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Foreword

The papers in this volume resulted from a call for papers for the 1994 TRB Annual Meeting issued by V. Setty Pendakur, chair of the Global Task Force on Nonmotorized Transportation (NMT). The resulting papers were peer-reviewed and are presented here in four topical groupings. The first four papers are about various aspects of transportation in the People's Republic of China. Navin et al. describe road safety in China and discuss the benefits of applying additional safety treatments. The current and future roles of bicycles and ways to achieve those roles are described by Kubota and Kidokoro using a medium-sized city in China as a case study. The pedestrian mode in Beijing is studied by Tanaboriboon and Jing; in particular, the types of facilities for interacting with vehicular traffic (e.g., crosswalks and over- and underpasses) are surveyed from the perspectives of pedestrian preference and safety. Yan and Zheng identify the problems of parking bicycles in a large central business district (Shanghai). They model the situation and develop plans for the year 2000 to address the problems noted.

The next group of papers centers on the cost and consequences of mobility. Philpott begins with a discussion of the role of women in African economies and women's use of transportation to fulfill those roles. Goodland describes global environmental impacts and land transportation and then suggests public policy solutions. Another cost and consequence of mobility is crashes; Navin et al. propose a fundamental relationship to explain road accidents in developed and developing countries and test the relationship with data from five countries.

The third series of papers discusses NMT in Asia and Africa. Kuranami et al. address major NMT issues and recommend policies for each. Shimazaki et al. develop a graphical model that analyzes the modal choice pattern in major Asian cities. A new approach to planning called integrated transport planning is presented by Zegras and Birk; the approach emphasizes accessibility for individuals, not vehicles, and the experiences of four very different Asian cities are used to demonstrate the need for it. In Hanoi, Vietnam, and Phnom Penh, Cambodia, NMT is being phased out; Bell and Kuranami argue for a more balanced and affordable approach to transportation planning in these cities. Grieco et al. studied attitudes toward cycling in Accra, Ghana, and discuss policy consequences of the findings with a view to promoting NMT. In the next paper, Hook outlines the public policies in Japan that enabled urban transportation to be dominated by NMT and rail and argues that these policies contributed to the economic success of Japan and can better guide developing countries than can past U.S. transportation development policy. On the basis of a 10-city study of NMT, Kuranami and Winston summarize the existing situation and trends and assess factors influencing the ownership and use of nonmotorized vehicles.

The final group of papers covers NMT issues and experiences in developing countries. Mitric describes the transportation situation in Cairo, Egypt, in the early 1980s; he traces what happened with investments that did not follow a suggested low-cost improvement approach and identifies four issues to be addressed in Cairo transportation planning. Bicycle promotion can be incorporated into transportation demand management programs, according to Litman, who discusses problems with bicycle promotion and offers encouragement strategies and guidelines. Beck and Immers give a better understanding of the constraints that hinder bicycle ownership and use in Amsterdam, proposing measures and incentives to promote bicycle use. Hope describes the shift during the past 4 years toward examining the nature of and design for nonrecreational cyclists in Ottawa, Canada.

PART 1

People's Republic of China

Road Safety in China

FRANCIS NAVIN, ART BERGAN, JINSONG QI, AND JIANG LI

China is in the early stages of motorization. The road safety issues that arise are interesting since they indicate that although a few are unique to early motorization, many are associated with more motorized countries such as Canada. The 1.2 billion Chinese are concentrated in roughly the eastern third of the country. Recent economic reforms have greatly expanded the motorized vehicle fleet to 16 million but have done little for the road system. Bicycles dominate personal transport and number over 300 million. There were 49,271 reported highway fatalities in China during 1990. The fatality rate per 10,000 motor vehicles is 48, roughly 19 times that of Canada. Cyclists and pedestrians account for about 60 percent of the fatalities. The majority of accidents may be attributed to a driver's violation of laws, carelessness, vehicle mechanical faults, and poor road facilities. An interesting question for road safety professionals is Can China avoid an enormous carnage on its highways by adopting Western road safety programs? Lives saved could number up to half a million a year.

The characteristics of China's traffic safety record are those associated with early motorization. They result from many unique factors, yet certain similarities to other motorized countries exist.

China is divided into 27 provinces and three city districts (*1*). The country's area is slightly larger than that of the United States, and the population of 1.2 billion is about four times that of the United States. Two-thirds of the country is mountainous or semidesert. The eastern regions are fertile plains and are densely populated. The densest areas have more than 500 people/km^2 and include the largest cities of Shanghai, Beijing, and Tianjin.

Since the end of the Cultural Revolution of 1966 to 1976, China has concentrated its efforts on economic development. The gross national product (gnp) per capita in 1988 of U.S. $320 does not yet reflect the effects of the new policies. Color television, refrigerators, private motorcycles, and private four-wheel "agricultural" tractors are now pouring into the market.

Chinese cities normally administer not only their urban districts but also the surrounding rural districts. The city is the commercial center. Suburban and rural areas have the role of providing agricultural products and major industrial sites. However, many rural industrial sites find themselves surrounded by rapidly expanding urban development.

Because of the fast pace of development, the demand for mobility by both people and goods has become greater. Roadway capacity cannot match the rapid growth in the number of vehicles. Road capacity growth is less than 5 percent, whereas motor vehicle growth is at 20 to 25 percent annually (*2*). Figure 1 presents the expansion of capacity compared with the number of vehicles in Beijing (*3*). In many cities, traffic volumes have exceeded the design capacities of existing road facilities, and congestion is common.

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The mixing of motor vehicles and nonmotor vehicles is characteristic of China, and another is the mixed traffic of ordinary motor vehicles and slow-moving vehicles, such as tractors. More commercial vehicles than passenger cars use the roads. The proportion of motor vehicles in China (*4*) was as follows (in thousands): cars, 845; commercial vehicles, such as trucks, 3,367, buses, 439, and other, 607; tractors, 6,367; and motorcycles, 4,141. The number of bicycles is given in Table 1. Buses and bicycles are the major modes of personal travel in urban China. Passenger cars are largely government owned or taxis. Trucks comprise the majority of the motor vehicles. Most trucks weigh between 4000 and 5000 kg and are manufactured in China. Trucks also are used frequently to transport people in the cargo area, although this practice is illegal. To relieve congestion, trucks often are prohibited from entering major downtown streets during the day.

The volume of goods transported and the number of passengers who traveled by agricultural tractors (with tires) are quite significant, although the relevant data in China do not always include those tractor-related trips. Tractors often are banned on major streets in central urban areas.

The majority of motor vehicles are owned by the government and driven by professional drivers. Driving is a job position in China. Recent policies allowed for the private ownership of motor vehicles, such as tractors and motorcycles. A total of 43 percent of the 6.89 million tractors and 42 percent of the 5.24 million motorcycles were privately owned in 1988 (*4*). A few trucks and buses are owned by private companies or individuals, but they tend to be in poor repair.

ACCIDENT SEVERITY IN CHINA

China has a very high rate of road accident deaths. During 1988, China had 54,814 roadway deaths, the highest among the four largest-population countries on the planet (*1,5,6*) (see Figure 2). The rate of deaths per 10,000 motor vehicles in 1985 was 48, which was about 19 times that of Canada or the United States, and is similar to that of India, another early motorized country (*5–7*).

The absolute numbers of reported accidents and casualties in all of China are given in Table 2 (*8*). Note that the number-of-deaths peak was 54,814 in 1988, the injury peak was 187,399 in 1987, and the accident peak was 298,147 in 1987. The same indexes in urban China have similar trends. In 1988, 136,926 (50 percent) of the total 276,071 accidents; 20,214 (37 percent) of the total 54,814 deaths; and 75,077 (44 percent) of the 170,598 injured in China happened in urban areas.

The accident rates in several large cities (nationwide urban rates are unavailable) revealed the severity of accidents in urban China. Table 3 lists some major indexes from 1982 of roadway safety in 10 major cities (*9*). In 1982, the average ratio of deaths per 10,000

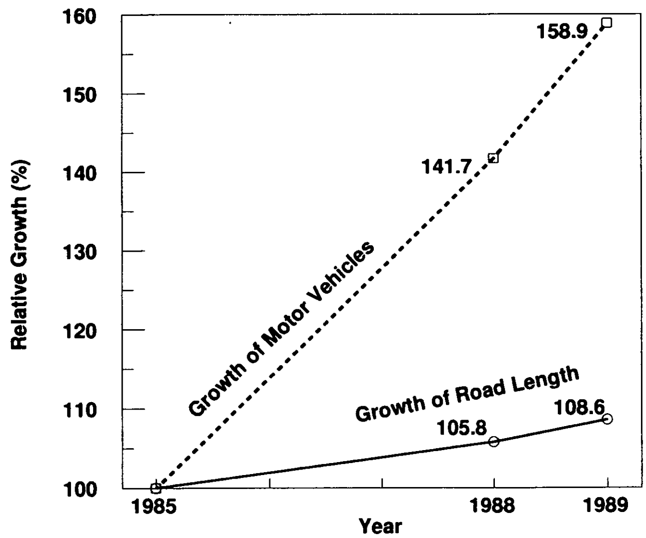

FIGURE 1 Comparison of growth rates between motor vehicles and road length in Beijing (*3*).

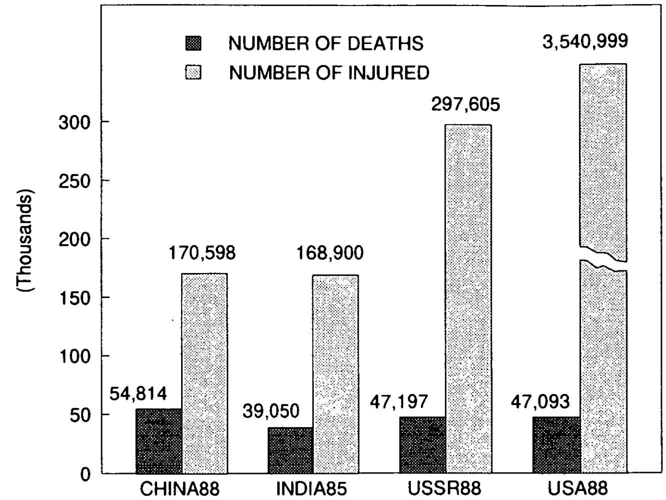

FIGURE 2 Casualties in largest-population countries (*1,5,6,7*).

registered motor vehicles was 46; the average ratio of deaths per 100,000 people was 8; and the motorization ratio of number of motor vehicles per 1,000 people was 17.

ACCIDENT CHARACTERISTICS

Bicycles are involved in a high proportion of accidents in urban China. Shanghai's statistics give the 5-year trend of bicycle-involved accidents (Table 4). According to the Shanghai Statistics Bureau Shanghai's cyclists were involved in 42.4 to 27.2 percent of the total accidents, 36.2 to 30.6 percent of the total deaths, and 44.5 to 38.9 percent of the total injuries. The Beijing Statistics Bureau shows that nonmotor vehicle users (mainly cyclists) and vehicle occupants were the two major classes of casualties (each had similar shares), whereas pedestrian victims had only a minor share, as shown in Table 5.

India, another developing country, has a level of motorization similar to that of China. The reported traffic safety rate of 15 deaths per 10,000 vehicles is much lower than the 46 in China. Studies in India reveal that 45 percent of the victims in a city are pedestrians (15.6 percent, Beijing), 19 percent are cyclists (38.7 percent, Beijing), and 16 percent are motorcyclists (*6*). These differences probably reflect the significantly different urban traffic situations in the cities of these two countries. One significant difference is that China had 224 million bicycles, 7.2 times that of India (31 million) in 1985, whereas China's population was 1,045 million, just 1.4 times that of India (749 million) (*4,6*).

Urban statistics showed that most accidents happened on road sections away from intersections. In 1985 in the cities of Beijing, Guangzhou, Changchun, and Tianjin (*1*) between 71 and 80 percent of traffic fatalities occurred on nonintersection parts of streets, and only 20 to 29 percent occurred at intersections. In Beijing most fatalities occurred on arterial streets and very few occurred on small alleys (*Hu Tong* in Chinese). Changchun's data revealed that the most frequent accident locations were at those road sections adjacent to the entrance or exit gates of large units. Units in China are best described as compounds and are locations where people go for their work, school, and recreation, and related activities. These compounds often have a main gate that handles the majority of access to and from the urban roads. The gates are usually away from the intersections. Among 14 frequent-accident locations in Changchun, 12 of them are at such gate locations and only 2 are at intersections. Drivers' carelessness often contributes to accidents at these gate locations. Unlike intersections, where drivers are aware of the presence of police and of the potential dangers of accidents, drivers are often oblivious of the potential dangers on roads between intersections and especially at the entrance-exit gates of large units.

The casualty accidents in Beijing from 1981 to 1985 as given in Table 5 indicate that among urban, suburban, and far-suburban areas, each had about one-third of the accidents. However, the fatal accident number indicates that they happened in far-suburban and suburban areas and only 12.3 percent happened in urban areas. The more mixed-traffic stream and higher-speed differences are

TABLE 1 Bicycles and Motor Vehicles in China (in thousands) (*4*)

Year	Number of Motor Vehicles*	Number of Bicycles
1985	9,242	223,640
1986	11,930	258,030
1987	15,766	293,130
1988	N.A.	333,120

* Motor vehicles also include tractors (tired) and motorcycles

TABLE 2 Accident Data in China (*8*)

Year	Number of Accidents	Number of Injuries	Number of Deaths
1985	202,394	136,829	40,906
1986	221,948 (105,880)	144,200 (63,443)	42,237 (12,579)
1987	298,147 (199,568)	187,399 (80,612)	53,439 (18,293)
1988	276,071 (136,926)	170,598 (75,077)	54,814 (20,214)
1989	258,030 (128,570)	159,021 (70,784)	50,441 (19,148)
1990	250,297	155,072	49,271

TABLE 3 Road Safety Indexes in 10 Chinese Cities, 1982 (*9*)

Cities	No. of Motor Vehicles per 1,000 People	Deaths per 1000 Vehicles	Deaths per 100,000 People	Deaths per 1,000 km of Road
Beijing	25.81	38.63	9.97	208
Shanghai	12.94	55.66	7.20	473
Tianjin	14.97	55.30	8.28	393
Shenyang	13.61	43.57	5.93	179
Wuhan	14.51	56.22	8.16	185
Guangzhou	19.89	30.06	5.98	360
Haerbin	14.45	44.43	6.42	194
Chuongqing	13.75	60.14	8.27	185
Najing	21.05	40.53	8.53	230
Xian	20.73	49.07	10.17	362
Average	16.99	46.39	7.88	257

TABLE 4 Bicycle Accidents in Shanghai

Year	Bicycle Accidents		Injuries of Cyclists		Deaths of Cyclists	
	Number	% of Total	Number	% of Total	Number	% of Total
1984	3,445	41.4	3,348	44.5	167	33.1
1985	2,459	34.5	2,267	39.6	211	30.6
1986	2,596	30.8	2,414	39.2	224	33.0
1987	2,658	26.3	2,620	38.9	254	31.3
1988	2,422	27.2	2,194	39.6	256	36.2

TABLE 5 Traffic Accidents in Beijing, 1981–1985

	Vehicles %			Area		
	Vehicle Drivers	Cyclists*	Pedestrian	Urban	Sub-urban	Far-urban
Accidents	-	-	-	32.7	37.9	29.4
Injuries	41.6	45.7	12.7	36.3	36.0	27.7
Deaths	45.7	38.7	15.6	12.3	34.0	53.7

* Includes small percentage of other non-motor user victims.

TABLE 6 Accident Deaths by Career in Beijing, 1985

Victim Class	Number of Deaths	Percentage of Total
Peasants	305	40.2%
Workers	178	23.5%
Non-classified Residents*	79	10.4%
Office Personnel**	78	10.3%
Students***	34	4.5%
Drivers	34	4.5%
Others	51	6.6%
Total	759	100.0%

* "Shi-Min": city residents who do not work.
** "Gan-Bu": "Cadres" - those doing office work.
*** Students: elementary and secondary school students.

the major causes of casualties in suburban areas, where inexperienced peasant cyclists and drivers of slow-moving, less-safe tractors are sharing the narrow highway with high-speed and high-volume traffic.

Three factors come together to cause the severe safety problem in China: poor road conditions on roads at city boundary sections; risky driving of low-speed tractors and high-speed vehicles; and peasants.

Roads at the city boundary very often have no agency that is clearly responsible for their management. The city is managed by urban development management bureaus and rural sections by provincial highway departments. There is lack of coordination between the two departments in designing and managing the connections, and road facilities in these places are usually poorly maintained. In addition, there are always high demands of mixed traffic volumes. For example, the east gate in Xian during 1980 (*10*) had an average volume of 8,657 bikes and 4,599 motor vehicles (including tractors and motorcycles) per hour in two directions, on a road 12 m wide. This volume was counted during a 14-hr observation period. At the west location, average volumes of 6,426 bikes and 3,369 motor vehicles per hour were counted on a 10- to 11-m wide road during 13.5 hr of observation. These volumes far exceeded the design capacity of the roads. Similar situations exist in many other Chinese cities. Bicycle-related accidents are dominant at these boundary points. At Xian's west connecting point, 65.5 percent of total accidents were bicycle related from 1976 to 1980 (*10*).

The mix of slow and fast motor vehicles in suburban areas creates many potential conflicts. Higher volumes of tractor traffic exist with other motor vehicles, as well as cyclists, animal-drawn carts, and pedestrians. Since tractors are slow vehicles, the frequent passes by high-speed vehicles on the narrow roads impose extra dangers on tractors, cyclists, and pedestrians, as well as the drivers themselves. In 1987, tractors in China caused 15,922 (registered) accidents, 4,215 deaths, and 10,804 injuries. The corresponding increases from 1986 were 5.3, 7.9, and 5.8 percent. The fatality rate, measured as rate of death per casualty, was very high at 28 percent (*1*).

Private vehicles also cause serious safety problems in China. Unlike government-owned companies, private companies are concerned about their productivity and tend to ignore safety. Having poor vehicles and a limited budget, they willingly risk lives to make quick and temporary benefits by cutting maintenance and other operating costs. Often overloaded, these vehicles always rush to their destinations at speeds much higher than are safe speed limits on narrow roads in poor condition. The potential for severe accidents is especially high in rural areas.

Accident deaths of peasants accounted for 40.2 percent of the total in Beijing during 1985 (see Table 6). The national census of 1990 shows that Beijing's rural population was 26.92 percent of the total (*1*), and deaths of peasants in 1985 overrepresented their population. Peasants reside in suburban or rural areas and are often unfamiliar with the urban streets that they visit. More importantly, they are unfamiliar with the traffic regulations. Even city residents may not know enough of those rules to be safe. Moreover, peasant cyclists are not very experienced in dealing with high volumes of mixed traffic, and it is difficult to handle bicycles if they carry big racks of agricultural goods—a common scene. In an emergency, peasants may hesitate to take actions to avoid accidents, be unable to stop immediately with control, or make sudden turns to avoid collisions with other bicycles, hence finding themselves facing a severe collision with a motor vehicle.

ACCIDENT CAUSES

Most traffic accidents in China are caused by motor vehicle drivers, and a significant number are also caused by cyclists, who are the second largest group of road users causing accidents. Shown in Figure 3 are those responsible for Beijing's accidents (*11*). The

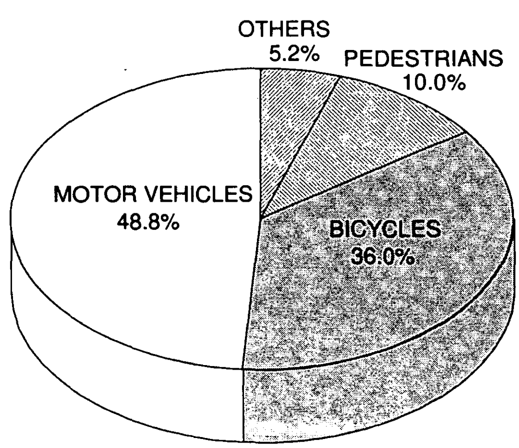

FIGURE 3 Casualty accidents caused by road users in Beijing (1986–1990) (*11*).

same is true for many other Chinese cities, although the accidents caused by cyclists may vary slightly. For instance, in Changchun between 1987 and 1988, drivers alone were responsible for about 70 percent of all accidents, whereas cyclists among the nondriver factors caused the majority of accidents (Figure 4).

The accidents in Changchun caused by road users other than motor vehicle drivers are shown in Figure 5, and similar results for Beijing are shown in Figure 6. In Xian between 1980 and 1981, cyclists were responsible for 26 to 29 percent of the total accidents, and in 1981 they were responsible for 16.3 percent of the total 147 deaths and 33.7 percent of the total injuries (*10*). Cities highlight four causes of accidents: drivers' violation of traffic laws and regulations; drivers' carelessness and misjudgment; vehicles' mechanical faults; and problems in the road facility and management.

Violations of traffic laws and regulations by drivers in China are the major causes of accidents. Drivers are supposed to have knowledge of traffic regulations and are required to abide by these regulations. Many drivers do not obey traffic regulations. The Changchun Statistics Bureau lists as typical driving offenses (Figure 5) ''driving against regulations,'' ''operating vehicles against regulations,'' ''exceeding speed limits,'' ''drinking and driving,'' ''driving without a driver's license,'' and ''overtaking illegally.''

The Chinese have the impression that many drivers (the majority of whom are men) like drinking. Alcoholic drinks can be bought easily in stores and restaurants. Furthermore, beer and wine are regarded as almost nonalcoholic or less-alcoholic drinks when compared with liquors of high alcohol content, which are more popular among men. The percentage of alcohol content is normally higher than that in North America.

Drivers also overestimate the capability of their vehicles and their driving skills in complex situations. Included in this category are careless driving, overtaking in the opposing traffic lanes, overtaking illegally, and trying to go first without yielding. Drivers are normally required to have 3 to 6 months of training in traffic safety. The complexity of the human-road-vehicle-environment system in China, such as mixed traffic and the road users' behavior, makes any carelessness and misjudgment extremely dangerous, as determined by the Beijing Traffic Engineering Institute (*12*).

''Driving against regulations'' accounts for about 42 percent of the driver-error accidents and includes going through red lights and disobeying stop signs. Beijing's statistics present more detailed causes, such as ''driving on the wrong side of roads'' and ''overtaking illegally,'' which cause three out of four major accidents. Traffic signals and signs are not respected when traffic police are off duty in the evenings as they are in most Chinese cities. Drivers tend not to wait at intersections for green signals. Stop signs are not obeyed because it is common knowledge that the chance of police coverage is minimal.

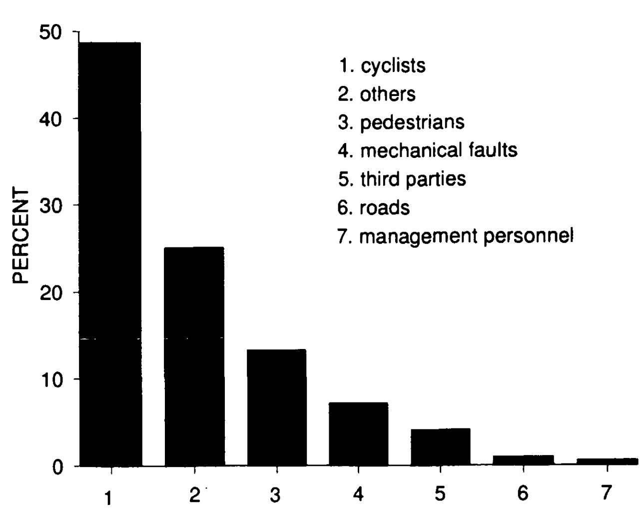

FIGURE 4 Accidents caused by nondriver (statistics of Changchun in 1987–1988).

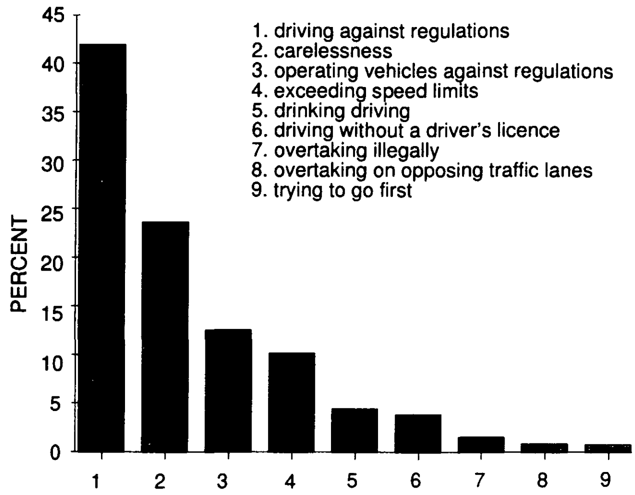

FIGURE 5 Accidents caused by drivers (statistics of Changchun in 1987–1988).

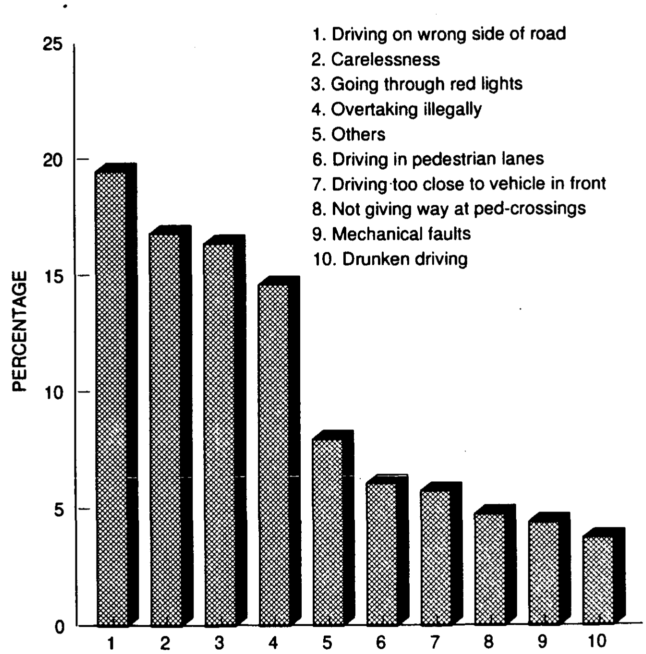

FIGURE 6 Major cause of casualty accidents in Beijing by motor vehicles (1986–1990) (*11*).

Drinking and driving is not yet a major problem compared with many other causes of accidents. However, there is a lack of awareness about the extent of alcohol's effects on drivers. No optimism can be assumed in China's ability to solve this problem, which has resisted solution elsewhere.

