI), 2005). In Beijing, the combined walking and cycling share fell from 66% in 1986 to 53% 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). Finally, in Shi-Jia-Zhuang, it fell from 92% in 1986 to 86% in 2000 (Ministry of Construction of China, 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. Moreover, cycling and walking facilities in Chinese cities have been worsening: many pavements and cycle lanes are being eliminated or narrowed to accommodate more car lanes. Some streets and districts are now off-limits to cyclists.

Public transport use has risen in almost all Chinese cities due 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.

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 fewer 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 (Ministry of Road Transport and Highways, 2003; National Bureau of Statistics of China, 2004).

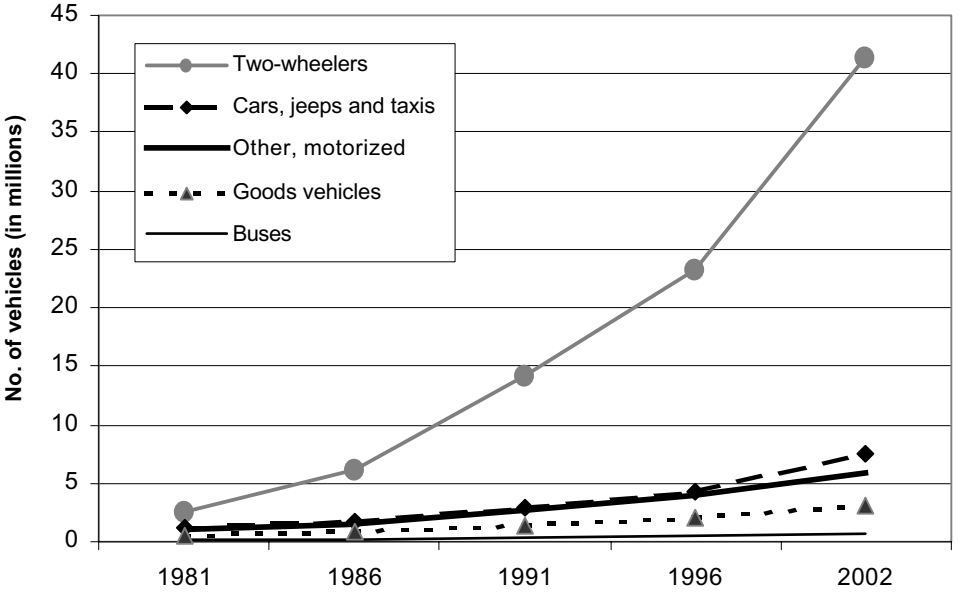

Figure 5. Growth of India's motor vehicle fleet by type of vehicle, 1981–2002 (in millions). 'Others' includes tractors, trailers, motorized three-wheelers such as auto rickshaws and other miscellaneous vehicles that are not separately classified. *Source:* Ministry of Road Transport and Highways (1999, 2000, 2003)