Beijing's statistics show that disobeying traffic regulations by cyclists is the major cause of accidents compared with the other cyclists' faults (see Figure 7). Included in this category are the causes "going through red lights," "turning without signaling," "cycling in pedestrian lanes," "cycling on the wrong side of the street," "cycling in motor vehicle lanes," and "carrying passengers on the back seat." It is illegal to carry passengers on the back seat of a bicycle in China but, as can be seen from many photos, this law is often ignored. Education and enforcement of traffic regulations have not yet fully reached cyclists or pedestrians. It is a positive sign that cyclists have been forced to obey city traffic signals in recent years. Enforcement of bicycle traffic rules is mainly executed by organized citizen inspectors who are not taken seriously by cyclists.

Another cause of accidents worth noting is mechanical faults. The recent economic reform allows a situation that connects productivity with an individual's salary. When this reform is applied to transport companies, people tend to place more emphasis on making money and ignore vehicle maintenance.

The poor road conditions added to the vehicle mix of tractors and bicycles increase the potential for accidents. There is roughly 1.03 million km of roadway in China, about 80 percent of which is low quality or substandard. These substandard roads have no traffic control systems, no zebra crossings, and no lanes to separate the motor vehicles, bicycles, and other road users (*12*).

Often traffic signs, signals, and road markings are not informative or complete enough to get drivers through a potentially dangerous location. "Driving on the opposing traffic lanes," "carelessness," "overtaking illegally or on the opposing traffic lanes," "not giving way at pedestrian crossings," and "trying to go first" in Beijing's and Changchun's statistics imply that either there is a lack of concern for safety or insufficient information has been provided by the traffic control system.

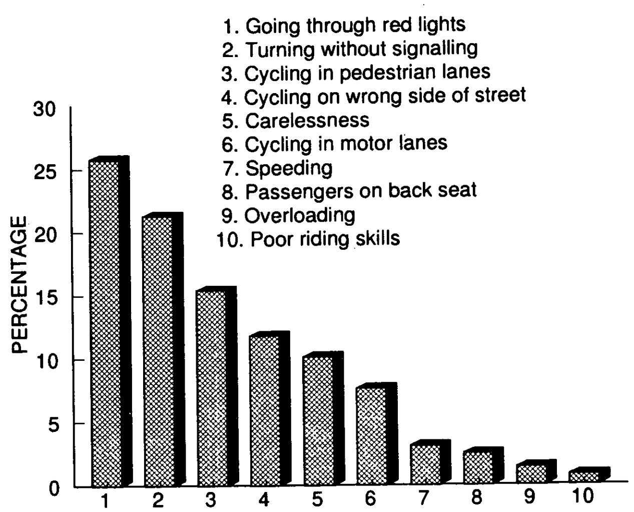

FIGURE 7 Major causes of casualty accidents in Beijing by bicycles (1986–1990) (*11*).

Among the road users, there are conflicting attitudes toward each other and a lack of courtesy such as yielding. Cyclist and pedestrian attitudes toward drivers usually assume that drivers dare not hit them. Cyclists may cycle and make sudden turns wherever and whenever they wish, whereas drivers seldom yield to the nonmotor vehicle users and take it for granted that others should get out of their way. Because of these conflicting attitudes, some road users ignore the others and do whatever they wish. Turning without signaling (sudden sharp turning without even careful observation) and cycling in wrong places for a cyclist's own convenience (cycling in pedestrian lanes, on the wrong side of the street, and in motor vehicle lanes, etc.) are a few typical examples.

Pedestrians also are very vulnerable to severe accidents in China, although the percentage of pedestrian victims is small compared with the large number of cyclist victims. Pedestrians have not been forced to follow traffic signals in most cities and they cross streets wherever they wish. China has so many people that drivers do not yield to pedestrians, as is the practice in some North American cities. Motor vehicle drivers have to zigzag skillfully through the crowds of cyclists and pedestrians using loud horns, but few stop or yield.

SAFETY COUNTERMEASURES

China has realized that the roadway system must be run by laws. A large proportion of accidents occur because traffic laws are disobeyed. To counter this problem, three things are being attempted. First, the traffic control systems are being completed and traffic regulations are being clarified. Second, road users are being educated on traffic systems and regulations. Third, the law violators are being challenged.

Traffic regulations must be known and understood by all. Education includes first letting ordinary people know the traffic regulations and second letting people know the dangers of violating them (*13*). The official news medium is involved so that major traffic accidents are reported by television news; street posters are used; TV programs and fictional movies involving traffic safety education have been made; and the newspaper *Chinese Traffic Safety* is available free to drivers in some areas (*14*). However, only vehicle drivers must know the meaning of traffic signs.

To challenge traffic law violators, a large number of urban citizens are being organized both by conscription and voluntarily by local governments to help police enforce traffic laws. For example, in 1989 in Beijing, 12.47 million traffic law violators were stopped at a rate of 30,000 a day (13.5 percent increase from 1988). Among them, 10.19 million were fined (20.6 percent increase from 1988). Statistics are inflated relative to moving violations because they include many bicycle-related incidents, such as illegal bicycle parking. Furthermore, 50 violators causing accidents were sentenced and an additional 150 were arrested by the police (*15*). Substantial improvement to the people's respect of traffic laws cannot be expected soon. In the West, the traffic systems work well by relying on the trust that the vast majority of road users will obey traffic control systems rules. For example, most people obey traffic signals at intersections without constant police surveillance. In China, many of the road users do not have such a concept of either trusting or willingly obeying a traffic control system. They are accustomed to enduring certain risks of potential traffic accidents. With luck and the fact that there are not many motor vehicles, they often avoid accidents. However, as traffic increases, their chances of avoiding accidents decrease.

Roadway vehicles including cars, trucks, and rubber-tired tractors are such modern machines that the majority of citizens has little knowledge of their safe use. The fact that this machinery is being run without knowledge of or compliance with safety procedures causes a large number of deaths. For this reason, both developing and developed countries should share not only the hardware technology but also the concept of using it safely.

The establishment of a comprehensive evaluation system of roadway traffic safety has been proposed, according to the Beijing Statistics Bureau. Research on traffic accidents is being conducted extensively in many Chinese academic institutions and traffic departments. Accident characteristics and countermeasures suitable to China, as well as the technology and experience from countries, also are being studied. For example, the suitability of a person for driving a motor vehicle is being researched. Because most drivers in China are professional, it is possible to use some appropriate scientific methods to evaluate drivers and to hire only those having good physical and psychological profiles.

The knowledge of safety management personnel is being updated. Many training programs are available in academic institutions and some other organizations. Courses are also being given to university and college students. Traffic police are being equipped with more vehicles, telecommunications networks, alcohol detectors, speed detectors, and video equipment. However, the levels of their mobility and communication are still at an early stage, and much must be learned to make them completely effective in China (*14*).

In urban areas, China is trying to separate bicycle traffic from the motor vehicle traffic. Wherever possible, either lane fences or lane markings are used to separate the two traffic streams.

The bicycle will remain the major personal transportation mode for a long time. China should make greater efforts to modify bicycle safety features. For the near future, mandatory installation of bicycle reflectors and lights could be a practical option in urban areas. For the long run, bicycle brakes, turning signals, reflectors, light systems, and other built-in safety features should be studied and redesigned if necessary. Bicycle design and manufacture should be part of a traffic management system. Even though many people in China can now afford color televisions, which cost about 10 times more than a bicycle, they continue to ride a poorly maintained bicycle. No one bothers to wear helmets when riding a bicycle. Only motorcyclists are required by Chinese law to wear helmets.

Although human errors caused most accidents, improved roadway facilities and traffic environments, together with appropriate traffic control measures, should be able to reduce the potential and consequence of accidents. Accident sites should be analyzed to determine the safety-related problems in design, construction, and maintenance. This is particularly true at frequent-accident locations.

In addition, measures should be taken before accidents occur. Many road users are experiencing similar traffic situations routinely and their voices requesting safer traffic are valuable. The questionable locations they identify should be studied by safety experts so that timely corrective measures can be taken. It is very difficult in China for individuals to communicate directly with management departments. Those individuals who care for the "public's business" have no incentives; therefore, it is important that road users can easily contact officials in traffic safety branches. For example, because of the limited budget, not all of the intersections and the entrance and exit gates of trip-generating units are equipped with traffic signs or signals. Lobbying by road users may help decision makers identify and solve some of these safety problems.

Information and statistics on traffic accidents should be more easily and more fully utilized. China has been collecting accident statistics at various levels of government for a number of years. A great amount of work on safety and accidents already has occurred by departments and organizations, but the information is not widely distributed.

Traffic accidents in China have to be solved relevant to the Chinese situation, which is challenging to the Chinese as well as to foreign experts who come to help. Traffic accidents are a worldwide phenomenon, and information exchange on accident statistics and countermeasures with international organizations is beneficial to all communities. Not only will China benefit from the experiences of other countries, but the others, especially countries with similar situations, may benefit from China's experiences as well. The actual success of any new road safety countermeasures will depend very much on how well they are adjusted to fit the needs of China.

CONCLUSIONS

China's road safety problem is enormous in part because the country contains about a quarter of the world's population but also because of its early stage of motorization. The need to develop an efficient road transport system is well known; less apparent is the need to develop a reasonably safe system. This paper has brought together the available road safety statistics from throughout the country and made a number of suggestions for countermeasures.

If China can implement effective road safety measures, it could save the lives of roughly half a million people a year.

ACKNOWLEDGMENTS

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Analysis of Bicycle-Dependent Transport Systems in China: Case Study in a Medium-Sized City

HISASHI KUBOTA AND TETSUO KIDOKORO

There is a growing awareness that bicycle transport should be an important element in urban transport systems in the "postmotorization" era. In view of this, the factors to promote the appropriate use of bicycles in China, where bicycles are used as a dominant transport mode, were examined. To this end, the characteristics of bicycle ownership and use were analyzed on the basis of a household questionnaire survey in Baoding, a typical medium-sized city in China. It was determined that people use bicycles because there is a lack of choices primarily because of an inadequate supply of public transport, a low level of motorization, and implicit government subsidization in the use of bicycles. However, it is expected that the current bicycle traffic environments should change drastically if the government's policy becomes more tolerant to motorization. Thus, it is concluded that the creation of traffic environments in which bicycles can play their diversified role is one of the highest-priority issues in China's urban transport policy.

Bicycle transport is increasingly attracting notice as an important urban transport mode in many developed countries with an expectation that it could be one of the important elements in transport systems of the "postmotorization" era (*1,2*). In particular, Chinese cities, where bicycles are by far the dominant mode of transportation in the urban transport system, are considered as models of the antimotorization society. Yet in China, the numbers of motorcycles as well as cars are growing at a considerable pace, and transport problems incurred by mixed transport modes with different speeds are increasingly observed, which suggests that a future vision as well as practical policies toward bicycle transport should be established soon (*3,4*).

Against such a background, this paper aims at clarifying key factors that enable bicycle-dependent urban transport systems in Chinese cities and examining the areas to be improved to promote the further use of bicycles. To this end, first, brief analysis is made to understand the key characteristics of urban transport systems in China compared with those in other Asian countries. Second, the characteristics of bicycle ownership and use are analyzed on the basis of a household questionnaire survey in Baoding, a typical medium-sized city in China in terms of population size (1989 population, 590,000) and transport systems. Although China is famous for its dominant use of bicycles as urban transport, few studies have been conducted on the use of bicycles on a person-trip basis. It is therefore important to examine users' perceptions toward bicycle use as well as their transport behavior. The reason that a medium-sized city was selected for the case study is because bicycle transport will continue to be an important transport mode in those cities in the short term, considering that bicycle transport is advantageous in short-distance trips.

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CHARACTERISTICS OF URBAN TRANSPORT SYSTEMS IN CHINA

Bicycle transport in Asia is concentrated in several countries such as China, India, and Japan. Among them, Japan and China have a higher rate of bicycle ownership (559 and 352 bicycles per 1,000 persons, respectively). In particular, China is known for its overwhelming number of bicycles compared with motor vehicles. In fact, trip characteristics in urban China are very different from those in other cities in Asia in terms of modal share, where 30 to 40 percent of trips are made on bicycles, even in large cities such as Shanghai and Tianjin, and more than 80 percent of trips in medium-sized and small cities such as Baoding. These figures are remarkably high even when they are compared with those in medium-sized and small cities in The Netherlands that are famous for their popular use of bicycles, where approximately 50 percent of trips are made on bicycles.

Except for walking, the main means of transport in China today is by bus (including trolley buses and microbuses) and bicycle; rail mass transit systems such as subways exist only in a few big cities such as Beijing and Tianjin; the total length of their routes is still short. The supply of bus service is inadequate even in large cities such as Shanghai (less than 1 bus per 1,000 persons). In medium-sized and small cities, the level of public transport supply is much lower, as in Baoding (0.2 bus per 1,000 persons); bicycles are by far the predominant means of transport in these cities.

In many cities in China, the rates of bicycle ownership are as high as those in The Netherlands: more than 700 bicycles per 1,000 persons. The numbers of motorcycles and cars are increasing by more than 10 percent annually, yet the rates of ownership are still very low in China. The numbers of motorcycles are rapidly increasing in many Asian cities. In China, too, it is estimated that a growing number of people can afford motorcycles in large cities, judging from their current levels of income, although purchases of motorcycles are strictly restricted to buyers in large cities such as Beijing and Shanghai. On the other hand, in some cities in the southern coastal region, such as Guangzhou, where the market economy has been increasing progressively, the rates of motorcycle ownership by individuals have already reached the level of more than 10 motorcycles per 1,000 persons and are rapidly increasing.

FACTORS THAT HAVE PROMOTED BICYCLE USE IN URBAN CHINA

Chinese urban transport is characterized by a dependency on bicycles. Bicycle use has been promoted predominantly in urban China because, first, motorization has been strictly restricted and, second, mass production of low-cost bicycles has been promoted. As a result, the average annual increase rate in the number of bicycles in China has accelerated rapidly: 7 percent in the 1960s, 9 percent in the 1970s, and more than 15 percent in the 1980s (*5,6*). In particular, the number of bicycles has increased since the late 1970s because most urban residents can now afford to buy a bicycle because of the rapid economic growth due to the drastic change in economic policy since then. On the other hand, ownership of cars or motorcycles by individuals has been strictly restricted in urban areas and thus the means to improve personal mobility has been limited to the use of bicycles.

Second, bicycle use is subsidized implicitly, which has further boosted bicycle ownership. In 1978 the bicycle use tax (2 yuan per year, where 1 yuan = U.S. $0.175 in 1993) was abandoned and the maintenance subsidy started to be given to bicycle commuters, the amount of which is equivalent to that of the subsidies given to bus commuters (presently 5 yuan per month). Thus, bicycle commuters are able to purchase new bicycles after a few years, if they save all the maintenance subsidy.

Third, the level of public transport supply is considerably low. The bus fleet sizes per population in Chinese cities are not very different from those of other Asian cities. Paratransit services operated by the informal sector exist widely and supplement the bus services operated by the formal sector in many other cities in Asia's developing countries. In China, however, such paratransit services have not been allowed to run, in principle, although recently they have been allowed to be operated in some cities. The inadequate provision of public transport causes a rise in the use of bicycles that becomes one of the causes of traffic congestion in urban centers together with the increase in number of motor vehicles. As a result, the travel speed of buses has been decreasing over time, which has further promoted the diversion of bus users to bicycle use. In fact, it was not until the late 1980s that bicycle users outnumbered bus users in large cities.

Finally, urban land use patterns in China are such that bicycles can play an advantageous role: high-density habitation is commonly observed in traditional urban centers, and factory apartments are located close to workplaces, particularly in small and medium-sized cities. These urban development patterns are believed to be associated with a rise in the predominant use of bicycles, which are best used for short-distance trips.

BICYCLE USE IN BAODING

Description of Baoding and Its Transport

Physical Setting

Baoding (area, 126 km^2) is located 140 km southwest of Beijing in the central area of the Hebei province. The urban areas of the city are divided into two areas by the railway that connects Beijing and Guangzhou. The old urban area is located east of the railway; new residential and industrial areas have been developed west of the railway since 1950s, where 70 percent of the job opportunities are located. Thus commuting traffic tends to concentrate on a few east-west corridors.

Road Traffic Conditions

The number of bicycles is ever increasing: from 340,000 in 1984 to 460,000 in 1990. The number of motor vehicles—in particular, trucks and motorcycles—is also increasing at a considerable rate, and as a result, the vehicle ownership rate that includes cars, trucks, and motorcycles reached 54.1 vehicles per thousand persons in 1990. In response to the rapid increase in bicycles, bicycle paths alongside the main roads have been constructed since the early 1980s. The total length of these paths is steadily increasing, with the aim of creating a bicycle path network alongside the main roads.

The 3- to 5-m setback is normally observed when new buildings are constructed along main roads; this space is often used as bicycle parking space on the sidewalk in front of shops. This seems to be a convenient facility for bicycle users, but the city government believes that it is not a desirable solution because it deteriorates the townscape. Government policy is to construct off-road bicycle parking facilities at the sites of large-scale traffic-generating facilities such as shopping centers.

The number of fatalities by traffic accidents is gradually increasing: it was 25 in 1990, which is equal to 1 death per 230,000 persons or 1 death per 562 automobiles (cars and trucks); this number is problematic at this level of motorization. Out of all traffic accidents, 30 to 40 percent are reported to be related to bicycles.

Residents' Perceptions of Bicycle Ownership and Use

The main results of an analysis of a home interview survey in Baoding are discussed.

Outline of Survey

Three residential areas that have different characteristics were selected for the home interview survey (Area A, factory apartment area in the suburbs; Area B, mixed residential and commercial area in the traditional city center; Area C, residential area in the traditional city center) and a total of 748 samples were collected within these areas. The questionnaire form used was composed of a household survey form and an individual survey form. The survey was conducted in December 1991. Most households were composed of nuclear families: the average number of household members was 2.9, and 49.3 percent of them were composed of three family members (father, mother, and child). Most household heads were factory workers in the city.

Bicycle Ownership.

On the average, 2.4 bicycles were owned by a household. A total of 27 motorcycles were owned (12.6 motorcycles per 1,000 persons), but only two automobiles were owned by the sample households. The purchase prices of bicycles were 150 to 300 yuan (the average price was 221.4 yuan), which was almost as much as the average monthly household income. A total of 94 percent of bicycles were brand new when they were purchased, and most (98.9 percent) were purchased with cash. Other points to be noted are the following: (a) most bicycles were new (48.6 percent were less than 3 years old); (b) two-thirds of bicycles were parked inside the buildings at home; (c) most bicycles (95.8 percent) were used exclusively by particular family members (not for common use by the family); and (d) headlamps were not installed on almost all bicycles (97.5 percent).

Bicycle Use

Among respondents, 93.7 percent of bicycle owners answered that they use a bicycle almost every day, and 82.3 percent of trips (including to work, school, and shopping) were made by bicycles. Few persons used buses for their trips. The average travel time was 20 to 30 min for commuting to workplaces, less than 10 min for going to school, and 10 to 20 min for shopping. In most cases off-road parking sites are available at the destinations of trips (workplaces, schools, and shops), and very few bicycles are parked on streets.

Among those who use bicycles almost every day, 70 percent use bicycles even if weather is not suitable. Of those, 30 percent answered that they may use other transport modes if weather is not suitable. From that group, most (52.2 percent) answered that they walk and only 16.7 percent answered that they ride the bus.

Perception Toward Bicycle Use

A total of 91.6 percent of respondents answered that bicycles are good for their health, whereas a considerable percentage of people (37 percent) believed that bicycles are tiring when used every day. Because most people use bicycles, few respondents related bicycle use to neither high social status (6.7 percent) nor low social status (14.7 percent), and very few respondents (8.8 percent) said that bicycles are expensive. One-fourth of bicycle users answered that bicycles are dangerous in terms of traffic accidents, whereas 68.2 percent of bicycle users expressed concern about theft.

When answering "In what cases do you feel uncomfortable during the bicycle ride?" (multiple answer up to two choices), many respondents marked "when there are many pedestrians in narrow roads" (27.6 percent) and "when roads are congested by bicycles" (22.3 percent), and a few respondents marked "when there are many automobiles in narrow roads" (13.6 percent) and "when you have to travel mixed with automobiles on the main roads without bicycle lanes" (6.4 percent). It follows that the traffic problems incurred by mixed traffic have not yet become visible because there are only a few automobiles on roads.

Routes and Distance of Travel by Bicycle

Maps of Baoding were attached to the questionnaire forms for interviewees to mark the locations of their destinations (home, workplace, school, and daily shopping site) and in the routes and transport modes.

The routes taken by all bicycle users (commuting to workplaces and shopping trips only) in three selected areas (A, B, and C) for the home interview survey are shown, with volumes, in Figures 1 and 2. The commuting (to workplaces) trips generated from Area A in the suburbs concentrated on a few roads; this is because Area A is a factory apartment area, and most residents commute to a nearby factory. Factories in principle are supposed to provide accommodations to their workers; thus this situation should be commonly seen in the suburbs of China's medium-sized cities. The trips to work generated in Areas B and C in the traditional city center as well as the trips to shopping generated from all areas are distributed on many roads. When compared with the distribution of bicycle lanes, it was found that many bicycle users indeed use those lanes, yet many other roads are also used for bicycle routes. In the present policy, bicycle lanes with separators are being installed only on the main roads that are wide enough, but the network of bicycle lanes should be created in accordance with the bicycle routes that are actually taken by many bicycle users.

Figure 3 shows the distribution of trip distance by mode in the case of the trips to work. Most people use bicycles for both very

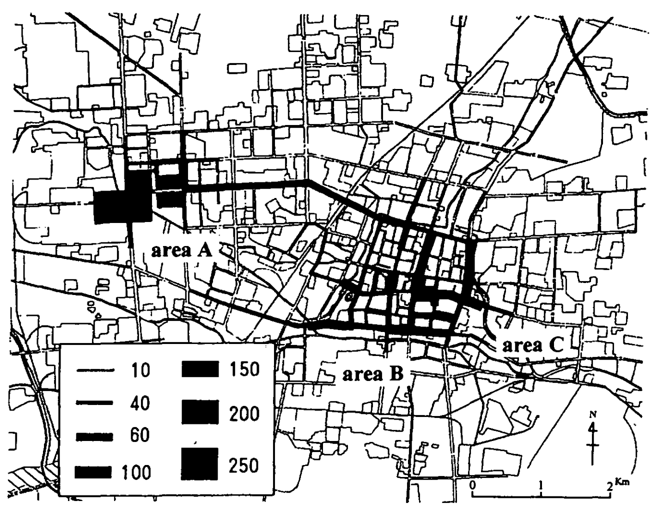

FIGURE 1 Bicycle routes used in commuting trips.

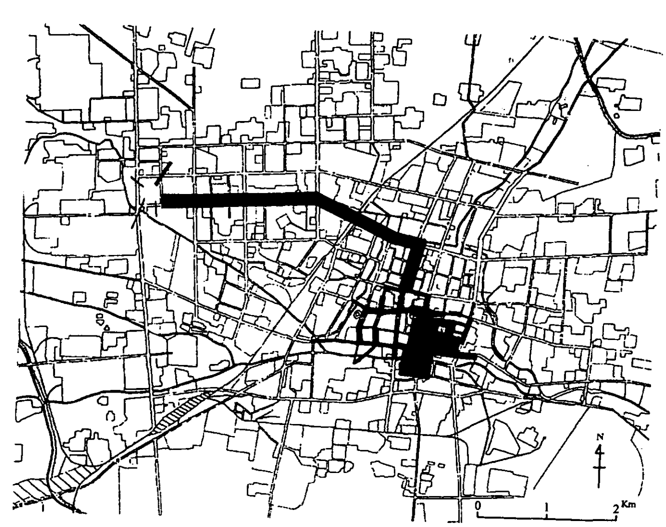

FIGURE 2 Bicycle routes used in shopping trips.

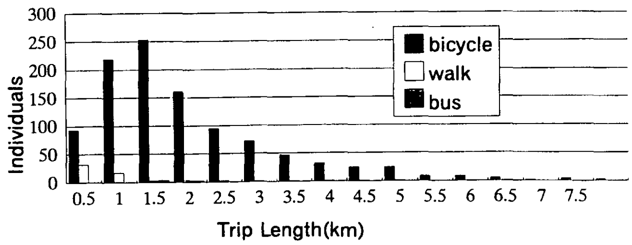

FIGURE 3 Trip length distribution by mode, commuting trips.

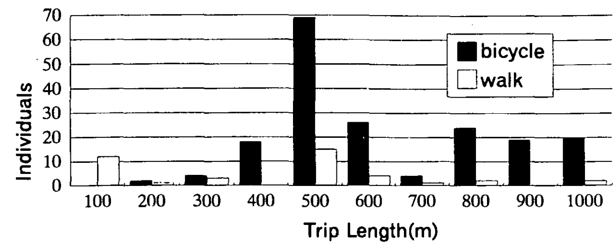

FIGURE 5 Short-distance trip length by mode, commuting trips.

short trips (less than 500 m) and for long-distance trips (5 to 6 km). On the other hand, few people use buses for the trips to work. Most trips to shopping are also made by bicycles, although many people walk on very short trips (less than 500 m), as shown in Figure 4. Figures 5 and 6 show the distribution of trip distance by mode in the case of shorter trips (less than 1 km) for the commuting trips and the shopping trips, respectively. These figures indicate that bicycle use becomes the main form of transportation when trip distance reaches approximately 300 m. Bicycles are used frequently even for very short trips.

Behavior of Vehicles at Intersections

To examine the behavior of different vehicles at intersections, a video recording survey was conducted at a typical major intersection in the central city area. The number of vehicles that entered the surveyed intersection during 10 min in the morning peak period was 1,301 bicycles, 11 buses, 19 cars or trucks, and 10 motorcycles. Although the number of bicycles was much larger than that of other vehicles, it was observed that different speeds of vehicles were mixed in confusion. This fact suggests that the safe and efficient movement of traffic will be threatened in the near future, given the current high rate of increase in the number of automobiles.

At the surveyed intersection, bicycle lanes are provided on both sides of the roads from 25 m before the intersection. Of 381 bicycles that entered the intersection from one direction, 378 bicycles used a bicycle lane. Although a quick observation gives the impression that bicycles do not travel in an orderly fashion around intersections because of their overwhelming numbers, this fact indicates that most bicycle users obey traffic regulations well. It follows that traffic movement around intersections can be well managed if traffic flows are properly channeled into intersections and the design of the intersection as well as the phasing of traffic lights are improved.

CONCLUSIONS

As examined for Baoding in the previous sections, urban transport in the small to medium-sized cities in China is heavily dependent on bicycles. People have no other choice than to use bicycles in the city because of the inadequate supply of public transport and the low level of motorization. Yet it appears that people have no strong complaints about this situation, probably because the size of the city is suitable for travel by bicycle. The city government also has been making efforts to install bicycle lanes; thus there is a good possibility that the city can continue to retain a comfortable bicycle traffic environment if the issues such as improvement of intersections are properly tackled.

There exists a tendency to promote the use of bicycles in the city, but it is unclear whether this tendency will continue. The central government seeks further rapid economic growth of the country, and the urban sector is expected to be an engine of economic development. Thus, to achieve further economic development, personal consumption in urban areas should be more heavily promoted. If the scenario of the future economic development materializes along these lines, it is difficult to restrict motorization, although at present it is strictly restricted at the personal level. A symptom of this is already clear in the cities in the southern coastal region, where rapid economic growth goes along with the acceleration of motorization.

Another factor believed to affect significantly the present balance of motor traffic and bicycle traffic is the changing transport policy of the central government. The central government has the view that bicycles are overused in large as well as medium-sized cities, and the promotion of the use of public transport is recognized as the highest-priority issue. Although there is implicit sub-

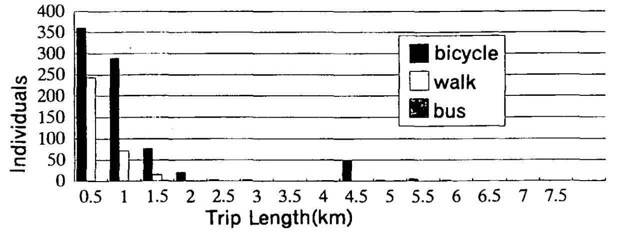

FIGURE 4 Trip length distribution by mode, shopping trips.

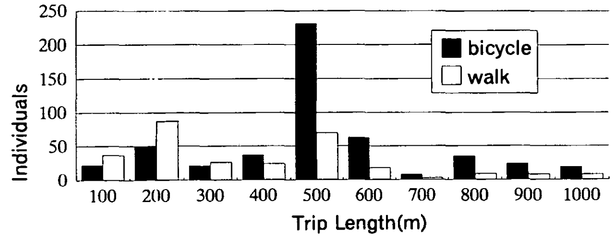

FIGURE 6 Short-distance trip length by mode, shopping trips.

sidization for the use of bicycles, this does not mean that government policy is to promote the use of bicycles; it is only a response to the reality that bicycles have rapidly increased at an unexpected rate. In other words, although the government keeps the view that bicycles are useful for short-distance trips, the diversified role that bicycles can play in urban transport systems has not yet been fully explored in the government's policy toward bicycles.

Given the conditions discussed earlier, one cannot deny the possibility that a bicycle traffic environment will change drastically if government policy is shifted to being more tolerant of motorization at the personal level. Thus, the creation of the traffic environments in which bicycles can be as diversified as they have the potential to be should be one of the highest-priority issues in urban transport policy in China. If the diversity of transport mode choice is the barometer of the soundness of the urban transport system in a given city, Chinese cities are at a crossroads with respect to whether they can be transformed from ''a bicycle society in which people are forced to choose bicycles'' to ''a bicycle society in which people can choose or are inclined to choose bicycles.''

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Chinese Pedestrians and Their Walking Characteristics: Case Study in Beijing

YORDPHOL TANABORIBOON AND QIAN JING

The walking activities and characteristics of Beijing pedestrians, particularly in reference to the use of pedestrian crossing facilities, are highlighted. Walking serves many purposes in Beijing and is popularly used for commuting by the populace regardless of gender and age. A study revealed that although Beijing pedestrians were less enthusiastic about using the overpasses and underpasses than they were about using signalized crossings, mainly because of the ascending and descending movements required, when the safety aspects and other related attributes were appraised, these pedestrians did not favor any type of crossing in particular. Thus, Beijing pedestrians would accept any type of crossing facilities as long as they are appropriate and sufficient.

Because of ongoing policies to curb the use of bicycle ownership in Beijing by implementing bicycle taxes, raising bicycle prices, and imposing higher parking fees, walking plays an even more important role for the mobility needs of the populace. According to the origin-destination (O-D) surveys conducted by the Beijing Traffic Safety Bureau (1) in 1987, it was revealed that among the five major urban transport modes, walking accounted for 13.8 percent of the total trips made in Beijing. Even though bicycles were the most dominant mode of traveling—consisting of 50.3 percent of the total trips made and followed by buses (27.7 percent), institute buses (4.4 percent), taxis (0.6 percent), and others (3.2 percent)—commuters sometimes do not reach their final destinations by bicycle. Often, commuters must walk to reach their final destinations. In fact, they use walking as a means of transport the way Westerners use their vehicles in commuting—not only to work and school but for other social and recreational activities as well.

However, unlike Westerners but similar to people in other developing countries, local commuters do not perceive the need for discipline in using the pedestrian crossing facilities. It may be useful to identify the reasons that Beijing pedestrians are not willing to comply in using the crossing facilities and whether this unwillingness is legitimate. Excuses include improper location, insufficient crossing facilities, lack of safety aspects, and lack of convenience and comfort.

This paper intends to examine the walking activities and characteristics of Beijing pedestrians, particularly in reference to the use of pedestrian crossing facilities. In addition, their attitudes toward and acceptance of the crossing facilities are also scrutinized. It is hoped that the results will pave the way toward improving pedestrian facilities in Beijing.

DATA COLLECTION

To fulfill the desired objectives, questionnaires were used to collect relevant information about pedestrian characteristics and attitudes toward the crossing facilities in Beijing. A total of 1,500 questionnaire forms were distributed randomly to pedestrians in 70 locations. Of these, 1,126 forms were returned; after uncompleted forms were removed, only 930 forms were used for analyses. Table 1 gives the locations of the survey sites and the response rates.

In addition, pedestrian volume counts were also made at two signalized crossings to determine the number of illegal walkers. Detailed descriptions of the two study sites are presented in Table 2. A photographic technique through the use of a video camera was employed to record pedestrian volumes. To avoid any bias results and to obtain the normal walking conditions, data were collected during the off-peak period (2:00 to 5:00 p.m.) and during weekdays at the two study sites.

BEIJING PEDESTRIANS

To ensure the unbiased selection of the interviewed pedestrians, which would represent the typical Beijing pedestrian, demographic characteristics of these pedestrians were first determined. Results of the questionnaires revealed that walking in Beijing has become a common mode of transport among all commuters regardless of gender and age, as shown in Table 3. Female and male pedestrians appeared to be nearly evenly represented by 53 and 47 percent, respectively. Age distinction among various pedestrians' age groups, in particular the groups between 16 and 55 years, is almost undistinguishable. However, the young and the elderly appeared to be the smallest group among Beijing pedestrians.

Compared with another study of nonmotorized transport (NMT) in another major Chinese city (Shanghai) on the demographic characteristics of bicycle users (*2*), there was a slight difference in the female-male users ratio. It was known that male bicyclists in Shanghai outnumbered women by 20 percent (60 versus 40 percent). Perhaps Chinese men are more active in riding bicycles than women but not in walking. Nevertheless, compared with their income and educational background, the studies of the two cities did not indicate any distinction, as indicated in Table 4. Beijing pedestrians are also quite well educated: 95.7 percent (94.7 percent in Shanghai) of the total pedestrians interviewed received at least a middle school education, and 28.2 percent hold bachelor's degrees. Thus, NMT in China is used by all citizens regardless of educational background.

Considering the monthly income of all pedestrians interviewed in Beijing, it is seen clearly from Table 4 that the majority of the Beijing pedestrians earned less than 300 yuan (U.S. $66) per month, represented by 83.2 percent of the total respondents. Although 77.2 percent of the Shanghai bicyclists interviewed earned

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TABLE 1 Questionnaire Survey Sites

Locations of Survey Sites	No.	No. of Forms Distributed	No. of Returns	Respond Rates	No. of Effective Forms	Effective Rates
Factory	17	400	264	66.0%	193	73.1%
Government Office	20	400	279	69.8%	248	88.9%
Private Company	6	60	35	58.3%	16	45.7%
University	3	120	87	72.5%	72	82.8%
School	6	120	101	84.2%	90	89.1%
Hospital	2	50	34	68.0%	21	61.8%
Department Store	4	50	36	72.0%	18	50.0%
Residential Area	5	230	223	97.0%	212	95.1%
Survey Site	7	70	67	95.7%	60	89.6%
Total	70	1,500	1,126	75.1%	930	82.6%

less than 300 yuan, most (71.2 percent) earned between 100 and 300 yuan (U.S. $22 to 66). Only 56.5 percent of the Beijing pedestrians earned between 100 and 300 yuan, and the other 26.7 percent received less than 100 yuan per month. Nonetheless, according to the official statistics (*3*), the average annual income of Beijing citizens in 1991 was 2,877 yuan, or 240 yuan per month. Because of the low income of the people and the government's restrictive policies on the use of automobiles, NMT in China will probably remain as a significant means of transportation in the country.

WALKING CHARACTERISTICS IN BEIJING

To reinforce other studies' findings on the vital role of walking trips in China, this study also inquired about the trip purposes and average walking time of Beijing pedestrians. It was known that various types of trip were completed through walking. In many Western countries walking is used mainly for recreation, exercise, or commuting to and from transit stations. In Beijing, however, Chinese pedestrians walk not only to transit stations (15.1 percent) and for recreational activities (9.8 percent), but also to work (22.7

TABLE 2 Descriptions and Dimensions of Selected Signalized Crossings

Name of Site	Description	Length of Crossing, meter	Allocated Crossing Time, seconds
Xidan Intersection	1) Located on Changan Street which is one of the important arterial roads in Beijing 2) Close to Xidan CBD 3) Medians with 0.5 m. height fence at the center of the road 4) More vehicles with relatively high speed	37.8	Average Green Time: 32 Average Red Time: 68
Dongsi Intersection	1) Located in Dongsi commercial area 2) Medians with 0.5 m. height fence at the center of the road 3) Residential areas nearby 4) Moderate vehicles with relatively low speed	22.08	Average Green Time: 32 Average Red Time: 75

TABLE 3 Distribution of Pedestrians in Beijing and Cyclists in Shanghai by Age and Gender

		Age Groups (Years)								Total
		<15	16-20	21-25	26-35	36-45	46-55	56-65	>65	
Male	Beijing	36 41.9%	64 41.6%	69 52.7%	86 42.0%	64 44.8%	80 54.4%	23 50.0%	11 61.1%	433 46.6%
	Shanghai	17 68.0%	59 59.0%	132 53.2%	403 55.5%	561 58.4%	215 63.4%	166 86.9%	16 69.6%	1,569 60.0%
Female	Beijing	50 58.1%	90 58.4%	62 47.3%	119 58.0%	79 55.2%	67 45.6%	23 50.0%	7 38.9%	497 53.4%
	Shanghai	8 32.0%	41 41.0%	116 46.8%	323 44.5%	400 41.6%	124 36.6%	25 13.1%	7 30.4%	1,044 40.0%
Total	Beijing	86 9.2%	154 16.6%	131 14.1%	205 22.1%	143 15.4%	147 15.8%	46 4.9%	18 1.9%	930 100.0%
	Shanghai	25 1.0%	100 3.8%	248 9.5%	726 27.8%	961 36.8%	339 13.0%	191 7.3%	23 0.9%	2,613 100.0%

percent), school (15.2 percent), and, surprisingly, to shop (22.8 percent). These three trip purposes accounted for nearly 61 percent of the total responses, reflecting the vital role of walking in Beijing. Moreover, considering the walking time and the trip purposes as shown in Table 5, even though nearly 60 percent of the interviewees responded that they walk fewer than 20 min, still a considerable amount of pedestrians walked more than 30 min not only to work or to school but to shop as well. In fact, about 19 percent of those pedestrians who went shopping must spend at least 45 min walking, as shown in Table 5.

Considering the walking time by gender as shown in Table 6, the findings clearly revealed that walking in Beijing is influenced neither by gender nor by walking time. Unlike the riding time of bicyclists in Shanghai (*2*) as shown in Table 6, which indicated the declining trends of the female riders toward the longer trips, Beijing female pedestrians place less concern on their walking distances. The same trends, in which women slightly outnumber men, can be noticed on any walking time except for the range of 21 to 30 min, as shown in Table 6. Furthermore, considering the average walking time among various age groups of Beijing pedestrians, results also revealed that walking time has no effect on any age group. Regardless of their ages—young, adult, or even elderly—they all walk with about the same average walking time, as shown in Table 7. Moreover, when questioned about their maximum tolerable walking time, most age groups reflected the same endurance—they could walk for an average of 36.5 min. However, the elderly (older than 65) could tolerate only 26.7 min of walking time, but the young generation (under 20) could manage up to 41 min of walking.

The ability of Chinese pedestrians to walk longer distances can be noticed especially if compared with Westerners. Taking into account the average walking time of Beijing pedestrians of 22.5 min and the average walking speed of 73 m/min found in other Asian countries (*4,5*), the average walking distance of the Chinese would be 1,643 m. This average walking distance is much longer than that of their Western counterparts. The average walking distances of New Yorkers and Calgary citizens were 523 and 335 m, respectively (*6*). Not only do the Chinese spend more time walking than Westerners, but even compared with one of their Asian counterparts, they also walk much longer distances. In Riyadh, Saudi Arabia, for example, the average walking distance was found to be only 859 m (*7*). The endurance of the Chinese reflects not only the versatile roles of walking in China but also a significant means of NMT in the country.

ATTITUDES TOWARD CROSSING FACILITIES

Like other developing countries, discipline in crossing the roads according to law is not generally observed in Beijing. Pedestrians normally must be forced to use the crossing facilities by law enforcers or through some barriers. However, it would be appropriate to verify the legitimacy of this statement, so this study employed the pedestrian volume counts at two signalized crossings, namely, Dongsi and Xidan. These two crossings are located in bustling areas (detailed descriptions can be found in Table 2). Results of the volume surveys indicated that there is a considerable number of pedestrians who crossed the roads illegally—particularly at the Xidan crossing. (Illegal crossings are defined in this study as crossing the road during the red signal.) During the 3-hr observation period, approximately 30 percent were illegal crossings at the Dongsi crossing and 43 percent were illegal at the Xidan crossing, as presented in Table 8. The high percentages of illegal crossings reflect the impatience of pedestrians and perhaps the lack of effective enforcement.

Despite the shorter red time of 68 sec regulated at the Xidan crossing compared with 75 sec at Dongsi, a still higher percentage of illegal crossings was noticed at Xidan. This may be because more pedestrians were using the Xidan crossing and they became more daring to cross illegally as the group grew. Therefore, it is imperative to impose strict law enforcement and to provide information on how to use the roadway facilities properly. Doing so

TABLE 4 Comparison of Monthly Income and Level of Education of Pedestrians in Beijing and Cyclists in Shanghai

Education Level		Monthly Income (Yuan)																		Total	
		<100		100 - 200		201 - 300		301 - 400		401 - 500		501 - 600		601 - 750		751 - 900		>900			
P.S.	B	20	8.1%	5	2.5%	6	1.8%	9	7.8%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	40	4.3%
	S	3	1.9%	26	3.3%	15	1.4%	10	2.6%	2	2.7%	7	9.9%	0	0.0%	5	16.1%	0	0.0%	68	2.6%
M.S	B	110	44.4%	77	38.9%	119	36.4%	37	32.2%	6	26.1%	2	50.0%	1	20.0%	3	60.0%	2	40.0%	357	38.4%
	S	52	33.3%	218	27.3%	243	23.1%	101	26.7%	17	22.7%	11	15.5%	7	23.3%	7	22.6%	1	33.3%	657	25.3%
H.M	B	72	29.0%	55	27.8%	94	28.7%	34	29.6%	3	13.0%	1	25.0%	1	20.0%	1	20.0%	1	20.0%	262	28.2%
	S	42	26.9%	294	36.8%	429	40.7%	128	33.9%	28	37.3%	23	32.4%	5	16.7%	8	25.8%	1	33.3%	958	36.9%
B.D	B	41	16.5%	52	26.3%	99	30.3%	30	26.1%	8	34.8%	1	25.0%	2	40.0%	1	20.0%	1	20.0%	235	25.3%
	S	57	36.5%	232	29.0%	344	32.6%	117	31.0%	24	32.0%	22	31.0%	17	56.7%	10	32.3%	0	0.0%	823	31.7%
A.B.D	B	1	0.4%	7	3.5%	8	2.4%	4	3.5%	6	26.1%	0	0.0%	1	20.0%	0	0.0%	0	0.0%	27	2.9%
	S	0	0.0%	26	3.3%	21	2.0%	22	5.8%	4	5.3%	7	9.9%	1	3.3%	1	3.2%	1	33.3%	83	3.2%
O	B	4	1.6%	2	1.0%	1	0.3%	1	0.9%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	20.0%	9	1.0%
	S	2	1.3%	3	0.4%	2	0.2%	0	0.0%	0	0.0%	1	1.4%	0	0.0%	0	0.0%	0	0.0%	8	0.3%
Total	B	248	26.7%	198	21.3%	327	35.2%	115	12.4%	23	2.5%	4	0.4%	5	0.5%	5	0.5%	5	0.5%	930	100.0%
	S	156	6.0%	799	30.8%	1054	40.6%	378	14.6%	75	2.9%	71	2.7%	30	1.2%	31	1.2%	3	0.1%	2597	100.0%

Legend :

P.S. - Primary School
M.S. - Middle School
H.M.S. - High Middle School
B.D. - Bachelor's Degree
A.B.D. - Above Bachelor's Degree
O - Others
B - Beijing
S - Shanghai

TABLE 5 Trip Purposes and Walking Time of Beijing Pedestrians

Walking Purposes	Average Walking Time, Min.								Total
	1-5	6-10	11-15	16-20	21-25	26-30	31-45	>45	
Work	9 4.3%	33 15.6%	44 20.9%	36 17.1%	20 9.5%	28 13.3%	22 10.4%	19 9.0%	211 22.7%
School	8 5.7%	14 9.9%	29 20.6%	25 17.7%	21 14.9%	20 14.2%	10 7.1%	14 9.9%	141 15.2%
Shopping	6 2.8%	26 12.3%	32 15.1%	36 17.0%	18 8.5%	24 11.3%	30 14.2%	40 18.9%	212 22.8%
Business	1 8.3%	1 8.3%	0 0.0%	2 16.7%	2 16.7%	1 8.3%	2 16.7%	3 25.0%	12 1.3%
To/Fr Transit Stations	9 6.4%	30 21.4%	29 20.7%	26 18.6%	9 6.4%	15 10.7%	7 5.0%	15 10.7%	140 15.1%
Returning Home	2 6.9%	7 24.1%	3 10.3%	4 13.8%	3 10.3%	4 13.8%	4 13.8%	2 6.9%	29 3.1%
Recreation	1 1.1%	4 4.4%	11 12.1%	11 12.1%	11 12.1%	17 18.7%	13 14.3%	23 25.3%	91 9.8%
Social Activity	1 3.7%	4 14.8%	5 18.5%	6 22.2%	2 7.4%	1 3.7%	2 7.4%	6 22.2%	27 2.9%
Others	5 7.5%	18 26.9%	13 19.4%	9 13.4%	3 4.5%	5 7.5%	4 6.0%	10 14.9%	67 7.2%
Total	42 4.5%	137 14.7%	166 17.8%	155 16.7%	89 9.6%	115 12.4%	94 10.1%	132 14.2%	930 100.0%

not only will ensure the safety of the pedestrians but may promote greater use of NMT in Beijing.

In addition to those crossing the road illegally at the designated crosswalks, some may totally ignore the crossing facilities and cross the roads where they wish. It is necessary to identify their reasons for not using such crossing facilities. One reason could be the insufficiency of crossing facilities. According to the *Beijing Statistics Year Book* (*3*), in 1991 there were 1,818 crossing facilities in Beijing, including 1,287 zebra crossings, 371 signalized crossings, 53 overpasses, and 107 underpasses. Although it is not the intention of this paper to verify whether these 1,818 crossing facilities are adequate to handle 10 million Beijing pedestrians, 52.7 percent of the pedestrians interviewed stated that crossing facilities in Beijing are not adequate, as given in Table 9. Only 10.2 percent agreed that there are enough crossing facilities; the other 37.1 percent could not decide. Despite the higher number of signalized crossings than of overpasses and underpasses combined, pedestrians still preferred to have more signalized crossings, according to 34.5 percent of the total respondents (Table 9). Pedestrians also demanded other types of crossing facilities but selected the zebra crossing as their last choice, according to only 15.3 percent of the respondents. Further analyses about the adequacy of each type of crossing facility also revealed similar results, as indicated in Table 9. Those who claimed that crossing facilities in Beijing are inadequate ranked signalized crossings as their first choice.

The main reason that more people preferred signalized crossings may be convenience and faster crossing compared with the overpasses and underpasses, which require ascending and descending movements. This hypothesis is further reinforced by the findings on the willingness of pedestrians to use such facilities. Among the three types of crossing facilities, Beijing pedestrians are more willing to use signalized crossings than the other two types (Table 10). About 75 percent of the pedestrians interviewed were willing to use signalized crossings, whereas only 50.7 percent and 52.5 percent expressed their willingness to use overpasses and underpasses, respectively.

In addition to the insufficient number of crossing facilities, it is more appropriate to identify other reasons that Beijing pedestrians ignored the crossing facilities. Those pedestrians who exhibited their unwillingness to use the crossing facilities were asked to state their reasons for refusal. For signalized crossings, they complained mainly about the location of the crossing ("too far away to use") and the long waiting time to cross the streets. These two reasons accounted for 60 percent (Table 11). Sixteen percent expressed that the crossing time is inadequate, and another 15 percent did not appreciate having to cross the roads in a hurry. These two reasons prompted them to avoid using the signalized crossings. Judging from these two comments, along with the previously mentioned complaints about crossing lengths of the two selected signalized crossings, these complaints should not be totally overlooked. Although the crossing length of the selected signalized crossing at

TABLE 6 Walking Time of Beijing Pedestrians and Riding Time of Shanghai Bicyclists by Gender

Beijing Pedestrians									
	Average Walking Time, min.								Total
	1-5	6-10	11-15	16-20	21-25	26-30	31-45	>45	
Male	19 45.2%	65 47.4%	71 42.8%	64 41.3%	46 51.7%	66 57.4%	41 43.6%	61 46.2%	433 46.6%
Female	23 54.8%	72 52.6%	95 57.2%	91 58.7%	43 48.3%	49 42.6%	53 56.4%	71 53.8%	497 53.4%
Total	42 4.5%	137 14.7%	166 17.8%	155 16.7%	89 9.6%	115 12.4%	94 10.1%	132 14.2%	930 100.0%
Shanghai Cyclists									
	Average Riding Time, min.								Total
	1-5	6-10	11-15	16-20	21-25	26-30	31-45	>45	
Male	16 43.2%	121 55.8%	198 51.8%	279 53.8%	208 61.5%	255 60.4%	229 68.2%	255 73.5%	1,561 60.1%
Female	21 56.8%	96 44.2%	184 48.2%	240 46.2%	130 38.5%	167 39.6%	107 31.8%	92 26.5%	1,037 39.9%
Total	37 1.4%	217 8.4%	382 14.7%	519 20.0%	338 13.0%	422 16.2%	336 12.9%	347 13.4%	2,598 100.0%

TABLE 7 Average Walking Time and Maximum Tolerable Walking Time by Age in Beijing

Age	Average Walking Time (Min.)	Max. Tolerable Walking Time (Min.)
<15	19.62	38.84
16-20	23.98	41.04
21-25	21.92	35.80
26-35	21.13	35.10
36-45	22.63	35.14
46-55	24.33	35.68
56-65	24.35	35.22
>65	22.62	26.67
Average	22.5	36.5

TABLE 8 Number of Illegal Crossings During Red Time Signal

Survey Time	No. of Pedestrians (pedestrians/hour)					
	Dongsi Signalized Crossing			Xidan Signalized Crossing		
	Legal	Illegal	Total	Legal	Illegal	Total
2:00 - 3:00 P.M.	1,233 70.1%	527 29.9%	1,760 29.6%	1,879 54.3%	1,579 45.7%	3,458 30.8%
3:00 - 4:00 P.M.	1,417 69.7%	616 30.3%	2,033 34.2%	2,152 57.8%	1,572 42.2%	3,724 33.2%
4:00 - 5:00 P.M.	1,527 70.9%	627 29.1%	2,154 36.2%	2,351 58.2%	1,686 41.8%	4,037 36.0%
Total	4,177 70.2%	1,770 29.8%	5,947 100.0%	6,382 56.9%	4,837 43.1%	11,219 100.0%

TABLE 9 Attitudes Toward Crossing Facilities

Crossing Facilities	Attitudes Toward the Sufficiency			Total
	Enough	Not Enough	Not so Sure	
Zebra Crossing	20 21.0%	72 14.7%	50 14.5%	142 15.3%
Signalized Crossing	22 23.2%	168 34.3%	131 38.0%	321 34.5%
Overpass	22 23.2%	120 24.5%	67 19.4%	209 22.5%
Underpass	31 32.6%	130 26.5%	97 28.1%	258 27.7%
Total	95 10.2%	490 52.7%	345 37.1%	930 100.0%

TABLE 10 Willingness To Use Crossing Facilities

Type of Crossing	Willingness to Use the Facility		Total
	Yes	No	
Signalized Crossing	697 74.9%	233 25.1%	930 100.0%
Overpass	471 50.7%	459 49.3%	930 100.0%
Underpass	488 52.5%	442 47.5%	930 100.0%

TABLE 11 Reasons for Unwillingness To Use Crossing Facilities by Gender

Reasons for their Unwillingness to Use the Crossing Facilities		Signalized Crossing			Overpass			Underpass		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
Common Factors	Too far away to use	32 45.7%	38 54.3%	70 30.0%	52 55.9%	41 44.1%	93 20.3%	35 47.9%	38 52.1%	73 16.5%
	Too crowded	11 52.4%	10 47.6%	21 9.0%	10 55.6%	8 44.4%	18 3.9%	7 63.6%	4 36.4%	11 2.5%
Specified Factors	The stairway is too steep	-	-	-	4 36.4%	7 63.6%	11 2.4%	3 33.3%	6 66.7%	9 2.0%
	Too tired to walk up and down	-	-	-	110 38.1%	179 61.9%	289 63.0%	61 37.4%	102 62.6%	163 36.9%
	Inconvenience to use	-	-	-	23 47.9%	25 52.1%	48 10.4%	1 50.0%	1 50.0%	2 0.5%
	Need to wait for red time	36 51.4%	34 48.6%	70 30.0%	-	-	-	-	-	-
	Crossing time is inadequate	16 43.2%	21 56.8%	37 16.0%	-	-	-	-	-	-
	Must cross in a hurry	16 45.7%	19 54.3%	35 15.0%	-	-	-	-	-	-
	Fear of Criminal	-	-	-	-	-	-	5 13.9%	31 86.1%	36 8.1%
	Bad Ventilation, Lighting and Cleaning	-	-	-	-	-	-	60 40.5%	88 59.5%	148 33.5%
Total		111 47.6%	122 52.4%	233 100.0%	199 43.4%	260 56.6%	459 100.0%	172 38.9%	270 61.1%	442 100.0%

Xidan intersection is longer than the Dongsi crossing (37.8 versus 22.08 m), their allowable crossing (green) time was 32 sec each. One may wonder why these two crossings had identical crossing times when their crossing lengths differed. Perhaps the authorities should pay more attention to designing the appropriate crossing time for pedestrians. This would not only ensure the safety and convenience in crossing but also would boost the confidence among pedestrians.