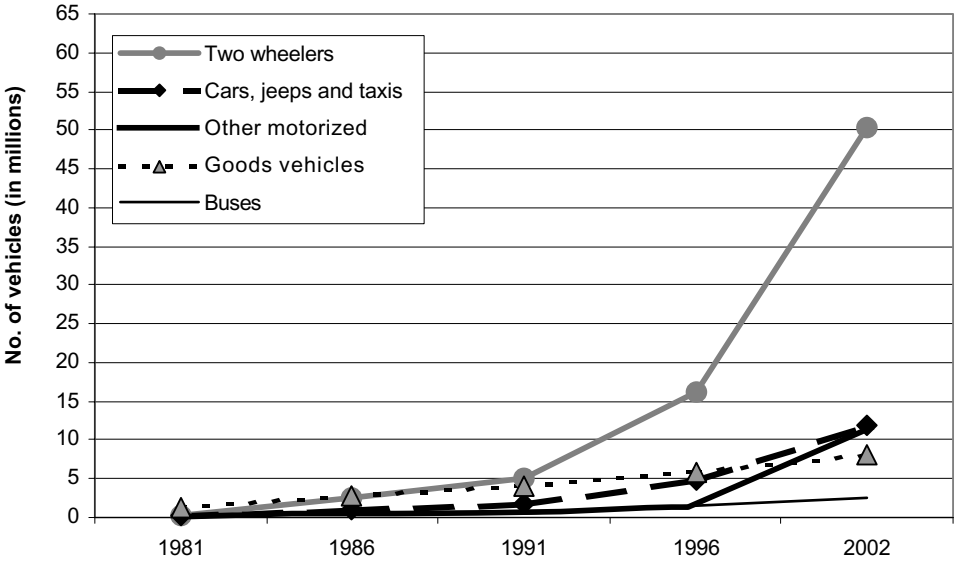

Figure 6. Growth (millions) of China's motor vehicle fleet by type of vehicle, 1981–2002. A motor vehicle consists of automobiles, freight vehicles (tractors) and other motor vehicles. Passenger vehicles include bus, car, jeep, etc. *Source:* National Bureau of Statistics of China (2004)

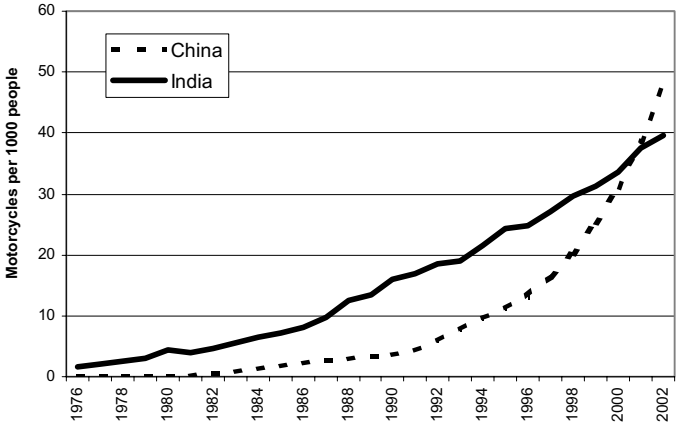

Figure 7. Rising motorcycle ownership in India and China, 1976–2002). *Sources:* National Bureau of Statistics of China (2003), Ministry of Road Transport and Highways (2003)

Figure 7 compares the growth in motorized two-wheelers in the two countries, and indicates that China overtook India around 2000, probably due to its much faster economic growth. Due to sharp restrictions on motorcycle use in northern Chinese cities, as well as lower incomes there, levels of motorcycle use in northern China are much lower than in southern China. For example, motorcycles account for fewer than 2% of all trips in Beijing, Tianjin, and Hangzhou, but for over 10% of trips in Fuzhou and Guangzhou (Ministry of Construction of China, 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 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. Due to those restrictions on motorcycles, recent years have seen a surge in sales of electric bicycles and scooters since many cities permit such electric vehicles provided they weigh less than 40 kg and have a design speed less than 20 km per hour. In 2005, about 10 million electric motorcycles and scooters were sold in China, and sales rose to 16 million in 2006 (Weinert *et al.*, 2006). If policies remain the same, the number of such electric bicycles and scooters will increase dramatically in the coming years, but some cities are already starting to restrict the use of electric bikes due to safety and congestion problems they cause on urban roads. For example, the City of Guangzhou enacted a complete ban on all electric bikes, scooters and motorcycles starting from 1 December 2006.

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 (Figure 8). From 1991 to 2003, the number of cars per 1000 population in China rose from fewer than two to almost ten—a fivefold increase in only 12 years. During the same period, the number of cars per 1000 population in India more than doubled, rising from about three to more than seven (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. 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.

These national aggregate statistics hide the variation in car ownership among regions and cities. For example, while China's national average in 2003 was only ten cars per 1000 population, the corresponding car ownership rates were 86 for Beijing, 27 for Shanghai, 20 for Tianjin, and 16 for Nanjing (Nanjing City

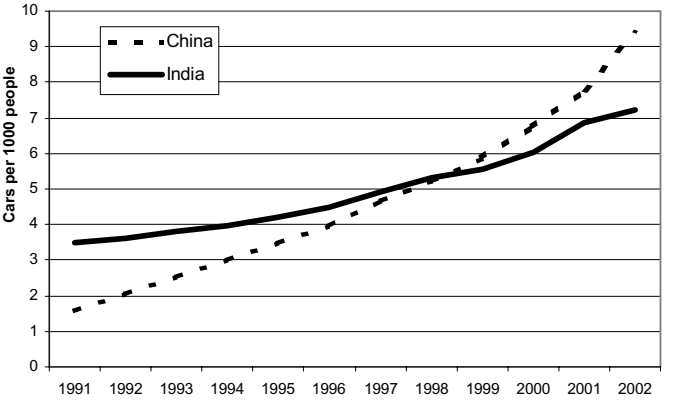

Figure 8. Rising car ownership in India and China, 1991–2002. *Sources:* National Bureau of Statistics of China (2003), Ministry of Road Transport and Highways (2004)