Among those who disliked using the overpasses, nearly two-thirds (63 percent) expressed their reasons about the ascending and descending movements required ("too tired to walk up and down"). Another 20.3 percent also complained about the location of the overpasses. These complaints, however, were not expressed strongly by those who disapproved of the underpasses. Instead, they were concerned about the conditions of the underpasses—in particular the ventilation, lighting, and hygienic conditions—as responded by 33.5 percent. Nevertheless, still another 36.9 percent complained about the ascending and descending movements needed. Only 8.1 percent were concerned about the safety aspects, particularly the criminal risks involved. This could perhaps reflect either the low crime rate in Beijing, the fact that only a few criminal cases occurred in the underpasses, or both.

With respect to the gender of those who disapproved of the crossing facilities, as shown in Table 11, it can be clearly seen that female and male pedestrians voiced different opinions especially about the overpasses and underpasses. Men are generally stronger physically, therefore fewer male pedestrians complained about the ascending and descending movements compared with their female counterparts. On the contrary, women were more concerned than men about their safety in using the underpasses. Nonetheless, despite the differing viewpoints, their comments should not be totally overlooked, particularly those involving the safety aspects. After all, it is a policy to encourage pedestrians to cross the roads properly as walking will perhaps continue to remain one of the major means of commuting in Beijing. Would it not be worthwhile to provide appropriate and sufficient crossing facilities that would not only minimize the accident rates but also ensure public confidence in using such facilities?

To provide further information about the preference of Beijing pedestrians toward each type of crossing facility, pedestrians were asked to rate the five given attributes of each crossing facility: convenience in crossing, safety, faster crossing time, condition of supporting facilities (lighting, cleanliness, etc.), and appearance (architectural design and compatibility with the environment). Pedestrians were requested to rate those attributes on a scale of 1 to 6, with 1 representing very poor conditions and 6, excellent conditions. Results of the analyses (Table 12) revealed that pedestrians respond differently to the attributes of each crossing facility. In other words, these three types of crossing facilities were graded differently depending on each attribute. As far as the convenience in crossing and crossing time, signalized crossings ranked first in both categories because no ascending or descending movements were required, followed by underpasses and overpasses, respectively. However, with regard to the safety aspect, Beijing pedestrians selected the overpasses and underpasses to be far superior to the signalized crossings. This expected result is obvious because this method involves fewer risks in crossing the roads. Although the weighted averages of both overpasses and underpasses were almost even (4.57 versus 4.47), overpasses are relatively superior because some pedestrians may fear the criminal risks involved in using the underpasses. For the remaining two attributes, supporting facilities and appearance, Beijing pedestrians also ranked overpasses and underpasses ahead of signalized crossings.

A consideration of all these five attributes together and the assumption that each carries the same weighted average suggest that underpasses (3.54) and overpasses (3.53) would be slightly superior to signalized crossings (3.42). Judging from these results and the previous findings on pedestrians' unwillingness to use the crossing facilities, one may conclude that unless safety is improved, Beijing pedestrians will not favor any type of crossing in particular. In other words, they would accept any type of crossing facility as long as the facility is appropriate and sufficient.

ACCIDENTS INVOLVING PEDESTRIANS

Even though there were fewer pedestrian casualties (83 victims) and only 374 injuries reported in Beijing in 1988 the safety of pedestrians in using the crossing facilities cannot be ignored. As

TABLE 12 Weighted Average of Each Crossing Facility in Beijing

Attributes	Type of Crossing Facilities		
	Signalized Crossing	Overpass	Underpass
Convenience in Using	3.85	3.23	3.34
Safety Aspect	3.50	4.57	4.47
Faster Crossing Time	3.55	3.01	3.13
Conditions of Supporting Facilities	3.09	3.18	3.16
Appearance	3.13	3.64	3.61

Note: 1 means "very poor" and 6 being "excellent".

TABLE 13 Frequency of Accidents from Crossing

Crossing Frequency	Accident Experienced				Total	
	Have		Have Not			
	No.	%	No.	%	No.	%
1 time or less	1	0.8%	127	99.2%	128	13.7%
2 times	4	2.2%	176	97.8%	180	19.4%
3 times	7	6.5%	101	93.5%	108	11.6%
4 times	14	7.8%	166	92.2%	180	19.4%
5 times	14	17.5%	66	82.5%	80	8.6%
At least 6 times	60	23.6%	194	76.4%	254	27.3%
Total	100	10.8%	830	89.2%	930	100.0%

such, Beijing pedestrians were questioned directly about their opinions of the safety aspects. Among the five provided opinions on safety, pedestrians responded positively: 90.3 percent of the respondents mentioned that walking in Beijing is either safe (46.5 percent) or not safe, but not dangerous either (43.8 percent). On the other hand, Shanghai residents had less faith in riding their bicycles, as only 7.4 percent claimed that riding bicycles is safe and another 64 percent responded that it is not safe, but not dangerous either for the same five given opinions. Nevertheless, it would be unfair to conclude that walking in Beijing is safer than riding bicycles in Shanghai. Among those who experienced accidents in these two cities, similar percentages of these victims were noticed (10.8 percent in Beijing and 11.6 percent in Shanghai). However, despite the low number of victims in both cities, the safety aspect of these two NMT modes cannot be overlooked.

Further consideration of those who experienced accidents by crossing frequency and by age showed that those pedestrians who need to cross the roads very often are more likely to experience accidents (Table 13). Among those pedestrians who must cross the roads at least six times a day, nearly 25 percent had experienced an accident compared with only 1 percent of those who cross once a day. On the other hand, among those pedestrians who experienced an accident in Beijing, teenagers (16 to 20 years old) appeared to be the most reckless group in crossing the roads compared with other age groups. However, as they grow older, they became more aware of the danger involved, reflected by the decreasing trend in accidents, as shown in Table 14. Among those pedestrians who are 15 years of age or younger, only 8 percent experienced accidents. These youngsters normally were primary school students. They were often requested to cross the roads as

TABLE 14 Frequency of Accidents by Age Group

Age Groups (Years)	Accident Experienced				Total	
	Have		Have Not			
	No.	%	No.	%	No.	%
<15	7	8.1%	79	91.9%	86	9.2%
16 - 20	28	18.2%	126	81.8%	154	16.6%
21 - 25	16	12.2%	115	87.8%	131	14.1%
26 - 35	22	10.7%	183	89.3%	205	22.1%
36 - 45	14	9.8%	129	90.2%	143	15.4%
46 - 55	11	7.5%	136	92.5%	147	15.8%
56 - 65	2	4.3%	44	95.7%	46	4.9%
>65	0	0.0%	18	100.0%	18	1.9%
Total	100	10.8%	830	89.2%	930	100.0%

a group where they can help guide each other in abiding by the traffic regulations. This reflects the importance in having proper knowledge to educate the pedestrians.

CONCLUSION AND RECOMMENDATIONS

One can never deny the vital role of NMT, particularly of bicycles and walking, in providing mobility to all citizens in China. Findings of this study revealed that walking serves many purposes in Beijing and is being widely used for commuting by the populace irrespective of gender and age. However, despite the significant role of walking in Beijing, a number of pedestrians ignored crossing the roads according to the laws. Many pedestrians intentionally cross the roads illegally. There were numerous reasons for their unwillingness to use the crossing facilities: some complained about the inadequacy of the crossing facilities, others worried about their safety and had to rush when crossing, some disliked the ascending and descending movements, some disapproved of the locations of the crossing facilities, and so on. Even though Beijing pedestrians were less enthusiastic about using the overpasses and underpasses than they were about using the signalized crossings, mainly because of the ascending and descending movements required, when appraising the safety aspects and other related attributes, these pedestrians did not favor any type of crossing in particular. In other words, Beijing pedestrians will accept any type of crossing facility as long as it is sufficient and appropriate.

As long as the government encourages the Chinese to continue commuting through walking, then certain recommendations may require attention. First, crossing time at all signalized crossings should be examined to be compatible with the crossing lengths and average walking speed of the Chinese pedestrians. Moreover, local commuters' average walking speed should also be used in designing the crossing time in Beijing.

Second, to ensure a proper crossing attitude that could help maximize the safety of pedestrians, immediate measures may be required, such as strict law enforcement and physical barriers. On the other hand, it is essential to provide proper knowledge to road users, particularly pedestrians, on how to use the roads properly and according to the law.

Currently, the government is imposing penalties on those pedestrians who violate the regulations. Each violation penalty fee is 1 to 5 yuan. This measure appears to be effective when there are adequate enforcers. However, as mentioned earlier, in reality pedestrians were still found to cross the roads illegally. Instead of the penalty tactic, would it be worthwhile considering another tactic, such as the incentive approach? For example, those pedestrians who have not had a violation in a specified period would receive a certificate of appreciation. This certification would be presented when seeking employment, or for deductions in medical fees, or perhaps to receive extra benefits in other social areas. Although this incentive approach seems to be better in theory than in practice, especially considering the Beijing population of 10 million, would it be worthwhile to scrutinize this tactic in detail if other measures failed to provide the satisfactory results?

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Study of Bicycle Parking in Central Business District of Shanghai

KEFEI YAN AND JILONG ZHENG

Bicycles are a frequently used transportation mode in the cities of China. Unavoidably, bicycle parking is becoming a serious problem in urban areas, especially in the central business district (CBD). A bicycle parking study in the CBD of Shanghai, begun in 1987, includes data collecting, parking generation modeling, and parking demand forecasting in the predicting year and suggests a parking plan for the year 2000 and a management package to improve short-term bicycle parking in the CBD.

In Shanghai, there are 7 million registered bicycles, almost 0.7 bicycle for each person. Bicycles influence peoples' everyday lives. Most people ride bicycles not for recreation or exercise but for work, shopping, school, and other trip purposes. Studies of mode selection in the city of Shanghai indicated that 40 percent of commuters are bicycle riders (*1*). Because of the level of economy development and the construction of a transportation facility, bicycles as a travel tool play and will continue to play an important role in urban transportation. Experts have forecasted that bicycles as a major transportation tool will survive into the next century.

The bicycle is a clear transportation mode. No air pollution is caused by bicycle traffic. To the residents of Shanghai, riding a bicycle is a convenient mode of short-distance transportation to access the city's downtown area, especially when the traffic congestion occurs in the area. This is why so much bicycle traffic is attracted to the central business district (CBD) of Shanghai. Compared with public transit, however, bicycle traffic occupies many road and land resources, both in moving and parking. In the CBD of Shanghai, traffic is extremely dense because the roads are insufficient. In addition, parking bicycles on the street causes even worse traffic conditions.

Bicycle parking is a puzzling problem to CBD transportation management officials. Continuous studies focusing on bicycle parking in the CBD have been carried out since 1987. Research topics such as *Parking Survey and Study in Shanghai* and *Studies on Parking Management and Strategy in CBD* have been done by a research team of the Shanghai Institute of Urban Construction (*2*). The achievement of such studies is the foundation of this paper.

In this paper, the demand and supply of bicycle parking and the distribution and behavior of parking time and space are discussed. Two types of bicycle parking models have been calibrated and tested. The input parameters used in those models are the numbers of employment positions and bicycle trip (destination) attractions. Short- and long-term schemes and strategies to improve the bicycle parking in Shanghai's CBD have been suggested. The results of the studies have been applied to the comprehensive urban transportation planning and transportation system management by the Shanghai municipal authority (*1,3*).

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CHARACTERISTICS OF BICYCLE PARKING IN SHANGHAI'S CBD

The CBD of Shanghai is the economic, commercial, and financial center of the city and is the largest trip attraction in the city. A high demand for bicycle parking as well as vehicle parking is an important aspect of transportation in the CBD.

Quantitative analysis of bicycle parking characteristics, which is based on the continuous on-site survey and data collection in the CBD of Shanghai, helps elucidate the bicycle parking situation in the CBD. Bicycle parking characteristics can be described by such parameters as the total amount of parking demand and supply, parking duration, maximum parking accumulation, and the behavioral characteristics of the parking demand.

Parking Demand and Supply

The distribution of space and time in parking accumulation in the city central area (CCA, covering 29 zones and about 8 km^2) and in the CBD (14 zones coded from 101 to 114 and about 4.16 km^2) are shown in Figure 1 and Figure 2. The maximum parking accumulation of the CCA and CBD, which both appear at 10:00 a.m. and 4:00 p.m. are 35,000 and 24,700 vehicles, respectively.

Most bicycles in the CCA park on the street. There are 14,529 and 9,601 legal parking spaces for bicycles in the CCA and CBD, respectively. Maximum parking saturations (the ratio of maximum parking accumulation and parking space) for CCA and CBD are 2.76 and 2.57. This indicates that bicycle parking in both the CCA and CBD is greatly oversaturated (see Figure 3).

Parking Duration

Parking duration is closely related to trip purpose and land use. Statistical data indicate that the average duration of on-street parking is 30 min and the duration in a recreation area (from 50 to 80 min) is longer than the average. The longest duration, of course, is found in parking for work or for transfer of the travel mode from bicycle to transit in the trip for work. Figure 4 gives the parking time distribution for various trip purposes.

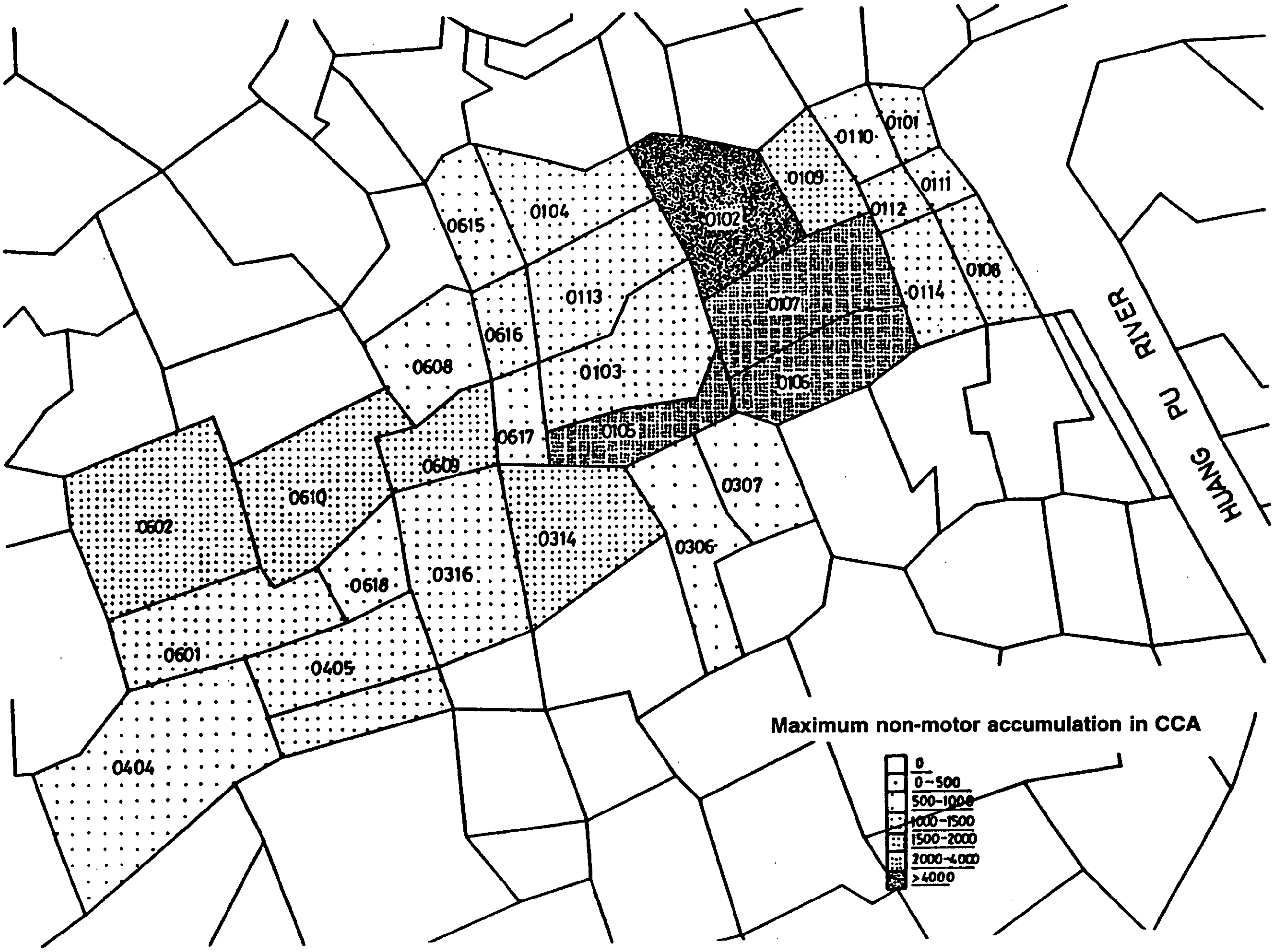

FIGURE 1 Distribution of bicycle parking spaces in Shanghai CCA and CBD.

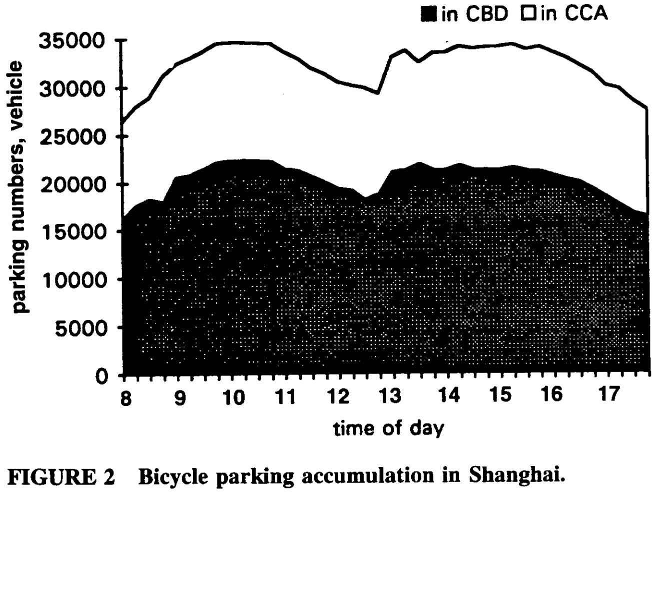

FIGURE 2 Bicycle parking accumulation in Shanghai.

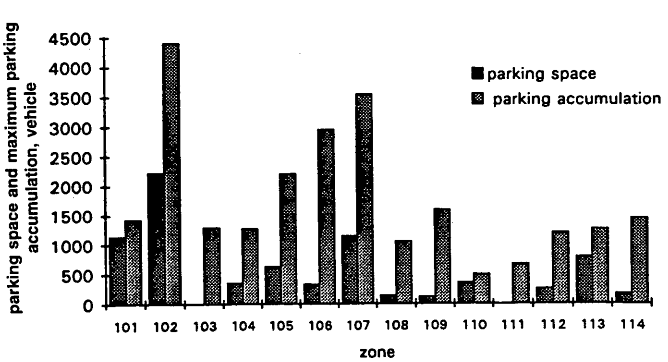

FIGURE 3 Bicycle parking supply and demand in Shanghai CBD.

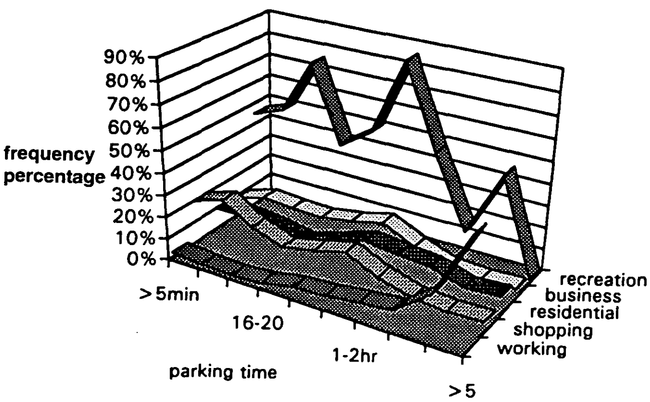

FIGURE 4 Distribution of parking time by trip purpose.

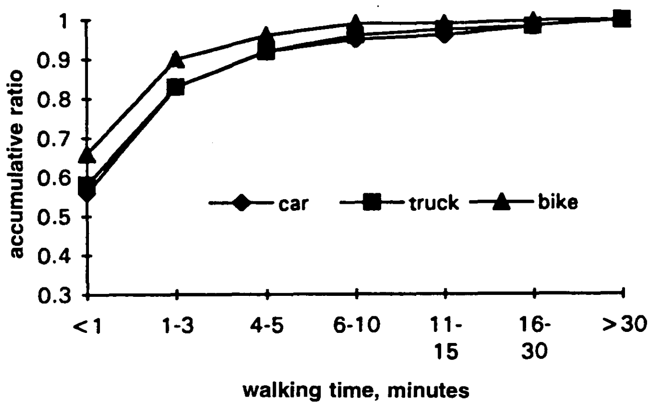

FIGURE 6 Distribution of parkers' walking time.

Parking Purpose Distribution

In the CBD, most bicycle riders are parking for shopping (about 40 percent), whereas those parking for business and work are 8.4 and 10.2 percent, respectively (see Figure 5).

Walking Time Distribution

The walking distance for bicycle riders after parking is shorter than that for motor vehicle drivers (see the accumulation curve in Figure 6). About 67 percent of riders walk a distance that is within 1 min of parking. This indicates that most bicycle riders do not want to walk long distances after parking.

Influence Factors of Parking Decision Making

A total of 4 influence factors (i.e., walking distance, safety, toll fee, and convenience in finding a parking place) and 790 samples of bicycle riders were selected for the study in June 1993. The first consideration for more than 80 percent of riders is walking distance (see Table 1). The weighted average of the order of riders' consideration is distance, security, toll-fee, and convenience, in turn. The tolerance level for walking distance after parking is 300 m (74 percent of interviewees, see Table 2).

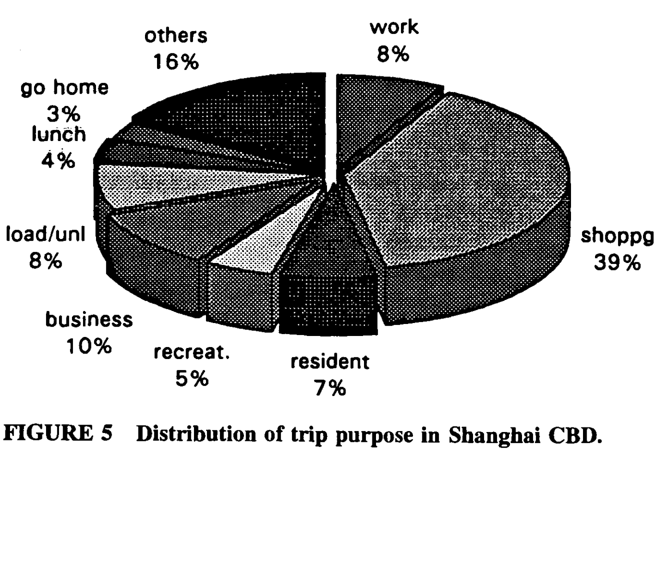

FIGURE 5 Distribution of trip purpose in Shanghai CBD.

Comments on Parking Payment and Travel Mode Selection

Payment for parking is not widely tolerated by most riders. The acceptable parking fee is 0.20 yuan (91.24 percent of the sample). Because most bicycle drivers believe that parking should be free because of the lower level of service in public transit, 78.01 percent believe that they will change the travel mode from bicycle to transit only if the travel time of transit becomes shorter than that on a bicycle. A total of 63.6 percent of bicycle riders expect to have a motorcycle even if the price of it is twice their monthly income.

FORECASTING DEMAND IN CBD BICYCLE PARKING

Forecasting the demand for bicycle parking precisely in a particular year is the foundation of bicycle parking planning in the CBD, the most concentrated source of traffic in the city. Two types of a parking demand forecasting model were set up by the authors: one is the model of the relationship between parking demand and land use, a kind of category analysis model, in which the intensity of land use in the city can be expressed by the number of employment positions; the other is the relationship between parking demand and trip attraction—a linear regression model.

Relationship Between Parking Demand and Land Use: Category Analysis Model

The relationship between parking demand (indicated by maximum parking accumulation) and land use intensity can be expressed by the following:

$$BP_{ik} = f(L_{ik}) = \alpha_i L_{ik} \quad (1)$$

TABLE 1 Order of Reasons for Bicycle Parking

Reason		Selected order 1	2	3	4	Weighted average of order
walking dist.		634	128	21	7	1.24
	(%)	80.3	16.2	2.7	0.9	
security		104	378	208	100	2.39
	(%)	13.2	47.9	26.3	12.7	
acceptable fee		25	265	327	173	2.82
	(%)	3.2	33.5	41.4	21.9	
difficult to find		27	124	208	431	3.32
other places	(%)	3.4	15.7	26.3	54.6	

where

BP_{ik} = maximum parking accumulation in land use Type i of Zone k,
L_{ik} = intensity of land use for land use Type i of Zone k, and
α_i = parking demand rate of land use Type i.

Total bicycle parking demand at peak hour BP_k for a zone is

$$BP_k = \sum BP_{ik} = \sum \alpha_i L_{ik} \qquad (i = 1,2,\ldots,m) \qquad (2)$$

Parking demand in n zones can be formulated as the following expression:

$$\mathbf{BP} = \boldsymbol{\alpha}\ \mathbf{L} \qquad (3)$$

where

BP = vector of bicycle parking demand,
α = parking demand production matrix, and
L = land use intensity index matrix.