Transportation Planning Institute, 2003; Bureau of Statistics of Tianjin, 2004; National Bureau of Statistics of China, 2004). Car ownership rates are even lower in small towns and villages. The especially high rate of car ownership in Beijing is due to higher incomes there, and also the concentration of government offices and firm headquarters, some of which provide cars for their high-ranking employees. Moreover, Beijing has encouraged car ownership through massive roadway expansion and inexpensive licensing and registration fees. Similar to Beijing, and for most of the same reasons, Delhi has by far the highest rate of car ownership in India: 75 cars per 1000 inhabitants, ten times higher than the national average of seven (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.

As noted below, 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. The next two sections 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, the focus here is 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

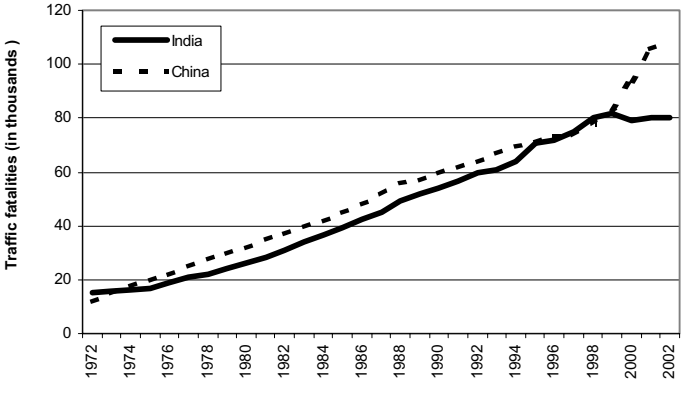

Figure 9. Traffic fatalities in India and China, 1972–2002. *Sources:* National Bureau of Statistics of China (2004), Ministry of Road Transport and Highways (2003)

fatalities in 2003, compared with 80 000 in India (Ministry of Road Transport and Highways, 2003; National Bureau of Statistics of China, 2004). The corresponding fatality rates per 100 000 motor vehicles were 128.3 in China and 108.1 in India, more than five times as high as the fatality rate in the USA (18.5) (US Department of Transportation, 2005).

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.

Similar to most other transport problems, the poor suffer more than other income classes from traffic dangers. Since they make most of their trips by walking or cycling, they are particularly vulnerable in any traffic crashes. Moreover, as Mohan (2002) documents, traffic deaths and injuries can have devastating financial and social consequences for poor families in India. Lacking any health insurance, they must either forgo professional medical treatment of injuries or sell what little they own to pay for treatment. Lost income from parents killed or seriously injured in traffic crashes can force children out of school and into the workplace, thus affecting future generations as well.

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 an inadequate road supply, unsafe vehicles and driving behaviour, 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 pavements.

Whatever the safety problem encountered by car occupants, it is far exceeded by the much more dangerous situation facing motorcyclists, cyclists, 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 lack of pavements, pedestrian crossings, and pedestrian traffic signals in Indian cities. Cyclist fatalities are higher in China than in India (18% versus 8% of traffic fatalities), but that is because cycling accounts for almost four times as high a percentage of total trips in China as in India. With four times as many bicycle

trips but only twice as many cyclist fatalities, cycling in China appears to be only about half as dangerous as in Indian cities, where there are virtually no separate facilities at all for cyclists. 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.

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 (Bose and Sperling, 2003; Sperling and Clausen, 2002; Sperling and Salon, 2002). Beijing and Delhi, for example, are among the most polluted cities in the world, far worse than Los Angeles. 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 sulphur oxides (SO_x) and nitric oxides (NO_x) are much higher in Chinese cities (Bose, 1998; Padam and Singh, 2001; Sibal and Sachdeva, 2001; Vasconcellos, 2001; Ministry of Petroleum and Natural Gas, 2002). Even the lower concentrations of suspended particulate matter in Chinese cities exceed the World Health Organization's (WHO) air quality standard, but the Indian levels are three to four times higher than the WHO standard, indicating a truly alarming public health hazard (Kandlikar and Ramachandran, 2000; World Health Organization, 2000).

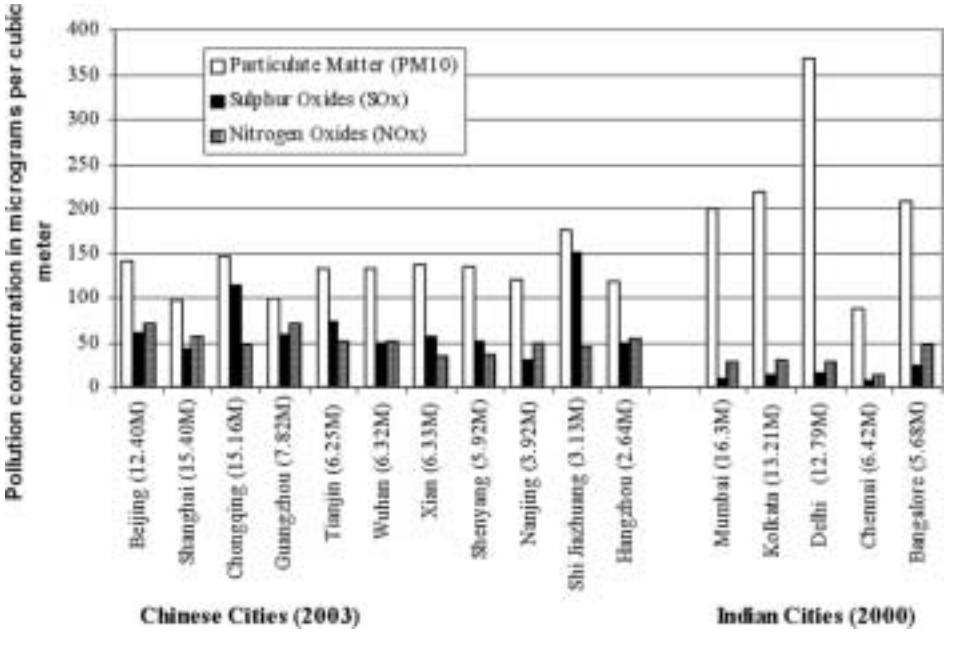

Figure 10. Air Pollution in Chinese and Indian Cities. *Source:* National Bureau of Statistics of China (2004), Ministry of Petroleum and Natural Gas (2002)

Concentrations of SO_x and NO_x in most Indian cities are well below the WHO standards, suggesting only moderate health dangers from those two kinds of pollution. In China, however, SO_x concentrations exceed the WHO standards in most cities. NO_x 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 SO_x 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 the country. 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.

Whatever the contributions of non-transport sources of pollution, the rapid motorization of both countries in recent years has unquestionably worsened overall air quality. For many years, fuel standards and exhaust emission standards were much lower than European and US levels. Only recently have China and India sharply raised their standards for fuel and motor vehicles to match those in the European Union (World Bank and Asian Development Bank, 2006). Unfortunately, there are still many older, more polluting motor vehicles on the road that must be converted or phased out. For example, strict emissions standards have been adopted for new buses, but the older diesel buses that still operate in some Indian and Chinese cities are much dirtier than in Europe, emitting high levels of suspended particulates. Moreover, on-the-road degradation of pollution control equipment is a problem in China and India, since vehicle inspection systems are either non-existent or less stringent than in Europe and North America. 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 two-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).

With rising motorization, traffic noise has worsened in both China and India, especially in large cities. In a survey of 31 large Chinese cities, the State Environmental Protection Agency found roadway noise levels ranging from 68 to 71 decibels (dB). Moreover, the largest cities report the highest values: 70 dB in Beijing and 71 dB in Shanghai (National Bureau of Statistics of China, 2004). Noise levels are much higher in Indian cities, with Mumbai and Delhi both registering more than 90 dB, making Mumbai the third noisiest city in the world, followed closely by Delhi (Bhat, 2003). Medium-sized Indian cities such as Nagpur, Varanasi, and Agra report noise levels ranging from 55 to 70 dB during peak hours. Virtually all large Chinese and Indian cities exceed the WHO's recommended level of 45 dB as the safe noise level for a city. Noises of 90 dB or louder, such as in Mumbai and Delhi, can cause long-term hearing loss and irreversible damage to the nervous system. While traffic noise is an especially serious problem in large Indian cities, it causes at least moderate health problems in virtually all Chinese and Indian cities.