Basic year **BP** and **L** collected in CCA of Shanghai can be input to calibrate **α** in Equation 3. The algorithm used in model calibration is nonlinear programming, that is, an objective function and constraint condition are selected. The nonlinear programming model can be expressed as the following:

Objective function:

$$\min f_m = \sum (BP_k - \sum \alpha_i L_{ik})^2 \qquad (4)$$

Subject to

$$\alpha_i \geq 0 \qquad (i = 1,2,\ldots,m) \quad (k = 1,2,\ldots,n)$$

The index of Demand Model α_i (see Table 3) is calibrated by inputting the maximum parking accumulation and employee numbers of 13 land use types in 14 zones of the CBD of Shanghai that were surveyed in the basic year (1987). To solve Equation 4 is to iterate the algorithm by computer model until the precision

TABLE 2 Tolerant Values of Bicycle Parking Service

Section of tolerant value		Acceptable percentage for different trip Purposes (%) Work	Shpg	Bsns	Rcrt	Othr	Sum	Number of sample
Walk dist.	<100	8.5	10.9	8.0	1.3	6.5	35.1	780
	100-300	11.9	9.2	6.7	1.2	10.5	39.5	
(meter)	300-600	3.9	3.5	1.9	0.6	4.7	14.6	
	600-900	1.3	0.8	0.4	0.1	1.8	4.4	
	>900	3.7	0.1	1.0	0.1	1.4	6.4	
Parking fee	<0.05	1.2	1.5	0.4	0.3	3.4	6.7	742
	0.05-0.1	14.6	12.4	8.9	3.2	12.7	51.8	
	0.1-0.2	9.6	6.2	7.8	1.4	7.8	32.8	
(yuan)	0.2-0.3	1.9	2.4	1.9	0.4	0.4	7.0	
	>0.3	0.1	0.4	0.9	0.0	0.3	1.7	
Critical	1/2-1	23.1	19.0	15.2	3.4	17.3	78.0	764
transit	1-3/2	3.8	4.3	2.9	1.1	3.5	15.6	
transfer	3/2-2	1.7	0.8	0.5	0.3	1.8	5.1	
time ratio	>2	0.5	0.4	0.0	0.1	0.3	1.3	
Critical	<1/4	4.5	4.3	3.8	0.9	3.8	17.3	445
motorcycle	1/4-1/2	12.8	15.3	8.1	1.4	8.8	46.3	
transfer	1/2-3/4	10.8	5.4	5.2	0.7	7.9	29.9	
time ratio	3/4-1	1.6	2.7	0.9	0.0	1.4	6.5	

TABLE 3 Forecast of Bicycle Parking Demand for Different Land Uses in Shanghai CBD, 2000 (4)

Zone	1 House hold	2 Heavy indst	3 Light indst	4 Colleg	5 High Schl	6 Admn Offc	7 Busn	8 Recre	9 Hotel	10 Ware-house	11 Const side	12 Hospl	13 Other	Total
α_i	0.038	0.023	0.05	0.099	0.011	0.242	0.100	2.087	0.010	0.080	0.011	4.069	0.011	
0101	8.7	22.5	226.0	11.4	2.4	1982.0	274.9	377.8	0.0	15.1	3.1	590.0	3.7	3517
0102	19.6	10.1	209.8	11.1	10.6	767.5	1472.9	943.5	22.8	14.9	3.5	596.6	6.1	4061
0103	5.3	4.0	60.6	18.6	4.0	294.9	228.3	2452.7	0.0	17.0	6.1	150.5	10.5	3252
0104	19.7	10.7	123.6	11.4	3.9	199.8	250.1	77.2	0.0	8.8	1.5	447.6	2.7	1157
0105	11.1	1.7	98.5	0.0	2.4	245.4	296.3	711.8	11.6	3.1	2.9	451.6	4.3	1841
0106	13.1	6.7	119.7	18.5	4.6	33.9	432.2	837.0	11.5	8.4	3.9	606.2	5.3	2401
0107	25.0	88.5	621.0	41.2	16.2	950.1	1296.1	1795.2	30.2	32.9	6.2	1066.0	8.1	5976
0108	8.4	17.4	142.8	28.5	6.9	1414.5	382.2	77.2	15.5	23.6	7.5	1224.7	2.0	3351
0109	12.3	4.2	103.7	4.1	3.5	834.2	657.9	75.2	3.7	18.0	3.0	455.7	8.5	2184
0110	4.2	7.5	87.4	6.7	3.2	1315.6	271.9	81.4	0.0	6.2	1.6	313.3	2.9	3873
0111	2.8	14.9	143.0	0.0	3.2	2174.0	302.5	761.9	3.7	11.2	9.9	447.6	2.9	3878
0112	5.5	2.4	111.2	7.2	2.4	809.5	287.2	148.2	14.8	2.9	1.1	150.5	3.7	1546
0113	10.8	0.9	47.2	0.0	1.9	126.8	343.9	1173.1	7.5	3.0	5.3	0.0	7.2	1727
0114	12.5	36.3	256.8	40.9	5.1	1190.5	510.3	548.9	15.4	27.4	3.4	1236.9	3.7	3888
Total	159	227	2351	199	70	12639	7006	10061	137	193	59	7710	72	40881

of the result is acceptable. If land use data of the particular year are available, the demand for bicycle parking in the CBD can be estimated using Equations 2 and 3 and the index of demand model in Table 3.

The number of employment positions in the CBD in the year 2000, as shown in Table 4, is available from the comprehensive urban plan of Shanghai (*1*). Included with those data are the estimated numbers of bicycle parking spaces needed for the future (Table 3).

Relationship Between Parking Demand and Bicycle Trip Attraction: Linear Regression Model

Demand for bicycle parking will be produced wherever there is an end to a bicycle trip. Obviously, the greater the trip attraction, the greater the need for bicycle parking. The relationship between parking demand and trip attraction is shown in Figure 7. Assuming that there is a linear relationship between bicycle trip attraction and bicycle parking demand,

$$BPN_k = a + b\,DB_k \qquad (5)$$

where

BPN_k = maximum bicycle parking accumulation in Zone k;
DB_k = bicycle trip attraction in Zone k; and
a,b = regression factors.

Regression factors a and b are calibrated by inputting basic year data from 14 sets of BPN_k and DB_k in the CBD:

$a = -136.59$

$b = 0.1829$

Relative factor $R = 0.88$

The model passed the t-test and the F-test.

Parking demand in the year 2000 also can be obtained from the above model if the number of bicycle trip attractions in that year is available (see Table 5).

Comments on Bicycle Parking Demand Modeling

The land use approach is widely used to forecast transportation demand. It is also used to predict the demand for bicycle parking. Comparing it with the land use–related model, the output of the trip attraction–related model does not directly link to land use parameters, but trip attraction is estimated using a land use parameter as an independent variable. Finally, the demand in parking is a function of the land use.

The total demand for bicycle parking in the CBD of Shanghai calculated by the category analysis model is 40,881; calculated by the linear regression model, it is 38,193. The difference between these two results is only 6.5 percent. Such a small variation shows that one model can be a proof to the other, although the models are set up differently. Thus the models are reliable in forecasting future bicycle parking demands.

Two models have different functions: the land use–related model is more likely to become the standard for bicycle parking spaces with different land use types, whereas the trip attraction–related model can be applied to quick-response parking demand estimation during the urban transportation planning process.

BICYCLE PARKING PLANNING AND STRATEGY

Quantitative analysis of bicycle parking in the CBD made the situation more understandable. Bicycle parking demands in a specific period can be figured out using the models mentioned earlier. The studies show that the quantity of bicycle parking demands surpasses the facilities that can meet the demands in this area. The fundamental way to overcome the shortage is to provide efficient facilities while controlling the demand.

Analysis of Shortage of Parking Facilities in Shanghai CBD

Shortage of Facilities

Nearly all the zones in the CBD bicycle parking are oversaturated during the peak period simply because of insufficient parking facilities. There are 275,000 bicycles registered in the CBD, and 150,000 to 180,000 bicycle trips are made to this area. But the area of total parking facilities for both motor vehicles and bicycles is only 55,000 m^2—only about 1.3 percent of the CBD area. Furthermore, there is no standard public garage or parking lot for bicycles.

Inefficient Parking Management

There is neither a form of authority and enough responsible staff to manage bicycle parking in the CBD nor a practicable policy and law to restrain bicycle parking. Many parking lots are unable to run because of the high cost.

Illegal Road Occupancy and Parking

Many bicycle riders ignore the traffic signs and park their bicycles casually. In addition, some foot vendors stand their bicycles and hawk their wares on the street.

Planning Bicycle Parking and Managing Measurement

Comparing the available bicycle parking facilities with the parking demand that is predicted using the earlier model indicates that there will be a shortage of 20,000 bicycle parking spaces in the year 2000. The way to solve the problem is to combine reasonable planning and effective demand control in this region.

Plan To Build Public Bicycle Parking Facilities

To keep the balance between parking demands and land use resources, five public bicycle garages are planned in the CBD (see Figure 8). The largest one (about 5,000 m^2) will be located at the People Square, the hub of public transit (subway and bus line). An increase of 13,000 parking spaces will be produced by the plan.

TABLE 4 Predicted Employment in Shanghai CBD, 2000 (*1*)

Zone	1 House hold	2 Heavy indst	3 Light indst	4 Colleg	5 High Schl	6 Admn Offc	7 Busn	8 Recre	9 Hotel	10 Ware-house	11 Const side	12 Hospl	13 Other	Total
0101	230	997	4687	115	227	8173	2743	181	0	188	291	145	332	17353
0102	519	446	4352	112	1005	3165	14688	452	226	185	332	140	557	24739
0103	142	180	1256	188	376	1216	2278	1175	0	212	579	37	957	6811
0104	523	475	2563	116	369	824	2495	37	0	110	141	110	252	7402
0105	295	74	2044	0	224	1012	2956	341	115	39	276	111	394	6946
0106	347	299	2483	187	438	1377	4312	401	114	105	374	149	484	9844
0107	664	3930	12882	416	1534	3918	12931	860	299	409	587	262	737	37135
0108	223	771	2962	288	664	5833	3813	37	153	294	713	301	185	14591
0109	327	186	2150	41	337	3440	6564	36	37	224	287	112	770	13081
0110	110	332	1813	68	302	5425	2713	39	0	77	151	77	266	10802
0111	73	660	2967	0	302	8965	3018	365	37	140	947	110	265	16350
0112	147	107	2307	73	227	3338	2865	71	147	37	100	37	332	9135
0113	286	39	979	0	184	523	3431	562	74	37	500	0	651	6004
0114	331	1610	5327	413	482	4909	5091	263	152	341	324	304	340	18426
Total	4217	10106	48772	2017	6671	52118	69898	4820	1354	2399	5602	1895	6522	198619

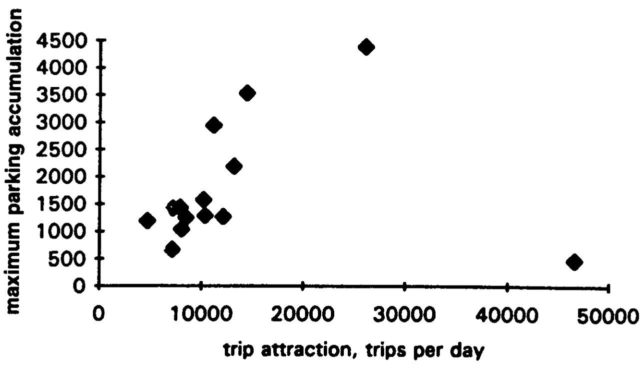

FIGURE 7 Bicycle trip attraction and parking demand in Shanghai CBD.

Administration authorities should provide a policy that would encourage developers to invest in bicycle parking facilities and make the construction, operation, and management an attractive business.

Restricting On-Street Bicycle Parking

Arranging an on-street bicycle parking lot while considering local conditions is the effective way to provide a short walking distance (within 200 m) and temporal parking at a lower cost. The capacity of a potential on-street parking lot is 5,000 bicycles, but inefficient control of on-street bicycle parking will disturb traffic greatly, especially where it is close to the arterial. Bicycle parking on the streets across the arterial should be restricted within 50 m of the intersections.

Work Parking

All employers in the CBD should provide bicycle parking spaces for their employees. Occupancy of the public parking space for work parking is forbidden and should be fined.

Short-Term Bicycle Parking Improvements

It will take a long time to realize the CBD bicycle parking plan. A pressing need to alleviate the shortage of CBD bicycle parking facilities is short-term improvements, such as strengthening the management, rigorously enforcing payment for parking, and restricting the parking demand. The following policies and measures will be exercised:

1. Establish an authority responsible for rectifying and enforcing the plan. The functions of the authority are to work out a scheme, examine and approve the business of a parking garage and parking lot, set up the parking payment standard, and participate in developing a large public garage.
2. Use societal resources to improve the bicycle conditions in the CBD. Encourage residents to open vacant lots for temporal bicycle parking with the help of a favorite policy and subsidy so as to increase the available parking spaces in urgent-need areas.
3. Adjust the parking demand by using economic levers. A parking toll system should be set up according to the differential price of land. All bicycle owners should be levied extra taxes and all bicycle riders should have to buy a special license plate if they enter the CBD.

SUMMARY

Bicycle parking, an important component of the transportation process in China, merits extensive investigation. Some of the important regular patterns of bicycle parking in the CBD, such as the relationship between parking demand and facility supply and the character of bicycle parking behavior have been revealed. In addition, because of the continuous study in the CBD and CCA of Shanghai, the relationship between land use parameters has been modeled and calibrated. All of these achievements are the

TABLE 5 Bicycle Parking Trip Attraction and Maximum Parking Demand in Shanghai CBD

	Survey Value(1987)		Forecasting Value(2000)	
Zone	Trip attraction	Max. parkg Accumulation	Trip attraction	Max. parkg Accumulation
0101	7180	1420	12717	2189
0102	26039	4399	33460	5983
0103	10362	1285	15770	2748
0104	12110	1269	13768	2382
0105	13196	2197	18303	3211
0106	11147	2942	19404	3412
0107	14455	3533	25906	4602
0108	8027	1040	6984	1141
0109	10194	1579	18471	3242
0110	4662	488	7884	1305
0111	7121	667	8615	1439
0112	4699	1192	6468	1046
0113	8483	1254	17291	3026
0114	7898	1441	14234	2467
Total		24706		38193

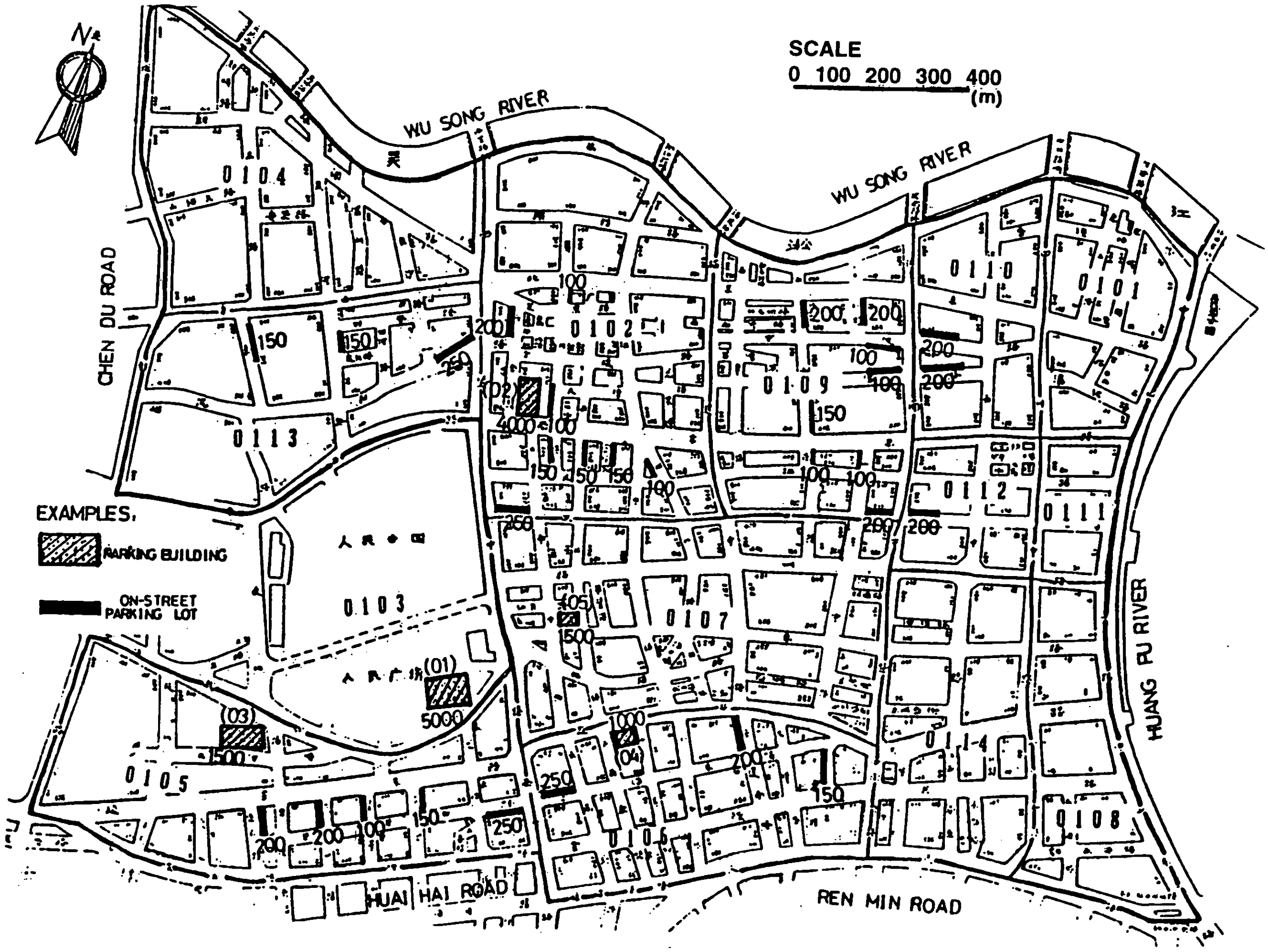

FIGURE 8 Plan for bicycle parking spaces in Shanghai CBD.

bases of demand forecasting, bicycle parking planning, management, and facility operation.

The main methods to alleviate the bicycle parking facility shortage and to maintain the equilibrium of supply and demand are to distribute the facilities in a rational manner and effectively control the excessive demand in this area. The package provided is feasible in most cities of China, where bicycle riding is the principal travel mode.

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PART 2

Cost and Consequences of Mobility

Women and Nonmotorized Transport: Connection in Africa Between Transportation and Economic Development

JULIA PHILPOTT

Transportation is a vital element of every healthy economy and is crucial to any strategy that addresses poverty. Africa, a region struggling to alleviate rampant poverty, will have its success dictated largely by development of its transportation sector. In Africa, as in the rest of the world, a planning process that does not adequately assess the transport needs of its users is rendered far less effective than one based on a more comprehensive and inclusive analysis. Women, responsible for most transportation demand in Africa, have been mainly ignored by the current process. Both rural and urban women carry out a variety of tasks that often require trips of considerable distance. Most of these women, members of Africa's impoverished majority, cannot afford motorized transportation. Chores requiring transportation are carried out using carts, shoulder poles, and bicycles. However, transportation planners, development professionals, and policy makers continue to address mobility needs with projects and policies that are based on motorization. If the intended outcome of transportation planning in Africa is economic development and an increased standard of living, alternatives to a transportation system based on motorization must be a primary part of any policy and planning effort. Women traditionally have been responsible for almost all household production and transport labor associated with agricultural production. They hold a primary transport role in both urban and rural areas. Adequately assessing and addressing the nonmotorized transport needs of low-income women are crucial to bridging the connection between transportation planning and policies, transport technologies, and economic development in Africa.

Transportation is a vital element of every healthy economy and is crucial to any strategy that addresses poverty. Given that Africa is a region with many struggling economies and high rates of poverty, transportation and poverty alleviation strategies should go hand in hand. A planning process that does not adequately assess the transport needs of transportation system users or stakeholders, many of whom are low-income women, is rendered far less effective than one based on a more comprehensive and inclusive analysis. The purpose of an efficient transportation system is typically to spur economic progress and enhance overall quality of life. A transportation planning process that emphasizes private automobile use and motorization at the exclusion of other options and does not adequately assess and address transport demand of the system's users or stakeholder groups typically does not result in an efficient transportation system that serves transport needs and spurs economic progress to its greatest potential.

The problem is that although transportation planners, development professionals, and policy makers address mobility needs with projects and policies based on motorization, most transport needs of low-income people are met by some form of nonmotorized transport. A recent United Nations survey shows that in several large cities in Africa walking accounts for at least half of all trips (*1*). In rural areas, which comprise some of the poorest and most undeveloped communities, most trips related to household and agricultural production are made by women hauling carts and using shoulder poles. The frequent marginalization of nonmotorized transport by development strategists has resulted in transportation systems that often fail to meet the needs of women.

Modern transportation planning has continued the trend of ignoring the needs of one of its major stakeholder groups. The region's transportation sector uses 20 to 40 percent of public investment funds, with over 80 percent of these funds for road construction. More than 20 percent of loans from the African Development Bank between 1973 and 1989 were targeted for transport projects, of which 90 percent went for roads mostly in urban areas (*2*). In the face of this high level of investment in a transportation system based on automobile ownership and the use of motorized transport, less than 1 percent of the population in developing countries can afford an automobile (*3*). The situation is similar in Africa. Given that the price of a medium-sized car is the equivalent of 12 to 15 years' salary for the average person (*4*), only a few people own automobiles in the region. Other forms of motorized transport are also expensive relative to income. Even with subsidies, the cost of a bus ride is often beyond the financial reach of many. But the emphasis on the automobile and motorized transport persists, at the exclusion of other more affordable alternatives.

If the intended outcome of transportation planning in Africa is economic development and an increased standard of living, alternatives to a transportation system based on motorization must be a primary part of any policy and planning effort. Women traditionally have been responsible for almost all household production as well as much of the transport labor associated with agricultural production. They hold a primary transport role in both urban and rural areas. Adequately assessing and addressing the nonmotorized transport needs of low-income women are crucial to bridging the connection between transportation planning and policies, transport technologies, and economic development in Africa.

RURAL AND URBAN WOMEN'S TRANSPORT: SOME CHARACTERISTICS AND EXAMPLES OF OPPORTUNITY COST

Are there really transport considerations specific enough to women that they warrant deliberate attention? If so, what are they

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and how can they be assessed? A list of the common daily responsibilities of African women demonstrates the importance of nonmotorized transport. Women use carts for hauling, shoulder poles for carrying, animals for traction, and a variety of other nonmotorized alternatives to carry out other chores. The emphasis on women does not imply that men do not have transportation concerns. This paper recognizes the traditional and specific division of labor between men and women at the household level in Africa and attempts to elicit the unique set of transport concerns that have resulted for the continent's women. In many situations, rural and urban women go unrecognized as a transport stakeholder group with a specific set of transport concerns. The result is that their transport demand and the level of their need for transport resources is often inadequately expressed in a transport demand assessment or analysis.

Historically, women and girls in rural areas have shouldered most of the transport burden for the household in terms of time and volume transported. The majority of women's labor time in household production is dedicated to transport. Study after study (*5,6*) have identified trips for collecting water and firewood and trips related to agricultural production and marketing for the household as the main sources of transport demand in rural areas. For example, women and girls are responsible for approximately 79 percent of the total time spent on household transport in the Makete district of Tanzania and carry 90 percent of the total volume (*5*). In Beira, Mozambique, women typically spend 28 percent of their time in a 12-hr work day transporting agricultural materials and produce (*7*). Transporting water and firewood for the household consumes another 30 percent of their time. Table 1 shows how much transport time the average woman spends on foot in 1 year in rural Tanzania.

The total annual time an individual woman spends in Tanzania on transport is 1,648 hr, compared with that of a typical man who spends approximately 531 hr contributing to the same tasks. Children, mostly girls, average 296 hr per year carrying water, firewood, and agricultural products. A study from Burkina Faso concludes that the amount of time that girls between the ages of 11 and 17 spend on transport is three times higher than that of boys of the same age.

The amount of time spent on trips and the frequency of trips also differ for men and women. On the whole, women make trips related to household needs more often than men. The average woman makes three to four trips per day. She spends over 4 hr solely on transport and moves approximately 50 kg/day. The average man, by contrast, makes one trip per day related to household production. Trips for transporting water and firewood or trips related to agriculture usually are made under difficult conditions and without the use of carrying equipment. The most frequent methods of transporting heavy loads are headloading and the use

TABLE 1 Average Annual Time for Women Spent in Transport in Tanzania

Transport Activity	Hours Spent per Year (%)
Household water needs	510 (31)
Household firewood needs	302 (19)
Agricultural materials and produce	237 (14)
Accessing markets and village center	234 (14)
Accessing health and education	65 (4)

TABLE 2 General Household Trip Characteristics and Observations

Trip Characteristic	Observations
Movement of small loads	10 to 100 kilograms
Short distances	1 to 7 kilometers
High trip frequency	3 to 4 trips per day
Primary household transport responsibility	Women perform majority of household transport tasks
Non-motorized transport	Headloading, backloading, shoulder poles

of a headstrap, both of which are known to cause considerable discomfort and countless injuries. In addition to carrying 40 kg by headloading, a woman often also carries one of her children. Despite potentially harmful physical effects, headloading and the headstrap remain prevalent because of their affordability. Rural trips related to household and agricultural production are characterized in Table 2.

A survey discussed by McCall (*6*) reflects that up to 50 percent of the average working day on a farm in Africa is devoted to walking to and from fields, often with a load on the head or back. In northern Nigeria, for example, women may spend as many as 7 hr/day traveling to and from the fields. Other studies confirm that up to 20 percent of women's total household labor time is spent walking and headloading. Because headloading goods uses labor that might otherwise be devoted to agricultural production, Pankaj of the World Bank observes that the opportunity cost of headloading makes it about 8 to 12 times more expensive than any other method of transport (personal communication, July 3, 1988). Inadequate transport causes a decrease in productivity and the effective working day. On the basis of an 8-hr working day, walking 4 km to a plot reduces fieldwork time by approximately 25 percent. Each additional kilometer walked to reach a plot represents an additional 5 percent reduction in the time that can be devoted to productive purposes (*6*).

Rural women are not the only ones who have a difficult time getting the transportation they need. Urban women face similar challenges. In Africa, the rate of urban population growth is much higher than that in the rest of the world. Most of the added population will probably join the existing urban poor in shanty dwellings located in extended areas that have sprung up within a radius of 10 to 20 km around the cities (*8*). These areas typically have bad roads and are far from city centers and other places with essential services. Women in these regions need transportation to work and run their households. Urban trips to and from paid work made by women replace those associated with rural agriculture. Many women work in the child care and domestic sectors and therefore have a wide variety of destination points throughout the city that are not necessarily on a public bus route. Generally, poor urban women make fewer trips than higher-income women because of transportation's high cost relative to their incomes. An average low-income family will spend approximately 30 to 40 percent of its earnings on transport, compared with 5 to 7 percent for families with more income. The mobility of the poor is therefore essentially limited to procuring necessities such as work, food, and water.

One of the most difficult dynamics faced by the urban poor is that, as rents in the city increase, they are pushed farther and farther to the outer perimeter, where rents are more affordable. Unfortunately, these residential areas are often seen as undesirable squatter settlements by governments. In an attempt to deal with them, some governments have a policy to periodically raze these settlements by bulldozer. Obviously, this policy adds to the difficulty of establishing public transportation services or paratransit services offered by the informal sector. People are left with very few economic choices of where to live and how to get themselves to work or to the city to search for work. Women in particular are hit hard; the nature of their employment is such that the destination points are often varied, making adequate transportation even more difficult to procure.

EASING THE BURDEN AND SPURRING ECONOMIC DEVELOPMENT: ROLE OF NONMOTORIZED TRANSPORT

Several obstacles to economic development are access to transportation resources and access to an accommodating transportation infrastructure. In any serious strategy to address poverty and spur economic development, through either microenterprise or increasing the volume of agricultural produce taken to market, transport is an important piece of the puzzle. To increase the productivity of women, transport is critical.

What are a few of the measures that can be taken to alleviate the transport burden for women and their communities and aid economic development? There are several. In household sites and services planning, for example, the necessity for trip making would be reduced if water pumps and health care facilities were located closer to households. In land use planning, reserving land for low-income residents through zoning regulations would assist in locating workers' homes closer to employment opportunities. Recognition of squatter settlements would permit transportation routes for bus service, paratransit, and nonmotorized transport to be established. Some of the most important steps that could be taken to reduce the transport burden are as follows:

- Reduce the frequency of trips and distance over which goods and services must be carried through land use and site planning;
- Improve, provide, and maintain a nonmotorized transport infrastructure, including roads, paths, and tracks; and
- Develop and stimulate the private sector to provide more efficient and affordable transport and load movement technologies.

Can nonmotorized transport serve as an economically viable part of a development strategy? If an individual is able to transport a larger volume of goods at a faster rate, the result is an increase in productivity and income. Although little analysis has taken place, some preliminary data show that nonmotorized transport can have an exceptional internal rate of return. According to preliminary data, although the average rate of return on road infrastructure projects is about 22 percent, the direct provision of bicycles at market value to fisherman in Mozambique showed an internal rate of return of almost 400 percent (*9*). Although the internal rate of return will certainly vary according to circumstance, these data suggest that infrastructure investment in nonmotorized transport is worthy.

Technology has a central role to play as well. Although it is clear that carrying aids (such as improved backframes or carrying poles) can help women carry heavy loads, pedal-driven vehicles can be more advantageous in the right situation. The reason is basically speed and the volume that can be carried: a person can travel about three times faster on a bicycle and move even heavier loads than headloading or porterage. Additionally, pedal-driven vehicles use human energy four times more efficiently than walking (*10*). Bicycles by themselves or with carts can be particularly beneficial to women because they can reduce total daily travel time. For example, if it takes a woman 15 min on foot to travel 1 km but 8 min by bicycle, with all other factors being equal, a bicycle would reduce her annual transport time by almost half, from 1,648 to 878 hr. The additional time available for other activities would amount to almost 2 hr/day. In Mozambique, the average cargo carrying capacity of headloading was 17 kg. After the acquisition of the bicycle, the average amount transported increased to 26 kg (*11*). It is important to note, however, that the type and size of the bicycle are important. For example, for most labor needs, it is not necessary to have a 15-speed bicycle. Additionally, a bicycle that is too big or bulky would not be as easy or as productive to use.

Optimum results are more likely to occur when a combination of solutions works together. Transportation initiatives should incorporate land use considerations, as well as site-specific factors (such as household proximity to a water pump) to be most effective. The result of this comprehensive style of planning would be to increase an individual's time and personal energy available for other economic activities such as cultivation, education, income generation, or any other activity associated with enhancing the quality of life.

OVERCOMING OBSTACLES AND STEERING A NEW COURSE

In much of Africa the prestige and power of automobile ownership, based on an emulation of Western ideals, have led governments to ignore nonmotorized transport as a legitimate transportation option. In many countries, an attitude of disdain exists toward bicycles; they are seen as vehicles of the poor and symbols of backwardness. To achieve successful integration of the nonmotorized and motorized sectors, several important conditions are needed, including (*a*) political support from local, regional, and national governments; (*b*) private-sector support, such as providing credit and finance arrangements for low-income people; and (*c*) inclusion of nonmotorized transport in all transportation and land use plans. Examples of each follow.

Political Support

An example of political support and commitment to human-powered vehicles as a partial solution to transport problems can be found in Accra, Ghana. After years of encouraging motorized transport, the government of Ghana recognized that its transport sector was failing to meet the most basic requirements for moving people and goods. With assistance from the World Bank and Intermediate Technology Transport, a nongovernmental organization based in the United Kingdom, the Ghanaian government is now promoting the production and use of bicycle trailers and handcarts and is considering a proposal to build low-cost rural roads intended for human-powered vehicles. The roads may also accommodate an occasional jeep without upgrading the construction standards. They would cost about $2,400/km, or roughly 8 percent of the conventional rural road cost (*12*).

Private Sector

Transportation affordability for low-income people is perhaps the most critical obstacle to overcome. In Santo Domingo, Dominican Republic, a credit union of *tricicleros* helped finance vehicle purchases and a tricycle assembly workshop (*12*). Another example of private-sector support is found in Hyderabad, India, where commercial banks were encouraged to lend money to cycle rickshaw operators for the purchase of vehicles. Another mechanism for extending credit in India is that every government employee is entitled to a loan for a vehicle, which can be a bicycle, motor scooter, or car, depending on salary level.

The average cost of a bicycle in West Africa is approximately 60,000 CFA, or U.S. $120 (assuming U.S. $1 = 500 CFA), depending on the model and import taxes levied. How will a domestic worker in Senegal, who typically earns 500 to 1,000 CFA (U.S. $1 to 2) a day, or a rural farmer in Tanzania whose income is irregular, save enough money to purchase a bicycle? Just as the typical middle-class family in an industrialized country buys its automobiles on credit, similar credit arrangements can be devised to enable low-income people in developing countries to buy bicycles and other forms of nonmotorized transport.

Land-Use Planning

There should be a review of zoning regulations and urban planning practices to remove provisions that contribute to excessive separation of residential areas, working places, and services. There should also be some means of providing affordable land for residential settlement to reduce urban sprawl. In terms of urban planning, design elements that accommodate pedestrian and bicycle uses should be standard elements in transportation and land use plans. The ideal physical design would separate cyclists and pedestrians from motorized traffic. Reducing speed limits for motorized traffic and educating the users of nonmotorized and motorized vehicles to respect one another's needs on the road would go a long way toward creating an environment in which all means of transportation safely coexist. In Rio de Janeiro, Brazil, the Institute of Technology for the Citizen is developing a bicycle master plan for the city that reallocates street space to enhance the safety and viability of nonmotorized alternatives.

Some Other Important Considerations

How can transport needs for women, and communities in general, be better assessed? In assessing needs at the community level, and of women in particular, one should begin with an analysis of the household. Although this is not a revelation in project planning or design for development programs and projects, it is still too often overlooked as an integral part of any development effort's success. A comprehensive and inclusive household analysis, disaggregated by both gender and age, should include the following:

- Household data on the means of transport, travel time and distance, travel volume and frequency, and trip purpose and destination;
- An analysis of transport requirements, the extent to which these transport requirements are currently being met, by what methods, and available resources; and
- Identification, in conjunction with the local people, of suitable, low-cost vehicles, available credit, and forms of ownership and operations.

One of the most important parts of any effective analysis of a transport project is affordability. A transport policy or project may be technologically appropriate, but if it is not affordable, it cannot be effective. Although bicycles and other nonmotorized vehicles are comparatively low cost, they are not always affordable to many of the poor, especially women. The issue of affordability is especially acute for women because, according to custom, many give their incomes to the male heads of the household and must gain their consent to obtain credit. Providing credit directly to individual women, therefore, should be a priority.

In the best of all possible worlds, a solution to the general transportation demand would meet the needs of the low-income majority. It would be affordable, serve a variety of destinations and points of origin, minimize capital outlays, and be environmentally sound. Such a solution exists: a comparative planning process that incorporates policy and technology options and social and environmental costs into regional and local transportation planning. Such a process would compare, for example, the cost of building a road with the cost of enhancing bicycling and pedestrian facilities and would offer a framework for choosing the least expensive means of satisfying transport demand. The results of this process would

- Provide a balanced mix of public and private transport modes that serve a given area in the prevailing social, economic, and environmental circumstances;
- Be convenient, reliable, and safe and serve the needs of all users, including pedestrians, cyclists, and those using animal-drawn vehicles;
- Have minimal adverse effects on the natural and manmade environment; and
- Make rational use of energy and land resources.

This type of planning process, which considers societal and environmental costs for each option, bodes well for low-income people, women in particular. It will allow options other than road construction for motorized transport to be considered—options that may be more relevant to women's economic and social circumstances. By comparing the costs and benefits of a variety of options, the particular transport requirements of women and the value of nonmotorized transport will become more difficult to marginalize. Without relevant transportation policies and technologies that provide for the needs of those who depend on the system, communities are isolated from the resources they need for economic development.

The need for increased and affordable mobility options, not just for women but for everyone, can be partially met with the bicycle as well as other affordable, traditional, nonmotorized means. Bicycles and other human-powered vehicles can enhance people's mobility at little cost, improve access to vital services, and create a wide range of employment opportunities. They are a legitimate transport solution that is long overdue.

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Urgent Need for Environmental Sustainability in Land Transport in Developing Countries: An Informal Personal View

R. J. A. GOODLAND

More attention to the environmental aspects of the transport sector and updated policies are needed—if not overdue. Global environmental impacts, i.e., more with land transport than with water or air are discussed. The main environmental impacts of land transport as well as social, human health, and international problems directly attributable to these environmental impacts are identified. A menu of public policy solutions is offered to address these problems from two directions. First, policy should be focused on managing the demand for transport. Full-cost pricing of transportation and improved traffic management are two such demand-oriented options. Second, from a supply perspective, the promotion of nonmotorized transport is the best way to ease transport-related environmental impacts.

Proponents of modern transportation confront a burgeoning global environmental movement. Where they see personal mobility as an expression of freedom and as essential to economic progress, many environmentalists view transport as a principal source of social and environmental ills. As expected, both poles have justifiable elements, and the truth lies somewhere between the extremes. Certainly the 14,000 mi/year traveled by the average American does not confer a higher standard of living than that of the average Japanese, who travels only 5,600 mi/year. Fortunately, increased efficiency within the transport sector is pleasing to proponents of modern transportation as well as to environmentalists.

Current trends in transportation demand and energy use impose massive environmental and social costs. Formerly, when such costs were small it was reasonable that these costs were externalized. Now, however, these environmental costs are so large that their continued externalization is decreasing welfare. The purpose of this paper is to identify problems and solutions pertaining to the environmental costs of the transport sector and to suggest much needed policy changes. At the core of the transport/environment dilemma is the fact that most options involve difficult trade-offs among technical feasibility, economic costs, and market acceptance (*1*).

Transport imposes major negative impacts on the environment, and these impacts are among the most severe of all sectors of the global economy. Quinn (*2*) goes so far as to state the basic premise that transport itself is a cost—a means to an end. The aim of environmentally sustainable development is to reduce such costs while increasing the benefits, or at least holding them constant. In the competition between people and machines, environmentally sustainable development must be met by shifting the balance in favor of people. Transportation spending as a percentage of domestic spending is high and rising. Historically, transport costs have not reflected internal costs such as road construction and maintenance, let alone external costs. Noninternalized social costs of road transport are about 5 percent of the gross domestic product for the Organization for Economic Cooperation and Development (OECD) (*3*). This means that environmental and social costs are exacerbated by the subsidized transport sector.

A fundamental shift is under way in the global motor industry. Until 1990, OECD nations accounted for 90 percent of the 50 million cars sold (*4*). Saturated markets in these countries are expected to grow very slowly in the coming years. Growth is expected to be in the advanced developing countries, especially Asia where demand grows at 7 percent a year—an unsustainable doubling every decade. Car sales are rising at 10 percent per year in Thailand and China, where the government has declared development of the motor industry to be a national priority (*5*). Developing countries need help to avoid the damage and expensive mistakes of the industrial countries.

Clearly, human populations and automobile populations are linked. Likewise, global environmental effects are related to human numbers: everyone needs an irreducible biophysical minimum of such items as calories, cooking fuel, shelter, and clothes. Equally clearly, above that biophysical minimum overconsumption by one affluent northerner affects vastly more than one southerner. But at the risk of appearing to compare apples and oranges, the impact of today's annual output of 48 million cars vastly exceeds the impact of the annual human population growth of 90 million. This comparison merits detailed study. In the decade starting in the mid-1970s, the world vehicle population increased 4.5 percent per year—far faster than the human population rate (1.74 percent per year). In terms of consumption of natural resources and energy, contribution to pollution and disposal, one car has an effect on many times more than one (average) human. Although human numbers are often claimed to be the prime environmental problem of our day, the global environmental impacts per vehicle are far greater.

Transport demand, both passenger and freight, is a function of scale of the economy, which suggests that the time to hold transport impacts constant, or even to reduce them, has been reached. Although energy intensity (the amount of energy used per unit of output [joules per automobile]) is being reduced in OECD nations, this is not the case in most developing nations. In fact, energy intensity is actually increasing in most developing countries. The

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energy intensity of transport in developing nations appears still firmly shackled and worsening.

Practically the entire global motor vehicle fleet runs on fossil fuels, primarily oil, consuming about one-third of the world's oil production. Transport modes differ greatly in degree and type of environmental impact. Study is needed to ascertain the decision thresholds for people to choose between cars, mass transit, bicycles, or walking for a particular trip. Transport is not one of the basic human needs, but it may be required to satisfy the other needs of food, shelter, clothing, and so forth.

ENVIRONMENTAL IMPACTS OF TRANSPORT

The foremost environmental impacts of transport are derived from energy consumption. The transport sector consumes roughly one-third of total energy consumption worldwide, and within developed nations road transport consumes 84 percent of the energy, whereas air travel consumes 11 percent of the remaining energy. The burning of fossil fuels places an enormous burden on the environment. Automobiles account for 55 percent of CO_2 emissions, three-quarters of which are derived from passenger transport. For each gallon of fuel consumed, approximately 19 lb of CO_2 (5.3 lb of carbon) is emitted into the atmosphere (*6*).

Transport Pollution

Pollution from transport presents a bigger challenge than does pollution from industry or power generation because of the multiple and mobile sources of pollution in the transport sector (see Table 1). Industry sources, which are fewer in number and stationary, are easier to monitor. Furthermore, transport pollution embraces a wide array of pollutants, including noise, vibration, greenhouse gases, lead, and waste streams (e.g., tires, oil, discarded vehicles), all of which combine with depletion of natural resources (e.g., oil, steel, aluminum, rubber, plastic). Cutting the global emission of CO_2 will require actions on the part of north and south nations alike. However, because industrialized nations are most responsible for pollution and have better acccess to technology, they must lead the way in reducing carbon emissions if the south is to cooperate in any approach to global sustainability.

Disposal of Old Vehicles

The disposal of 40 million unserviceable cars each year imposes massive effects on environmental sinks. Mountains of used automobile tires, which have the potential to cause calamitous ecological damage, testify to the problem. Only a small fraction of junked cars are being recycled. However, the recycling of automobile parts is so difficult and expensive that disposal is far from becoming a profitable enterprise. One solution is to require that manufacturers play a more active role in recycling their own products or to manufacture them in such a manner that recycling becomes more profitable. Volkswagen and BMW have begun this effort, reducing the number of types of plastic used from about 300 to 20, and in 1993 making disassembly and recycling easier in their two newest plants. This should lead to a major and profitable recycling industry. Component recycling is overdue on any scale, whereas mandatory recycling is essential, but facilities are rarely available. In addition, incentives are needed to demote planned obsolescence and to promote repair and updating of vehicles. Some transport planners advocate a service approach, whereby the service provider takes back the vehicle when necessary for updating or recycling.

Land Use Impacts

Transport infrastructure imposes major, permanent, and often irreversible impacts on land use, such as loss of agricultural land, environmental services, photosynthetic capacity, recreational space, involuntary resettlement, damage to cities to make room for roads and parking lots, damage to buildings, social and community trauma, and disruption for pedestrians. Western Europe's 2.5 million km of roads alone preempts 29,000 km^2 or 1.3 percent of total land area (excluding intersections, junctions, and parking). By contrast, railways claim only 706 km^2. Developing countries with higher population growth rates and those already densely populated (e.g., Bangladesh) can less afford to lose even more national territory to less than optimal use.

Reduction in environmental impacts will require stabilization of preempted areas and improvement in the efficiency of existing transport infrastructure space. This includes traffic management schemes and environmental assessment of transport-related activities, as well as shifts from road travel to rail travel, and from automobile use to mass transit.

Centers of production and centers of population density are often distant. In developing countries, highways can shift the agricultural frontier. For example, the Polonoroeste program in the Amazon part of Brazil in the early 1980s was mainly a 1000-km highway project. The highway enabled peasants displaced from elsewhere to settle on unsuitable and infertile forest soils, leading to severe, often irreversible environmental and social damage. This was exacerbated by Brazil's "uniform fuel price" policy, which meant that fuel prices at the refinery gate were the same as those on the frontier 2000 km away.

Low-volume rural roads and low-cost feeder roads often are much riskier than highways and can lead to much more environmental damage. In addition, roads expanding the frontier lead to agricultural extensification distant from markets, as well as to environmental damage (e.g., deracination of vulnerable ethnic minorities, tropical deforestation, and use of defoliants and biocides on rights-of-way). A preferable alternative would be agricultural intensification closer to markets.

Similarly, most tropical wet forests have diverse river networks, the conversion of which into transport infrastructure could be achieved with little or no social or environmental damage. Failure to promote fluvial transport, where possible, is a major failure in economic development. Of course, navigability in the low flow season must be factored in. If fluvial transport is not possible, rail is much less damaging than roads partly because trains stop only at stations, thus reducing unplanned settlement.

Furthermore, vehicle production and road construction have an extensive impact on sources such as steel, rubber, lead, plastics, and aluminum. The impacts from road construction, which include stone quarries, cement manufacturing, asphalt, and significant loss of land, are not all captured in cost-benefit analysis. However, these costs should not be externalized; rather they should be routinely factored into the environmental assessment of transport de-

TABLE 1 Air Pollution from Road Traffic

SUBSTANCE	SOURCE	LIMITS	HEALTH EFFECTS	ENV. EFFECTS
Carbon monoxide	90% from all of transport sector, 65% from motor vehicles	100mg/m^3 over 15 minutes (86 parts per million) 10mg/m^3 over 8 hours (8.6 ppm)	Fatal in large doses; can affect heart, central nervous system, oxygen capacity of blood	Contributes to global warming by removing hydroxyl radical from the air
Nitrogen oxide	47% from vehicle emissions (OECD)	(for NO_2) 400 $\mu g/m^3$ over 1 hr, (208 parts per billion) 150 $\mu g/m^3$ over 24 hours (78 ppb)	Affects respiratory tract, lung function, susceptibility to viral infections	Acid rain, indirect contribution to global warming by forming smog
Ozone	Interaction of hydrocarbons and nitrogen oxides in sunlight	150-200 $\mu g/m^3$ over 1 hr (75-100 ppb)	Eye, nose and throat irritation; risks to asthmatics, children, heavy exercisers	Damage to vegetation and crops; contributes to global warming
Lead	Gasoline additive	0.5-1.0 $\mu g/m^3$ over 1 year	Very toxic: affects nervous system and blood, mental development of children, hypertension	Remains in soil, from which it reaches the food chain; inhaled directly into blood stream
Hydrocarbons	Up to 50% from vehicle emissions (excluding methane)	No general limit specified	Drowsiness, eye irritation, coughing	Indirect contribution to global warming by forming ground level ozone (smog)
Benzene	Vehicle emissions, evaporative petrol losses	WHO allows no safe level	Carcinogenic	None identified to date
Aldehydes	Vehicle emissions	No limit specified	Irritation of eyes, nose and throat; respiratory difficulties	None identified to date
PAH	Diesel fuel		Carcinogenic	
SO_2	Diesel fuel		Source of acid rain	
CO_2	Vehicle emissions		None	Greenhouse gas
N_2O		Trace		Greenhouse gas
CFC	Air conditioning systems			Ozone depletion
Particulates	Diesels	Lung damage		
Asbestos	Brakes, Clutches	Lung damage		

(Source: Greenpeace, 1992.)

sign. These costs can be substantial: one-third of United Kingdom construction material demand is assigned to road construction.

SOCIAL EFFECTS

Congestion

Besides the economic cost of environmental damage caused by the transport sector, the amount of time wasted as the number of vehicles grows at an unprecedented rate also needs to be routinely factored into transport decisions. At present, vehicle-miles are increasing one order of magnitude faster than road capacity. Between 1970 and 1990, the number and size of OECD roads increased by approximately 4 to 9 percent, whereas vehicle miles doubled (7). The result is congestion, which costs the United States $300 billion each year. However, because automobile production rates far exceed road construction, the problem continues to worsen. Suffice it to say that traffic congestion can be cured by road pricing.

Urbanization

Urbanization is inextricably linked with personal mobility needs. The quantity of movement (person miles traveled) grows geometrically as the city size increases. Average trip lengths vary from about 2 mi for a city of 50,000 to about 6 mi for a city of

1 million. This is because as city size increases, more trips have to be made by motorized means, resulting in proportionately higher operating costs and the neglect of the mobility needs of the poorest, who often cannot afford public transport. Along with the increased growth of urban areas in recent decades, there has been a global trend toward increased motorization of transport, vastly increasing energy consumption per passenger per mile or ton per kilometer.

Environmental Implications of Privatization

Privatization of some passenger transport systems is not attractive at present because significant environmental costs are externalized rather than paid by those imposing such costs. This is especially true in those developing countries in which gasoline prices are highly subsidized. Internalization of environmental costs would make privatization much more feasible. Public transport could charge higher fees and hence would not need subsidies, and they would be privatizable. Fuel tax increases would raise revenues, reduce environmental costs (e.g., pollution), and perhaps even reduce congestion.

Poverty, Transportation, and the Environment

Just as unrestricted human reproductive freedom is becoming widely seen to have major social costs (although J.S. Mill pointed it out in 1859), so does unrestricted mobility or "car freedom" impose massive social and environmental costs on non-car users. This argues for accelerating the transition to "full cost" pricing of the transport sector. The focus on poverty should include a focus on accessibility needs of the poorest. Furthermore, the provision of a safer infrastructure for the poor, pedestrians, and nonmotorized transport users must be part of a comprehensive approach to minimize the negative impacts of transport.

Poor people successively expelled to the urban periphery spend proportionately more on transportation, thus excaberating social imbalances. The lack of (affordable) transport means that rural African women's role in transport is very important but often taken for granted. Collecting water, fetching firewood, and bringing grain to grinding mills is done mostly by head- or backloading, amounting to loads heavier than body weight over distances of 5 to 15 km. The health impacts of this transport are also alarming, varying from a high incidence of backache among developing country women to miscarriages. The transport solution is to increase the use of hand carts, wheelbarrows, or similar vehicles to carry fuelwood and water vessels.

HUMAN HEALTH AND SAFETY

Traffic Accidents

The human health and productivity costs of traffic accidents are stupendous but are so well known that they are not repeated here. On a global level, this amounts to 265,000 deaths and 10 million injuries per year, while costing $70 billion each year in the United States alone. Unfortunately, there is significant polarization about how to address this problem. For example, one recent fuel efficiency proposal that would have led to smaller cars was dubbed the "Highway Death Act" by the automobile industry.

Nonaccident Health Impairment

Health is impaired by inhaling vehicle air pollution in two main ways. First, carbon monoxide and other motor pollutants damage the respiratory and cardiovascular system. High-risk people (those with asthma, emphysema, and bronchitis, as well as the elderly and infants) are advised to stay home when the air quality is poor. Several major cities, such as Mexico City, offer coin-operated oxygen supplies on the street. Annual U.S. vehicular emissions cause up to $93 billion in health-related costs. Second, inhalation of leaded gasoline fumes raises blood lead levels, impairing learning ability. IQ levels of children in Mexico City have been found to have fallen two whole points or more because of high blood lead levels. Lead also contributes to an increase in blood pressure.

Health is also impaired as a result of a lack of exercise related to car use compared with bicycling or walking. The loss of human health and fitness because of a lack of exercise by motorists, while huge, is undercounted in cost/benefit analyses. Cycling has a positive net effect on health, and health benefits gained from cycling exceed accident costs (*8,9*). Car use, on the other hand, has a net negative effect on health because of higher disease and accident rates.

INTERNATIONAL ASPECTS

Increased Oil Imports

Oil imports affect social welfare in developing nations. Dependence on foreign oil imports decreases the security of poor nations. Indeed, the poorer the country, the greater the proportion of net imports spent on petroleum. This argues for increasing nonmotorized and alternative transport and alternative fuels in developing countries where possible.

Trade Impacts

Transport costs act as barriers to international trade and as excise taxes on local trade. Developing nations rely more heavily on exports of natural resources and on less-processed commodities than do industrial countries; hence the relatively higher transport costs for low-value/high-volume raw materials. The internalization of transport costs might reduce the benefits of lowered tariffs claimed by the movement to further deregulate trade.

Globalization

Globalization is a process that is rapidly expanding. An increasing number of national economies are heavily dependent on trade. The implications of globalizations are pervasive. The most obvious implication is that a larger portion of costs are transport related. Globalization means an acceleration of port and highway construction. When production is directed toward export markets, domestic demand patterns are significantly changed. Dependence on imported oil to fuel the transport sector places a heavy burden on the balance of payments. Furthermore, developing nations without domestic energy sources are extremely vulnerable to petroleum price swings, thus harming their export earnings stability. On the other hand, globalization can promote efficiency by accelerating technology transfer. Such transfers are essential if a nation wishes to participate in international trade. Older truck models commonly used in developing countries require 1.5 to 2.5 times as much energy per ton kilometer than do more efficient recent models. Furthermore, energy efficiency is lost because of poor maintenance, bad road conditions, and traffic congestion (*10*).

Communications

Significant innovations in communications technology during the 1980s have enabled merchants and industries in developed countries to outsource intermediate production processes to foreign enterprises in low-wage countries and to explore less costly supply sources. This has spurred economic growth in a number of developing countries, particularly in Asia's Pacific Rim, but also has caused growing pressure on resources. Clients demand smaller shipment sizes and higher shipment frequencies to reduce inventory costs and risks in the volatile markets of developed countries. Effective transport and telecommunications are prerequisites for participation in these new market practices, delinking a number of countries and less accessible areas from international trade and enhancing urbanization and motorization.

SOLUTIONS: REDUCING ENVIRONMENTAL IMPACTS OF TRANSPORT

A holistic approach to solving the transport problem is essential. Transport is not an independent variable because a multiplicity of interests is involved. Institutionally, few people are responsible for transportation policy. Overlapping jurisdictions are one of the major constraints. For example, land use planning (and, more generally, land use interactions) is usually separate from tax policy and so on (e.g., county, city mayors, federal, ministries of transport, and federal district bureaucracies, such as in Mexico City). The market in this case is far from perfect and is highly distorted. Each country and city is unique. Traffic flows are well known, but behavioral information about decisions behind trips, except work, is lacking.