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 socio-economic 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 to only 15–20 km/h (Gakenheimer, 2002). In Delhi, the average vehicular speed fell from 20–27 km/h in 1997 to only 15 km/h in 2002 (*Times of India*, 2002). Moreover, the periods of peak congestion in Delhi now last 5 hours, from 8.30 to 10.30 and from 16.30 to 19.30. In Chennai, the average speed is 13 km/h, and in Kolkata it ranges from 10–15 km/h but falls to only 7 km/h in the centre (*Times of India*, 2003). Roadway speeds have also fallen in Chinese cities. Average motor vehicle speed in central Beijing fell from 45 km/h in 1994 to only 12 km/h in 2003. Buses have been especially slowed by congestion, with average operating speed falling from 17 km/h in 1994 to only 9 km/h 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/h. 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 a traffic speed of less than 5 km/h (Yang *et al.*, 2004; Shanghai City Comprehensive Transportation Planning Institute (SCCTPI), 2005).

Traffic congestion is frustrating and time consuming for travellers. 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 3 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, and only 6% of workers needed fewer than 20 min 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 pavements nor cycle 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 with 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 1% 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 centres. 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 US 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 Los Angeles, CA (9.00 km/km^2), and London (10.70 km/km^2) (Bureau of Statistics of Beijing, 2004; Bureau of Statistics of Shanghai, 2004; Ingram and Liu, 1997). When measuring roadway supply instead as a percentage of total land area devoted to roads, Indian cities report quite a range of values, e.g. 21% in Delhi, but only 11% in Mumbai and 5% in Kolkata (Pucher *et al.*, 2004). Delhi appears to be 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 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, manoeuvrability, 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 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. Only major arterials in large cities are four lanes or wider. Most roads lack pavements, 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, travellers often ignore them, thanks to a lack of enforcement by police.

The situation in China is not nearly as chaotic. Most Chinese cities have comprehensive traffic signals and signs as well as some degree of traffic management, and many cities are modernizing these facilities. While traffic regulations are now strictly enforced in large Chinese cities, drivers in small cities often ignore traffic regulations, and taxi drivers, in particular, are notorious for running red lights and stop signs. In all Chinese cities, both large and small, taxi drivers weave in and out of traffic to save time and pick up and drop off passengers. 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 one-quarter of India's urban population fell under the official poverty line (Ministry of Finance, 2002; 2004), 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/year (US$900 in purchasing power parity), but it varies from one region to another due to differences in the cost of living (Ministry of Civil Affairs of China, 2005). The number of urban poor has been rapidly increasing in Chinese and Indian cities, especially since 1990, due to rising unemployment and massive migration from rural areas.

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 increasingly 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 government assistance (Peng, 2005). Thus, bus fares are unaffordable for most urban poor, and rail transit fares are even more expensive (Whitelegg and Williams, 2000; Mohan, 2001; 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 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, grow-

ing 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. This concluding section examines 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 (Tiwari, 2001; Vasconcellos, 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, and licensing are generally quite low, thus facilitating the affordability of cars. All three policies clearly favour motorized 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 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 to 14 452 km. By comparison, the length of roads in the urban portion of the Beijing metropolitan area increased by only 3% (from 3665 to 3786 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 km^2). Thus, much of the roadway expansion in central Beijing has come in the form of road widening. Perhaps most striking, there was almost a fivefold 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 US$5 billion. For the coming years, Beijing is planning to spend another US$4 billion on 390 km of additional expressways and over 1000 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 4818 to 11 825 km), and the total area of roads increased fivefold (from 3760 to 20 558 km^2) (Zhou, 1999; Shanghai

City Comprehensive Transportation Planning Institute (SCCTPI), 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 Britain in 1947 to 1997, the extent of the entire National Highway network increased by only 40%. Over that period, India built only 556 km of four- to six-lane roads, or about 11 km per year (Ministry of Road Transport and Highways, 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, which established the National Highway Authority of India as well as the new Central Road Fund. That fund receives revenues from increased petrol and diesel taxes dedicated to financing roadway improvements.