In reducing the environmental impacts of transport, policy needs to be avoidance oriented rather than supply oriented (see Table 2). Continuing to provide infrastructure simply to meet projected trends should cease to be part of a demand management strategy. A moratorium on new capacity would be a welcome step in many cities and countries. New capacity often fails to ease congestion and may even worsen it. Land use planning must become a major element, combined with market systems where possible. The relatively new city of Brasilia shows the appalling costs associated with designing for cars rather than for people. But the much more difficult challenge also is more common: how to improve existing urban problems. Least-cost planning should be adopted more in the transport and other sectors, as it currently is in the electric power sector. This should clarify decisions within transport supply and demand choices.

All that having been said, a most powerful means to reduce the environmental impacts of transport lies in modal choice, that is, away from road transport and toward rail, fluvial, and nonmotorized transport. The opportunities are greatest where basic infrastructure is not yet in place. Demand management and incremental improvement are the approach to take where infrastructure is in place. Quinn (*11,12*) points out that full-cost pricing is likely to lead to a greater priority to access or less transport.

Demand Management Options

In all of these options, it is clear that frequent marginal monetary costs (e.g., trip tickets, parking fees, tolls, fuel) seem to affect the

TABLE 2 Choices to Reduce Transport Impacts

Demand	Supply	Technical
▸ Raise fuel prices, especially where underpriced (e.g., U.S., Venezuela); Non-renewable energy tax or carbon tax; Annual fees commensurate with car size, weight, emissions.	▸ Promote efficient, affordable mass transit, but not over-subsidized.	▸ Accelerate phase-out of lead and other fuel additives.
▸ Road pricing; user fees.	▸ HOV, carpooling and similar devices to increase occupancy.	▸ Alternative fuels.
▸ Provide accessibility to congested areas by means of perimeter clustering and urban transport with due regard for consequent intensification of inner-city daytime populations and land uses.	▸ Urban & suburban planning.	▸ Effective vehicle inspection and maintenance programs.
▸ Restrict parking availability and increase its price; pedestrianization; car-free cities for periods of the day, such as in Cambridge, Siena and Bologna, or in neighborhoods, or in downtown.	▸ Telecommuting; "Work at home" (in cities with advanced telecommunications infrastructure) for selected services and manufacturing industries.	▸ Effective vehicle emissions/efficiency standards and enforcement.
	▸ Promote non-motorized transport.	
	▸ Traffic management systems.	
	▸ Improved telecommunications systems.	

choice of a transport model more than do fixed costs (e.g., depreciation, annual permits, insurance). Furthermore, encouraging employers and the private sector to support such measures, as well as efforts such as carpooling, would expedite implementation. Taxes and standards are necessary complementary policies.

Full-Cost Pricing

Car drivers should pay the "full cost" of their own driving. Several policies are needed to promote such behavior, including rescinding subsidies to automobile manufacturers as well as for highway construction. Vehicle and gas tax generally do not pay for a fraction of infrastructure. Subsidies include road construction financed out of general government funds, traffic police, and free parking if tax exempt, government provision of infrastructure (sewers, drains, roads), low-density zoning, preferential tax treatment for mortgages that aid suburbanization, and relatively lax safety requirements for used cars (*1*). Full-cost pricing means the internalization of all environmental, social, and health costs. Use of the full-cost principle in cost/benefit calculations and of the "polluter pays" principle, including road user fees, would help greatly to slow the growth in vehicle-kilometers traveled (*13*). Raising fuel prices to closer to their full costs may be almost as effective as regulating fuel efficiency standards in reducing currently externalized environmental costs. The U.S. improvements in fuel economy from 17 mpg in 1976 to 28 mpg in 1986 was in part achieved from the tripling of gas prices between 1973 and 1980. Median fleet age increased from 4.9 to 6.4 years over the last two decades, so a slowdown in new car sales reduces the effectiveness of fuel efficiency standards.

Full Costs of Automobile Manufacture

Car production accounts for a major proportion of the gross national product; therefore environmental accounting should be used to reflect the true cost of automobile production. Such true costs would raise car prices and hence decrease car production.

Best Available Technology

"Best available" cost-effective transportation technology includes mandatory fuel efficiency regulations, such as catalytic converters, electronic fuel injection, continuously variable transmission, variable valve timing for optimal combustion, and increased use of aluminum and plastic. Promoting such technology would save more than 25 percent of current fuel costs and decrease pollution substantially. Cost assessments and allocations should be mandatory for choosing appropriate technologies in transportation projects. All car manufacturers have nearly 100-mpg prototypes ready that could be advanced given correct pricing signals. For comparison, today's OECD car fleet averages 30 mpg. The United States finds a fleet average of 35 mpg feasible by 2002. Technology transfer needs to be accelerated, leapfrogging obsolescent technology, and promoting efficiencies and appropriate technology in developing countries. Using good economics would strongly promote subcompacts, thus reaping vast environmental benefits. Best technology should include increasing recyclability, reparability, and durability. The big advantage of technological solutions, such as more stringent fuel economy standards, is that they avoid the politically difficult land use issue.

Emissions Reductions

Creating more stringent emissions standards is another policy response. This can be done through monitoring, testing, and creating incentives such as tax proportional to emissions or efficiency. Policymakers might encourage earlier recycling of older automobiles. Because poorer drivers own older automobiles more frequently than do the rich, equity considerations should be taken into account.

Zero Emission Vehicles

Another policy response is to promote electric or hybrid vehicles for goods and passengers where possible. Electric vehicles certainly transfer the pollution from individual cars to power plants. But this is a plus because pollution is much easier to control in a few large immobile power plants than in many relatively small mobile vehicles. Plaudits to California's (the single biggest car market in the world) air mandate that 2 percent of the new cars sold there in 1998 must be emission free, increasing to 10 percent (200,000 vehicles per year) by 2003. This mandate was designed to force the development of new technology that is receiving only about 2 percent of the big three automobile manufacturers' research and development investments to date.

Speed Limit Enforcement

Cars are much less fuel efficient at higher speeds than at medium speeds, which also reduce the likelihood of traffic accidents. The fuel efficiency of many cars peaks between 35 and 40 mph and decreases again below 20 mph. Traveling at 70 mph reduces fuel efficiency by more than 25 percent compared with 55 mph, and by more than 33 percent compared with 40 mph. As not all speed limit enforcement is cost effective, this issue needs further study on its use.

Traffic Management

Another policy option is to increase the capacity factors of public transport, including carpooling, and facilitate bike use. Deferring road maintenance is a low-cost way to deter car use but is offset by increased fuel use and higher eventual repair costs, especially to the vehicle fleet. Some other improvements include the following: increase right-of-way lanes for mass transit; reduce duplication of competition between private bus operators and promote integration; ban cars on major commuting routes during rush hours; force cars to adapt to cities, not the historical converse of forcing the city to adapt to cars; and subordinate motorized transportation to pedestrians on all but the major corridors.

Mass Transit

Reduce highway capacity by dedicating one or more lanes to mass transit. More people will be transported faster by mass transit; car drivers refusing to switch to mass transit may cause even more congestion until enough drivers do switch.

Parking Policies

Parking restriction is perhaps the simplest and most effective constraint measure. In Tokyo one cannot own a car unless it can be shown that there is off-street parking for it at home (*14*). Correct pricing for parking is essential. Because so much time is wasted searching for parking, an automated system would help efficiently assign the limited places in some cities. Tightening up on parking violations also helps.

Land Use Planning

Land use arrangements can greatly affect patterns of urban growth, thereby reducing urban sprawl, transport distances, and the need for personal cars. Cars should be forced to adapt to cities, yet historically, cities have been forced to adapt to cars. Brasilia is a good example of a city designed for the automobile that severely penalizes the poor who cannot afford cars or even expensive mass transit. In contrast, long after Brasilia was built, Brazil's Curitiba has been retrofitted into one of the most transport-friendly cities.

Automobile Marketing Refocus

Demand management for transport use cannot overlook the role of advertising. Car advertisements exceed $5 billion/year in the United States alone. As restrictions on cigarette ads have decreased smoking in some societies, so some reduction in the number of advertisements seems feasible. Pickup trucks are an example of the counterproductive results of advertising that expanded the prestige market in the United States for pickup trucks. But these trucks actually decrease utility because they have less passenger seating than sedans. Pickups are rarely used for loads, are rarely used off road in 4-wheel drive, and get poor mileage—and yet they now account for a substantial share of the U.S. market. If car advertising regulations are deemed unfeasible, then possibly the marketing industry can be encouraged to promote "goods" (such as efficiency), rather than "trends" (such as chrome tailfins).

Supply Options

Nonmotorized Transport: Bicycles and Intercity Rail

Promote nonmotorized transport (NMT), or at least remove prevailing strong disincentives against NMT. The world's bicycle fleet (850 million) is double the car fleet (450 million). Bikes are now the world's leading vehicle for personal transportation. The two main policies to promote bicycle use are risk reduction measures by improving traffic safety and development of a network of roads suitable for bicycles (i.e., converting road shoulders into bike lanes). In transport project design, integration of bicycles is very cheap and should be routine and systematic. Other policy alternatives include facilitating credit for bike purchase; reducing bike import costs; subsidizing bike assembly plants and research into affordable bikes. The feasibility of bike use for goods transport is well evidenced by African bike ambulances, Asian bike trailers, and pedicab transport.

In addition, bicycle and intercity rail travel offer numerous environmental advantages.

For example, compared with automobiles, bicycling is free of emissions and thus does not contribute to urban pollution (*9*). Bicycling also is one of the most efficient forms of transport and one of the best ways to integrate physical activity into urban lifestyles (*8*). Finally, bicycling is highly cost effective.

One of the largest gains from bicycling is that the necessary infrastructure is exceedingly cheap compared with alternatives such as highways or rails. In addition, the savings in external costs of motor traffic are large. Furthermore, bicycles are inexpensive to all but the poorest, and they cost little to maintain. Because bicycles are more affordable than automobiles for the poor, bicycles decrease inequity as well as isolation. Even so, some credit assistance is needed to facilitate bike purchase by the poor.

The bicycle is often the fastest means of transport in urban areas. This is partly because bicycle on-road speeds (typically 15 to 25 km/hr) equal or exceed the speed of cars in urban areas (*7*). This is enhanced by the fact that bicycles require little parking space, thereby shortening the distance and time from origin to bike park and from bike park to destination. From a city manager's point of view, the bicycle's low space requirements mean that the bicycle is a more space-efficient form of transport. A parked bicycle occupies about 1 m^2, less than 8 percent of that needed for a car (and even less in the case of two-level bike parking). Thus, bikes often win over the car in door-to-door city race comparisons, rather than in the less-relevant road distance traveled.

In addition to low-space requirements for parking, bicycling is particularly efficient regarding actual transit space required. A 2-m-wide, one-way bike lane is able to accommodate 5,200 cyclists per hour (*7*). In comparison, a road lane with a vehicle capacity of 2,000 cars per hour needs a width of 3.5 to 4 m. Thus, bicycle passenger transport is significantly more space efficient than automobile traffic.

In Asia, bicycles are the predominant type of private vehicle in many cities. Bicycle ownership in the region is currently more than 400 million and is growing rapidly. In India, bicycles account for 30 to 50 percent of traffic on primary urban roads. The cities of Japan and the Netherlands, where 20 to 40 percent of trips are made by bicycle, demonstrate the importance that nonmotorized vehicles already have in healthy, wealthy, and efficient economies.

The main environmental advantages of intercity rail is that it is often substantially more energy efficient and less polluting per ton- or passenger-kilometer than automobile use. In addition, rail does not automatically lead to environmental destruction by unplanned settlements, as roads frequently do in frontier areas. This is partly because trains almost never let passengers disembark away from stations. Rail facilitates roads only related to stations (i.e., planned), whereas roads encourage footpaths, followed by tracks and finally roads at unplanned points.

The other massive benefit of rail is that it can almost always expand capacity with little or no further preemption of space. Two sets of rail tracks can carry the same number of people as 16 lanes of highway, taking only 15 m of right-of-way compared with 122 m for the equivalent highway. Improved train control technologies can triple track capacities. Unlike highways, which need median strips, shoulders, and buffers, new track can usually be fitted into existing rights-of-way. Installing a parallel track along segments of existing track can increase track capacity up to six times. Most rail systems are grossly underutilized; less so in some developing country cities. Shifting freight off highways and onto rail has the potential to reduce congestion, save energy, and decrease pollution. Furthermore, expanding rail can make expensive new airports unnecessary.

A big social benefit of rail is that it has the potential to unify cities because its rail stations are centrally located, rather than damage them as suburban malls and highways do. Furthermore, transport of humans, as well as dangerous materials, is much safer by rail. Rail has only 10 percent the number of accidents per passenger-kilometer as road transport.

It is often argued, with justification, that existing railways are poorly run and bureaucratically ''inefficient,'' thus justifying the need for modern highways. This implies that improving and modernizing rail is more costly, in full-cost terms, than new highways and truck traffic. However, where full-cost pricing is used, upgrading rail will become much more attractive than situations in which costs are externalized as they are now. Although initial new rail costs exceed new highway costs, this gap narrows or vanishes when external costs are internalized.

Pedestrians

Transport policies should reduce prevalant disincentives for walkers and maintain sidewalks as well as, or better than, road beds. Pedestrians in many developing countries use the road for walking because of lack of sidewalks or their disutility. Pedestrian and NMT, including hand- and bike-carts (Table 3), should be mandatory components of practically all road or transport projects. The onus for any exception is for the project designer to justify.

Mass Transit

Could mass transit temporarily (perhaps for 3 to 6 months) be free for all users first to win converts; thereafter to be partially subsidized for the poor? A combination of subsidized mass transit plus road pricing might create a virtuous cycle of improving mobility in both modes. The cost/benefit ratio for metro is six times better than that for an expressway and nearly ten times better for a tramway on an exclusive right-of-way. Although these figures differ in different situations, they suggest that full-cost pricing

TABLE 3 Performance Characteristics of Low-Cost Vehicles (*15*)

Vehicle	Relative Cost	Max. load (kg)	Max. speed (km/hr)	Max. range (km)	Route limitations
Shoulder pole	-	35	5	20	Unlimited
Chee-geh	10	50	5	20	Unlimited
Western wheelbarrow	20	100	5	2	Reasonably flat
Chinese wheelbarrow	30	200	5	20	Reasonably flat
Handcart	50-150	200-500	5	20	Reasonably flat, wide track
Standard bicycle	50-90	40	20	60	Reasonably flat
Load-carrying bicycle	60-100	50-200	10-15	30-40	Reasonably flat
Bicycle and trailer	90-150	100	10-15	30-40	Reasonably flat, wide track
Bicycle and sidecar	90-150	150-300	10-15	30-40	Reasonably flat, wide track
Tricycle	150-200	150-300	10-15	30-40	Reasonably flat, wide track
Pack animal	variable	150-400	5	20	Unlimited
Animal sledge	10 (sledge only)	200-400	5	20	Reasonably flat, wide track
Animal cart	100-180 (cart only)	500-3000	5	20	Reasonably flat, wide track
Motorized bicycle	150-200	50-200	20-30	50	Reasonably flat
Motorcycle	250-600	100-150	40-90	100-200	Steep hills
Motorcycle and sidecar/tricycle	350-800	250-500	30-60	80-150	Moderate hills, wide track
Motorcycle and trailer	350-800	250	30-60	80-150	Moderate hills, wide track
Single-axle tractor and trailer	1500	1500	15-20	50	Steep hills, wide track

would favor mass transit more than is the case at present where car driving costs are externalized.

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This personal view of the author should in no way be construed as the official position of The World Bank.

Fundamental Relationship for Roadway Safety: Model for Global Comparisons

FRANCIS NAVIN, ART BERGAN, AND JINSONG QI

A fundamental relationship to explain road accidents in developed and developing countries is proposed. The relationship relies on the interaction of traffic hazard measured as deaths per vehicle, personal hazard as deaths per person, and motorization as vehicles per person. The model is a generalization derived from work by other researchers to explain world accident rates. The model hypothesis is discussed that in the early stages of motorization personal hazard has a small value while the traffic hazard measure will be large. The other extreme is a completely motorized country in which a fairly high but decreasing traffic hazard measure exists and the personal hazard is a low and decreasing value. Between these two extremes, the relationship has a maximum value of population-based deaths as measured by deaths per 100,000 people. The change between the two extremes is due in part to the better engineering of vehicles and roads and greater understanding of the system by the road users. Data from Canada (1910–1940), the United States (1906–1991), and the United Kingdom (1905–1990) are compared with those of India (1961–1985), China (1985), and other countries (1980–1985). These data fit the proposed relationship surprisingly well, and deviations from the U.S. data are fairly easily explained. The model allows the future maximum road fatalities to be forecast for developing countries.

Roughly 6 million North Americans were injured in motor vehicle accidents during 1991, and of these some 50,000 were killed. If the rate of growth in fatalities that existed before 1970 had continued, there would have been an additional 40,000 deaths in 1991.

The downturn of the number of fatalities in most Western countries during the early 1970s has been noted by many researchers (*1,2*). Smeed proposed the earliest popular accident fatality global model (*3*). Another relationship was suggested by Trinca et al. (*2*) and an education-based model was presented by Koonstra (*4*). The work reported here combines the ideas of all of these authors into a more generalized model to estimate motor vehicle accidents.

The severity of traffic accidents in a country is a reflection of the country's economic situation as well as cultural background and government policies. Partyka and Boehly (*5*) have an excellent discussion of the vehicle factors influencing road safety. The complexity of including traffic into the system of human-vehicle-road-environmental regulations and variables such as culture into a simple model is almost impossible. The data suggest the existence of a simple global model relating deaths, population, and vehicle ownership.

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EARLY MODELS

Smeed's motor vehicle fatality model used fatalities per vehicle $[F/V]$ and vehicles per person $[V/p]$ in the following equation:

$$\frac{F}{V} = 0.003 \left[\frac{V}{p}\right]^{-2/3} \quad (1)$$

This model was extended by Broughton (*6*) to include time. He concluded that each country should have its own model. The same model formulation was applied to Iraq (*7*) to estimate all motor vehicle accidents and collision accidents. In this study a simple linear relationship between fatalities and vehicles was found.

The Trinca et al. (*2*) road safety relationship for any country used the variables traffic safety, personal safety, and motorization such that

$$P = T \times M \quad (2)$$

where

- P = personal safety measured by number of deaths per 100,000 people,
- T = traffic safety measured as number of deaths per 10,000 motor vehicles, and
- M = motorization measured as number of registered motor vehicles per 1,000 people.

Their study pointed out that there is a relationship between these variables and the stage of a country's motorized transport.

Koornstra (*4*) states, "The history of safety measures give no particular explanation for the marked fatality decrease after the beginning or mid-seventies." He proposed an industrial-based learning model that combined distance driving (D) and fatality rate per unit distance driven (F/D) to estimate total fatalities (F). In equation form it is

$$F = D \times \frac{F}{D} \quad (3)$$

This model is conceptualized as a risk-adaptation model that is based on individual risk being dynamically adaptive within the traffic system.

POPULATION, VEHICLES, AND FATALITIES

Three countries that have reliable and continuous data on population and vehicle fatalities over the last century are Canada, the United Kingdom, and the United States (*8,9*). The basic road

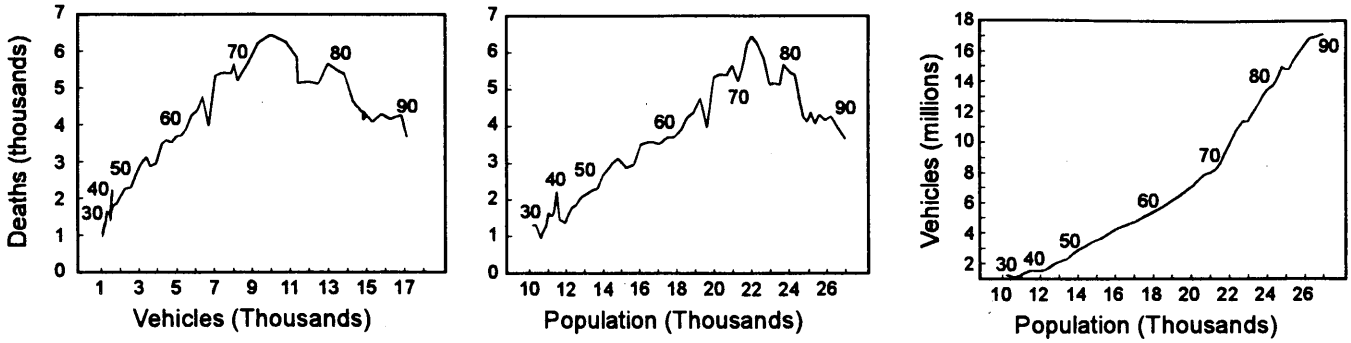

FIGURE 1 **Canada road safety record, 1910 to 1990.**

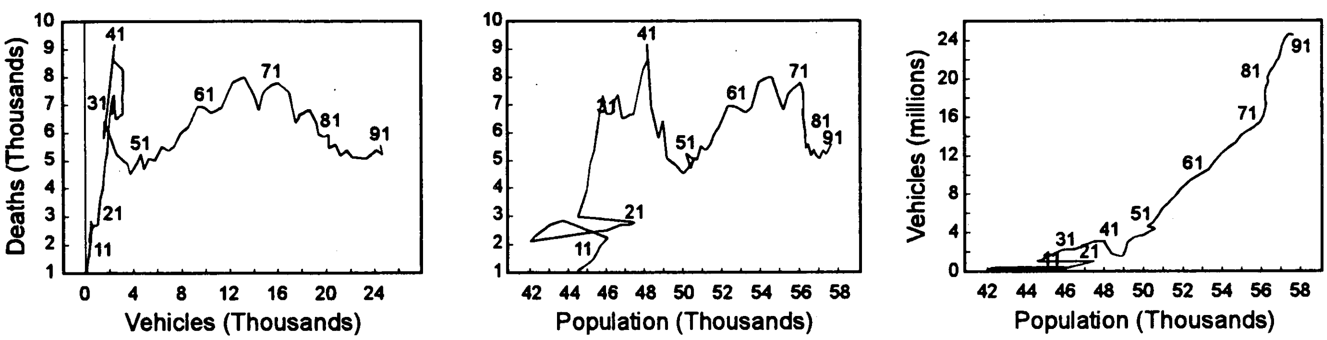

FIGURE 2 **United Kingdom safety record, 1905 to 1990.**

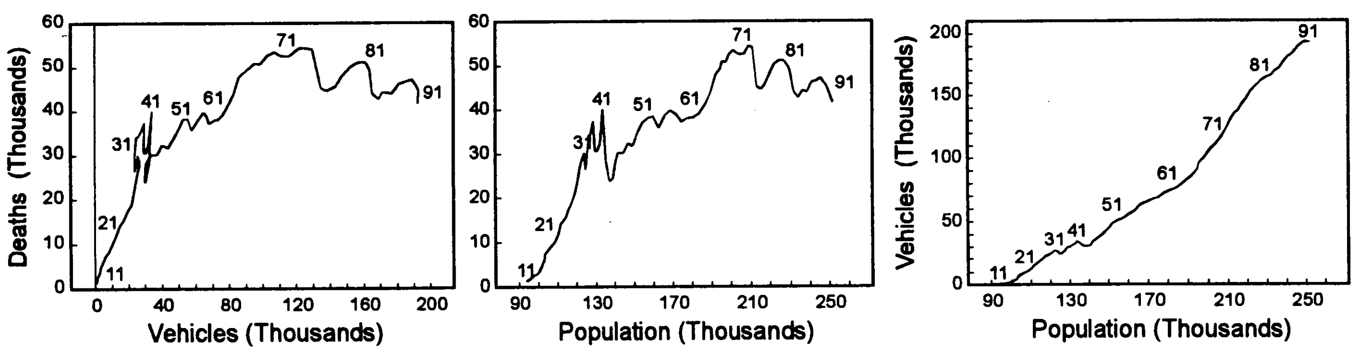

FIGURE 3 **U.S. road safety record, 1905 to 1990.**

safety data for each country are shown in Figures 1 through 3; data are given for number of deaths versus number of vehicles, number of deaths versus population, and number of vehicles per population. In all three cases when deaths and vehicles were compared, there was at first a rapid increase in the number of deaths, which peaked in the late 1960s or early 1970s and then declined. Each of the three countries had unique relationships within these general trends. The Great Depression of the 1930s and the World War II caused irregularities in the U.K. and U.S. data. Similar observations were reported for Germany and Japan (*4*) and for California, Michigan, and Ontario (*3*).

These data suggest that a fundamental model may exist to forecast the motor vehicle fatalities in any country. The general form of the model is given in Figure 4 using only the fatalities-vehicle plane. The general concept of what may be occurring follows an

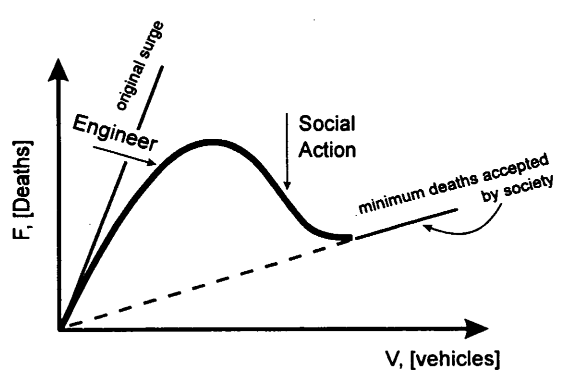

FIGURE 4 **Motor vehicle fatalities and registered vehicles.**

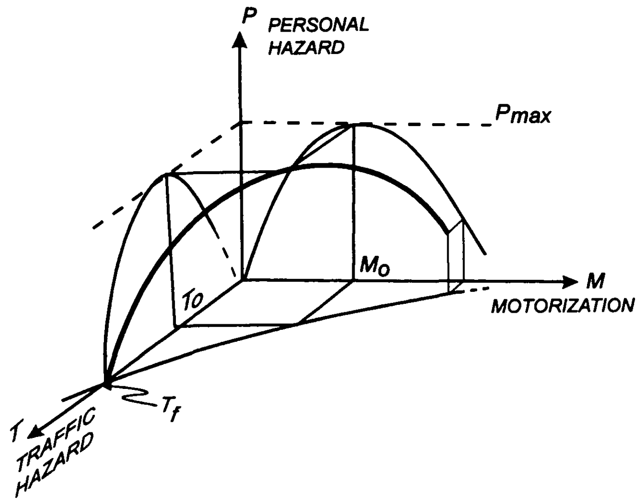

FIGURE 5 Fundamental relationship of road safety.

industrial component failure model not too different from that suggested by Koornstra (*4*). When the automobile is first introduced the population has little knowledge of how such a vehicle should be integrated into the system. Great Britain's "red flag" law is an example.