These developments initiated an ambitious programme of roadway expansion and modernization. From 1997 to 2005, the extent of Indian National Highways grew from 34 298 to 65 569 km. That 90% increase exaggerates the actual extent of roadway expansion, however, since it resulted partly from the improvement and reclassification of existing roads. Most of the roadway expansion in India since 1997 has been between major cities, such as the massive new Golden Quadrilateral (GQ) motorway system (5846 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 2008. Another major project is the planned North–South–East–West corridor (NSEW). Although its planned extent is 7300 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 two 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 one-seventh as extensive as China's. Most local roads in residential areas have only one lane for both directions, and even many arterials have no more than two lanes. Only major arterials in the largest cities have four or more lanes. And many of those four-lane arterials end up providing only two lanes for moving traffic, as curbside lanes are often blocked by parked vehicles, street vendors, and buses stopping to pick up passengers.

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 centres 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 US$10 billion for recent and planned future highway improvements (Ministry of Road Transport and Highways, 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 gross domestic product. 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 subsidised 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 increasingly more traffic, so that any congestion relief is temporary (Downs, 1992; Downs, 2004, pp. 82–86, 101–107). Obviously, some amount of roadway expansion is warranted, especially to deal with specific gaps or bottlenecks in the road network and to connect rural communities that are currently isolated and lack accessibility. Unfortunately, the many new and expanded roads built in China's crowded cities have disrupted many inner-city neighbourhoods and exacerbated both social and environmental problems.

Expansion of Public Transport

In response to rapidly increasing demand, most Chinese cities have invested heavily in their public transport systems, especially for new and expanded rail services. Six cities already have metro systems (Beijing, Shanghai, Guangzhou, Tianjin, 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, Tianjin, 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 sixfold 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 Tianjin, and doubled in Shanghai (National Bureau of Statistics of

China, 2004). Thus, the supply of both rail and bus services has greatly expanded over the past two decades to meet growing demands.

In recent years, however, Chinese cities have focused on rail services, spending massive sums 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. There can be little doubt that high-capacity rail transit is essential for moving large numbers of passengers through the very congested, 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 such prestige projects. 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 one-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 practical usefulness for daily travel in Shanghai. In February 2006, the Central Government approved a 170-km extension of the Maglev line to Hangzhou, at a projected cost of US$4 billion (Xinhua Press, 2006). That would probably increase use of the line, but its 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 is more than half of 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. 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 subsidised, low-cost tickets specifically 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 reduce bus services sharply and substitute new rail lines for them. Shanghai, for example, is planning to reduce its bus services in the 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 of only 9–10 km/h, bus passengers are now shifting to either rail transit or private motorized transport such as the electric bike, 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 with bus rapid transit (BRT). Beijing and Hangzhou recently opened their first BRT lines. At least 14 other Chinese cities are currently in the process of

constructing or planning BRT systems. Beijing's BRT system will be the most extensive in China. By 2010, there will be six lines with a total length of 100 km, increasing to 300 km by 2020, which would make it one of the world's largest BRT systems (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, e.g. 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.

Unfortunately, public transport services have lagged far behind in Indian cities, both in quality and in 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/m^2 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 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 manoeuvre 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 the 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 (Pucher *et al.*, 2005; Singh, 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 Zegras, 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.

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 Ltd, 2003). The Government of Delhi has tentative plans to construct over 100 km of BRT over the coming 5 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 has even begun construction. Kolkata's 9-km extension of its 16-km metro system seems rather feeble compared with 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, 2004; 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, of 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 many cities, especially small and medium-sized cities, providing convenient transport options in suburban areas poorly served by regular public transport.

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 behaviour 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 safety and environmental regulations as well as to government restrictions on paratransit services competing with regular bus services. Nevertheless, taxi drivers in China are also notorious for their unsafe driving behaviour, and the large number of taxis contributes to the severe traffic congestion on urban roads. Whatever their problems, paratransit services provide flexible, convenient, and affordable transport, as well as important employment for the numerous operators. Especially in small and medium-sized Indian cities, they provide crucially needed public transport services that are not provided by regular bus and rail services. Nevertheless, paratransit services 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 pavements are either non-existent or so cluttered with other uses that pedestrians are usually forced to walk in the roadway. Separate cycle 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, and 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-quarters 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, most Chinese cities provide pavements, crosswalks, cycle paths, cycle 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 (75% versus 55%), their percentage of total traffic fatalities is considerably lower in China (43% versus 64%). Surely, the more extensive pedestrian and cycling facilities in China account for the greater safety there. Nevertheless, those facilities are not nearly sufficient 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 bicycles in every Chinese city is viewed by government officials as a major source of roadway congestion, since bicycles 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 bicycle share of trips to about one-quarter or one-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 cycle paths and bicycle streets (Peng, 2005). Even those separate cycling facilities that are being built are mainly intended to get bicycles off the roads and out of the way of motor vehicles. The new transport policy guidelines issued by the central government in 2006 seem to suggest a new, more hopeful direction. They recommend that local governments encourage cycling by preserving and improving their cycling facilities. It remains to be seen whether city governments will actually implement those new pro-cycling recommendations of the central government. Over the past few years, many local governments have restricted cycling facilities in order to free more roadway space for cars, trucks, and buses.

Instead of restricting bicycle 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 bicycles 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 cyclist 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 favour 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 cannot 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 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 one-fifth of their revenues by leasing land to private developers. That helps explain the widespread establishment of high-technology zones and economic development zones on the outskirts of Chinese cities in the 1990s. 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, 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.

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 have been able gradually to 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, the present paper proposes a series of measures that should be considered for adoption in Chinese and Indian cities:

- Investment in expanded and improved public transport should be the top priority, while new roadway investment should be slowed down a bit and focus mainly 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 BRT and regular bus systems, both in terms of their routing and scheduling as well as their fare structures and ticketing.
  - BRT systems should be implemented as a cost-effective and quick way to provide high-speed service in key corridors. BRT and other forms of express bus services should have priority over new rail systems except where expected travel volumes are very high or roadway space cannot be made available.
  - Separate bus lanes should be provided on all expressways, arterials, and primary roads throughout metropolitan areas, with bus signal priority at key intersections.
- Restrictions should be made on car use and increased user charges assessed on motorists to reflect the social and environmental costs of car use.
  - Increase the cost of private car and motorcycle use through higher driver licence and vehicle registration fees, higher petrol taxes, higher parking charges, and roadway tolls, with some proportion of the revenue proceeds earmarked for improvements to public transport, pedestrian, and cycling facilities.
  - Shanghai already has limitations on the number of new car registrations per year, somewhat similar to Singapore. That sort of policy would be useful to slow the very sharp and problematic rise in motor vehicle use and thus give governments and planners more time to mitigate the negative impacts of rising motor vehicle use.
- More and better designed facilities for pedestrians and cyclists should be provided to separate them from motor vehicles, thus increasing their safety, while also reducing their interference with traffic flows, especially at intersections.
- Better traffic regulations, enforcement, and safety training.
  - Stricter enforcement of traffic laws and regulations both for motorists and non-motorists to ensure safer driving, walking, and cycling.
  - Driver training courses should be made more rigorous and compulsory, followed by strict testing before obtaining a driver's licence, including a probationary period at the beginning during which a licence can be suspended for unsafe driving.
  - Crackdown on rampant corruption among Chinese and Indian officials, who regularly accept bribes to grant licences and permits, and for not issuing traffic tickets, fines, etc.
- Improved land use and transport planning.
  - 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, cycling, and public transport services.
  - Improved coordination of land-use and transport planning through transit-oriented development such as in Singapore, Hong Kong, Tokyo, and dozens of European cities.
- Stricter environmental and energy efficiency standards.
  - Tax incentives to encourage the purchase of more fuel-efficient and less-polluting motor vehicles and quicker conversion of older vehicles to newer technologies.

- Strict enforcement of the new emissions and fuel-efficiency standards, including compulsory annual check-ups of all motor vehicles to ensure proper functioning of their pollution control equipment.
- Stricter regulations on motor vehicle noise, including restrictions on horn use, which contributes greatly to roadway noise.

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. 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 non-renewable 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).

Note

1. Population numbers of the Chinese cities cited in this article are lower than those reported in official Chinese statistics. The extensive rural populations within the official administrative boundaries of each city have been excluded, so that the population figures used here include only urban residents. The urban populations cited in this article include both officially registered urban residents and the estimated number of unofficial residents, those without a residence permit (Hukou), referred to in China as the 'floating population'.

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