The rate of fatalities per vehicle decreases after the initial surge. Many factors may be at work but the most important is probably an increased understanding of the driver-vehicle-road-regulation system. During this phase many organizations such as the American Automobile Association, highway departments, AASHTO, and the Institute of Transportation Engineers emerged in the United States to improve conditions. The combined efforts of all these agencies do make the system safer. The third phase occurred in the late 1960s to early 1970s with strong public demand for a safer system. The social forces that brought this about may be found in the political rhetoric of the day. Countries such as Canada instituted the Road Safety Directorate within Transport Canada, giving it the mandate to write rules and regulations to reduce the coverage on the nation's roads. The result was a vastly improved automobile and a renewed effort to make the roadside more forgiving. The final phases have yet to be implemented but it is speculated that there is some lower fatality limit that represents a willingness to pay for safety or some random lower limit, or both.

FUNDAMENTAL MODEL OF ROAD SAFETY

The fundamental model of road safety proposed by Navin (*10,11*) is shown in Figure 5. The model uses fatalities as the basic safety measure and, following Trinca et al. (*2*), uses vehicles and populations as the exposure measures. This model on the *T-M* plane is similar to that proposed by Smeed (*1*), except that the hyperbolic function has been changed to an exponential function that pierces the *T*-axis as a point T_f. The value of T_f is the fatality rate when motor vehicles are introduced. The equation for traffic hazard (T) as a function of motorization (M) is

$$T = T_f e^{-M/M_o} \tag{4}$$

where M_o is the value of motorization at maximum personal hazard ($P_{\max}$). From Equation 2, the estimate of personal hazard (P) is

$$P = MT_f e^{-M/M_o} \tag{5}$$

This model uses hazard rather than safety in the definitions. Equation 5 is similar to that developed by Underwood (*12*) for motor vehicle traffic flow. The coordinates of maximum personal hazard are given by

$$T_o = \frac{T_f}{e} \tag{6}$$

and

$$P_{\max} = M_o \frac{T_f}{e} \tag{7}$$

The next question is, How well does this fit the data? First, the data of Figure 1 through 3 are transformed to the rate values given in Figures 6 through 8. The high spikes in the fatality rates of 1940 to 1945 are ignored. A very approximate set of values representing the motorization and population trends produced the results in Table 1.

The method may be applied to other road-related incidents such as pedestrian fatalities or injuries. Pedestrian fatalities provide an interesting example of a process that has two peaks. In all three countries there was a peak number of pedestrian deaths in the late 1930s and another in the beginning of the 1970s. In the case of Canada the peak was higher than in the United Kingdom and the United States.

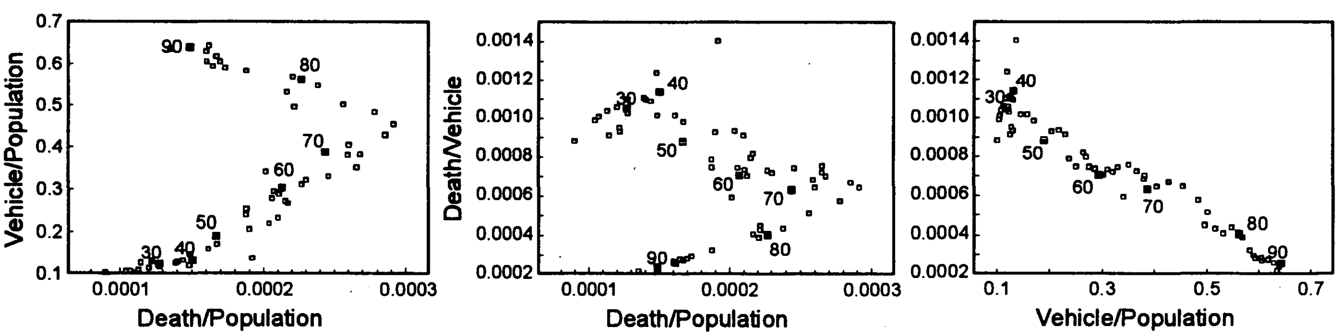

FIGURE 6 Data for fundamental relationship of road safety, Canada.

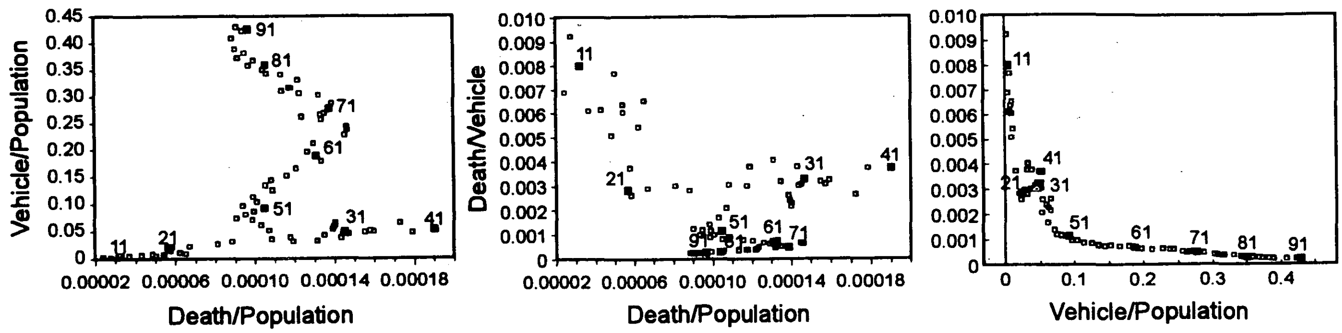

FIGURE 7 Data for fundamental relationship of road safety, United Kingdom.

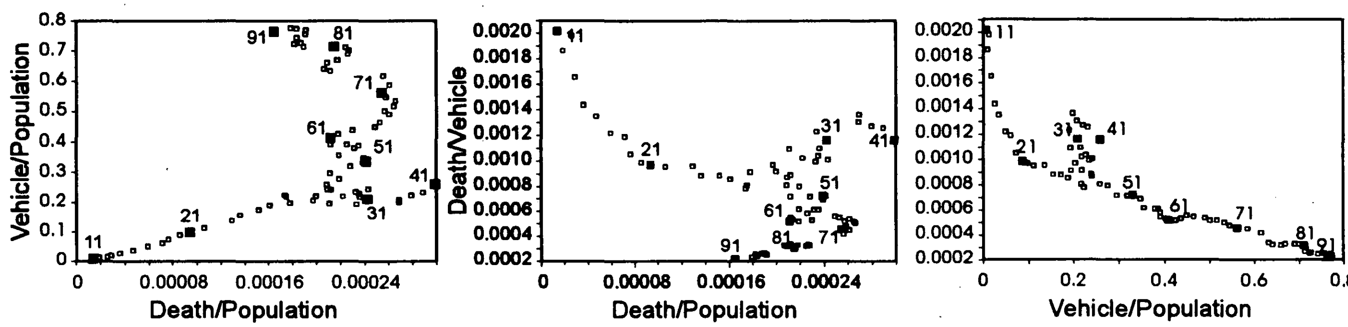

FIGURE 8 Data for fundamental relationship of road safety, United States.

TABLE 1 Equations To Estimate Traffic and Personal Hazard in Canada, United Kingdom, and United States

	Canada	U.K.	U.S.A.
T, Traffic Hazard	$0.0017\ e^{-\frac{M}{0.473}}$	$0.008\ e^{-\frac{M}{0.0645}}$	$0.002\ e^{-\frac{M}{0.427}}$
P, Personal Hazard	$0.0017\ Me^{-\frac{M}{0.473}}$	$0.008\ Me^{-\frac{M}{0.0645}}$	$0.002\ Me^{-\frac{M}{0.427}}$
P_{max}			
Estimated	0.0030	0.0019	0.0029
Observed	0.0030	0.0019	0.0029

Total motor vehicle injuries are more interesting simply because of their large number. Hauer (*3*) has injury data for a number of jurisdictions in North America and the United Kingdom. Analyses indicate that there is a negative exponential relationship between the ratio of fatalities to injury accidents and time. The approximate relationship for Canada is

$$R = 0.015 + 0.036e^{-0.05(y-1970)} \quad (8)$$

where R is the ratio of fatalities to injury accidents and y is the calendar year starting in 1970. This equation assumes that injury accidents will reduce to some stable relationship with fatalities. The injury data plotted against time for Canada, the United Kingdom, and the United States indicates that the rate of increase has reduced or even stopped. More detailed information is needed to confidently decide whether a peak in the injury accident rate is indeed occurring.

IMPLICATION OF MODEL FOR DEVELOPING COUNTRIES

Countries in the early stages of motorization have an underdeveloped and dangerous road network. Increasing motorization increases the rate of personal hazard measured as deaths per person. This, combined with the commonly large population density of many developing countries, means that more deaths are to be expected, so the traffic hazard increases. Once the motorization rate reaches a certain critical level, the population-based death rate peaks and starts to decline.

Some developed countries have reached an advanced phase of traffic hazard, and even the population-based death rate has started to drop. This drop may have resulted from a slower increase in the motorization rate with a much reduced traffic hazard rate.

The proposed model of roadway safety can have as the dependent variable either the stage of development, or time, or both. The model is dynamic; that is, there is both an economic force and a time-dependent force that somehow makes the resulting accident rate change.

The model may be used to eliminate improvements in the safety level of a country's traffic system (see Figure 7). Observing a country's data trend, one sees how the country's position in this model changes as its motorization progressed. The U.S. and Indian data trends *(13)* are examples of how rates of roadway safety have changed over time. The U.S. data have reached the position in the *P, T, M* space at a highly motorized stage, whereas India has been moving its data upward along the cluster. Data for China *(14)* show that in 1985 the country was at the early motorizing stage and needed to endure further accident rate increases as its motorization level keeps growing.

Using the average of the global data from Figure 9, it is possible to estimate China's traffic hazard as

$$T = 0.001e^{-\frac{M}{0.0480}} \tag{9}$$

$$P = 0.01\, Me^{-\frac{M}{0.0408}} \tag{10}$$

$$P_{max} = 0.00015 \tag{11}$$

These equations imply that for a country such as China, at the peak fatality rate, about 180,000 will die annually. This figure is lower than that expected if North American rates were applied. And if the ratio of injury accidents to fatalities is similar to that in the west, then there will be about 3.6 million injury accidents. This should occur when there are roughly 0.04 motor vehicles per capita—a tenfold increase from the current level of 0.004 motor vehicles per capita. Qi *(15)* estimated the relationship between

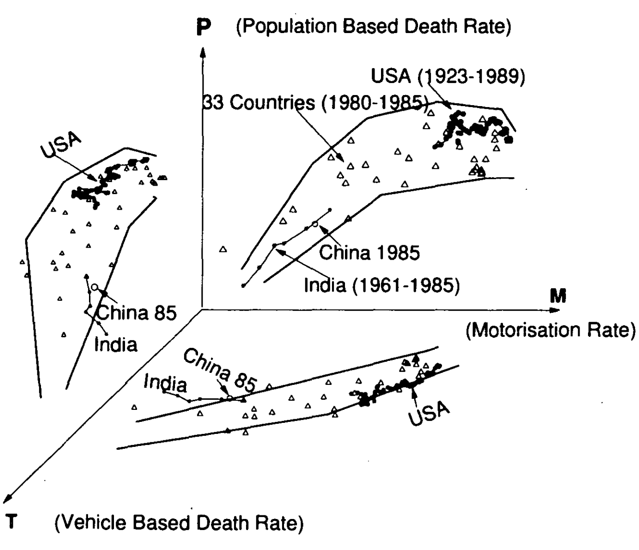

FIGURE 9 Traffic and population hazard by motorization.

traffic hazard and motorization as

$$T = 3,980,000\ (M \times 1,000)^{-0.76} \tag{12}$$

Qi's equation yields similar results to those of Equation 9.

The dynamic nature of the model implies that the relative road safety of a country is always changing. Some countries may change more than others. Whether they get better or worse depends in a large part on their stage of development and the policies that the country implements.

The model does hold out the prospect that road accident rates in more and more countries will tend to move toward those of highly motorized countries. Eventually, the scattered data may be concentrated into the end point of the model for all countries. The low vehicle-based death rate and a very low rate of population-based death rate should then prevail. The minimum population-based death rate indicates that society always will be adversely affected by the mobility derived from motorization.

IMPLICATION FOR ROAD SAFETY POLICY

The developing countries of today have more road safety advantages than the countries that pioneered the use of motor vehicles. During the early years of motor vehicle use, knowledge, and technology on how to design and build cars and roads were limited. The management of roadway operating systems such as traffic signals, signs, and markings and other traffic regulations, as well as emergency medical response systems, were limited. This knowledge and technology is available to today's developing countries; however, the knowledge may not be used. Technology transfer to developing countries in the early stage of motorization is extremely important to them and will no doubt alter the calibration parameters of the proposed model but not the shape of the fundamental relationship.

Currently in developing countries, the knowledge of the driver-vehicle-road-environment system has reached a higher level than that in Canada, the United Kingdom, and the United States at a similar state of motorization. A complete data collection system on roadway accident statistics enables better knowledge of safety-related issues and the corresponding countermeasures. For example, seat belt use has saved many involved in collisions. Restriction of drinking and driving is another example available to developing countries.

One of the similarities between the automobile's pioneer days and today's developing countries may be the large speed difference of the mixed vehicle stream on the roadways. This difference may have originated because of the lack of special roads in the early years of the pioneer countries and in developing countries of today because the budgets to finance the work were limited. Therefore, there is a high opportunity for accidents because a high risk is caused by the large speed differences. The result is that today's developing countries have large vehicle-based deaths (*T*) but small population-based deaths (*P*) because of a low motorization (*M*) level.

These similarities and differences between present and past and early and later stages of development are reflected by the low vehicle-based death ratios (*T*) but high population-based death ratios (*P*) that exist in developed countries today and very high *T* but low *P* that appear to hold true of countries at the early stage of road development. However, there seems to be too big a gap between today's developing and developed countries. Developing countries may have to go through the period of the ever-increasing population-based death rate before the trends turn down. Exactly how knowledge and technology can be used to more rapidly turn this around is not known.

In general, the world is relying more and more on road-based motorized transportation, as indicated by the high level of motorization in developed countries and the large number of overly used vehicles in developing countries. Therefore, the increasing potential of accidents and traffic hazards in the world should be closely monitored.

The model proposed in this report helps to illustrate how traffic hazard (*T*), population hazard (*P*), and motorization (*M*) may be related to stages of a country's development. There is nothing inherent in the model that says a country must go through these stages. In fact, the model does nothing more than report on the observed data for developed countries and assumes the same will apply to developing countries.

ACKNOWLEDGMENTS

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PART 3

Asia and Africa

Nonmotorized Vehicles in Asian Cities: Issues and Policies

CHIAKI KURANAMI, BRUCE P. WINSTON, AND PAUL A. GUITINK

Although the numbers of automobiles and motorcycles are increasing in Asian cities, nonmotorized vehicles (NMVs) such as bicycles and cycle-rickshaws still play a significant role. Some cities have experienced substantial growth of NMVs over the past several decades as a result of pervasive rural poverty and subsequent migration to urban areas. Because city buses usually provide poor services to the low-income areas in the periphery of cities and often are very crowded, and because motorcycles and private cars have been unaffordable for the majority of households, many persons still depend on NMVs. They offer low-cost personal mobility, are nonpolluting, use renewable energy, are labor intensive, and are well suited for short trips in most cities in Asia. However, NMVs operate at relatively slow speeds, are incompatible with the faster-moving flow of motorized traffic, and, compared with buses, tend to reduce road capacity in city centers and at certain intersections where they are heavily concentrated. For example, city officials in Dhaka (Bangladesh) criticize NMVs as the main cause of crime and the principal obstacle to the city's modernization; consequently, they plan a phased elimination of NMVs by continually introducing NMV-restricted streets. On the basis of a World Bank–funded inventory of NMV needs and opportunities in 10 Asian cities, major NMV issues in the categories of (*a*) urban transport systems issues; (*b*) economic, social, and environmental issues; and (*c*) general NMV planning and policy issues were addressed. Recommended policies are presented in response to each issue.

This paper assesses major nonmotorized vehicle (NMV) issues as distilled from a World Bank–funded study on NMVs (*1*) that inventoried needs and opportunities of NMVs in Asian cities. Sixteen issues have been identified, falling into three basic categories:

1. Urban transport system issues;
2. Economic, social, and environmental issues; and
3. General NMV planning and policy issues.

Table 1 gives the 16 issues, policy prescriptions at the local level, and implications for donor agencies. The discussion that follows focuses on the first two columns of Table 1: issues and policy prescriptions at the local level.

Throughout this paper local terms for NMVs are used to provide some sense of the flavor of the characteristics associated with each type of vehicle in different cities. The English term "bicycle," "cycle-rickshaw," and "cart" are used as common nouns, but local names are also used and are shown in italics. Cycle-rickshaws are, for example, referred to simply as *rickshaws* (also an English word) in Bangladesh and India, *cyclos* in Cambodia and Vietnam, *becaks* in Indonesia, *pedicabs* in the Philippines, *samlors* in Thailand, and *trishaws* in Malaysia.

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ISSUE 1: LACK OF APPROPRIATE NMV FACILITIES

Issue Statement

Facilities for NMVs are inadequate in most of the study cities. For example, in Phnom Penh, where all vehicles share the same road space, regulations require NMVs to occupy the far right-hand lane; however, without physical distinctions between lanes, many vehicles weave between and among lanes as they overtake slower-moving vehicles. Hanoi has physically separated lanes for motorized and nonmotorized traffic, with the lanes separated by a raised curb; however, the physically separated lanes are relatively ineffective because they do not provide continuous travel paths. Dhaka has NMV lanes, but only at three locations; Dhaka also has rickshaw waiting areas along certain road segments, but these facilities are not clearly marked and their capacities are insufficient to meet the demand. Surabaya offers few NMV-dedicated facilities, mainly parking facilities for bicycles at certain places, such as the city's night markets, transport terminals, and schools. Metropolitan Manila also offers few NMV facilities, except for faded yellow-striped lanes for bicycles on a small number of city streets and *pedicab* terminals designated by local governments in residential areas or along side streets. Although Chiang Mai has successfully implemented a *samlor*/bicycle lane on Nakhonping Bridge traversing the Ping River, dual-use motorcycle and bicycle lanes implemented several years ago were discontinuous, poorly maintained, and are now used mostly for parking by cars and trucks. George Town offers only a limited number of *trishaw* parking stands.

Policy: Development of Appropriate Facilities for NMVs

A few of the study cities provide examples of how adequate facilities for NMVs can be developed. Shanghai, perhaps the leading city in Asia in providing NMV facilities, had a 91-km NMV network in its urban area as of September 1992. This included NMV-exclusive links (including bridges and tunnels), NMV lanes demarcated with a physical barrier (e.g., a raised concrete median or a temporary barrier), and NMV lanes delineated by lane markings. Japanese cities are also very advanced in providing bicycle lanes, with more than 70 000 km (43,498 mi) nationwide; however, most (93.3 percent) bicycle lanes in Japan are shared bicycle/pedestrian facilities. An important feature of the Shanghai and Japanese examples is that the network provided is reasonably continuous, offering a relatively direct and convenient path between trip ends. Also worthy of note is the experience of Kanpur, where traffic authorities are experimenting with yellow lane markings on certain main streets, effectively separating fast- and slow-moving vehicles.

TABLE 1 Issues, Policies, and Implications for Donor Agencies

Issue	Recommended Policies at the Local Level	Implications for Donor Agencies
Urban Transport System Issues		
1. Lack of Appropriate NMV Facilities	o Develop appropriate facilities for NMVs	o Assist governments by funding adequate NMV facility improvements
2. Low Priority Accorded NMVs	o Accord appropriate priority to NMVs	o Provide governments with guidelines that accord priority to NMVs in relation to passenger and freight throughput
3. Lack of Compliance with Traffic Regulation by NMV Users	o Increase compliance with traffic regulations	o Support the efforts of local governments to increase compliance with traffic regulations by organizing seminars and training courses
4. Inappropriate Pricing/Tax Policies in the Urban Transport Sector	o Revise pricing/tax policies to reflect costs occasioned by vehicle use	o Assist governments in developing appropriate pricing/tax policies for private vehicles and assist in the provision of sustainable transport alternatives
5. NMVs and Congestion	o Improve public transport o Combat illegal bicycle parking	o Provide loans for economically justified public transport improvements o Provide guidelines for alleviating illegal bicycle parking
6. NMVs and Road Safety	o Improve traffic management and enforcement o Improve safety equipment o Establish safety education programs	o Fund programs to improve NMV safety
7. NMV Theft	o Provide secure parking for NMVs o Register NMVs to reduce theft	o Provide guidelines for promoting anti–theft programs
Economic, Social, and Environmental Issues		
8. Affordability of NMVs for the Poor	o Supply credit and offer targeted subsidies for the purchase of NMVs o Reduce tariffs on NMVs	o Fund programs to increase NMV ownership by the poor
9. NMVs and Economic Development	o In the short and intermediate term, promote NMV use and manufacturing o In the long term, ease the transition from NMV industries to other kinds of enterprises	o Provide framework for local governments in adopting appropriate policies to promote NMV industries in the short and intermediate term, and the conversion of NMV industries in the long term
10. NMVs and the Environment	o Implement pricing/tax policies that reflect environmental costs occasioned by vehicle use	o Fund research on the economic impact of NMVs and MVs on the environment
11. NMVs and Energy	o Consider the relative energy impact of MVs and NMVs	o Fund small–scale research on the energy impacts of NMVs
12. NMVs and Land Use	o Adopt land use policies that reduce commuting distance o If land use planning policies are ineffective, promote intermodal integration between NMVs and public transport	o Provide guidelines for planned urban development and the use of NMVs as a feeder mode for public transport

(continued on next page)

Such low-cost solutions may be particularly appropriate for cities with limited financial resources. Lane markings, however, may not work without disciplined traffic or strict enforcement, or both. In Lima (Peru) lane markings turned out to be a complete failure; the bicycle lanes were used as parking spaces by motor vehicles (MVs).

ISSUE 2: LOW PRIORITY ACCORDED NMVs

Issue Statement

A case can be made for giving priority to the movement of persons and goods rather than to vehicles (*2*). Preliminary studies suggest that the least efficient modes in terms of capacities measured by person-throughput are low-occupancy automobiles, whereas the most efficient modes are rail and bus. Bicycles tend to fall in the middle of the range, whereas cycle-rickshaws are relatively less efficient (*3*). Moreover, for short trips, NMVs are particularly efficient; in large, low-income cities NMVs are arguably the most efficient modes for trips of up to 10 km (*4*). Nevertheless, in most Asian cities a disproportionately high allocation of street space has been accorded to relatively inefficient low-occupancy automobiles compared with that allocated to NMVs.

Policy: According Appropriate Priority to NMVs

It is recommended that NMV priority schemes be considered in NMV-dependent cities where MVs are accorded greater priority than NMVs. The provision of NMV lanes and paths, as discussed earlier, is one kind of solution. Other NMV priority schemes are possible. Beijing, for example, has implemented bicycle priority traffic signals, which include bicycle detection loops. Preliminary findings indicate that a 15 percent reduction in delays for bicycles (and a 24 percent reduction in delays for car traffic) can be achieved with this system (*5*). Netherlands Railways gives higher priority at station entrances to bicycle users than to bus riders, taxi passengers, and private cars (*6*).

ISSUE 3: LACK OF COMPLIANCE WITH TRAFFIC REGULATIONS BY NMV USERS

Issue Statement

A lack of compliance with traffic regulations by NMV users was found to be a serious problem in many of the study cities. One problem is that traffic laws in many Asian cities, which often date to colonial times, need updating to reflect current conditions. Another problem is that the police force allocated to traffic duties is typically understaffed and inadequately trained. Finally, system users often are unfamiliar with existing traffic regulations (*7*) and need to be educated.

Policy: Greater Compliance with Traffic Regulations

A variety of measures are recommended to increase compliance with traffic regulations by NMVs. Reflecting the problems set forth in the issue statement, these measures include revision of

TABLE 1 *(continued)*

	Issue	Recommended Policies at the Local Level	Implications for Donor Agencies
General NMV Planning and Policy Issues			
13.	Biases Against NMVs and Unbalanced Urban Transport Planning	o Implement institutional measures to address biases against NMVs o Promote balanced transport planning	o Provide a forum to remedy anti-NMV biases and redress unbalanced transport planning
14.	Over-Regulation of NMVs	o Limit the regulation of NMVs to safety- and security-related concerns	o Provide framework for the deregulation of NMVs
15.	Scarcity of Funds for Urban Transport System Improvements	o Consider low-cost solutions o Develop NMV facilities only when economically justified o Adopt innovative approaches to financing	o Provide local governments with guidelines for low-cost solutions o Set guidelines for investments in NMV facilities to meet standard benchmark economic rates of return o Provide framework for innovative financing
16.	Lack of NMV Data, Analytical Techniques, and Engineering Guidelines	o Improve data, analytical techniques, and engineering guidelines	o Set guidelines for improving NMV data collection systems o Fund research to develop transport systems models incorporating non-motorized modes o Implement NMV pilot studies

Note: More detailed discussion of each issue and recommended policies at the local level are provided in the text.

traffic laws, strengthening of local traffic police, and education of system users (e.g., with billboards or decals, as used in Beijing and Lucknow, India, respectively).

ISSUE 4: INAPPROPRIATE PRICING AND TAX POLICIES IN URBAN TRANSPORT SECTOR

Issue Statement

Taxes (e.g., purchase taxes, fuel taxes, parts taxes) charged to MVs are not commensurate with the costs MVs impose on others (e.g., congestion, environmental damage) (*8–10*). Use of MVs tends to result in higher external costs than does use of NMVs. Bicycles, for example, are likely to impose significantly lower costs on others per passenger-kilometer than are low-occupancy automobiles and most other MVs, except for perhaps buses. Nevertheless, in certain countries customs duties and sales tax rates on bicycles are higher than on some MVs. In Bangladesh, for example, the import duty on bicycles (and other MVs) was 150 percent, whereas the rate for motorcycles and trucks (CBU) was 50 percent, and that for motor cars was 50 to 300 percent. In other countries (e.g., Cambodia), MVs are subsidized through the pricing of fuel at below-market prices.

Policy: Pricing and Tax Policy Revision To Reflect Costs Occasioned by Vehicle Use

The recommended policy prescription is to assess higher levies on automobiles relative to NMVs, both in absolute terms and measured in terms of charges per passenger- and ton-kilometer. Consider, for example, the case of Singapore, which instituted an area licensing scheme in its central business district in 1975 that is now being upgraded to full road pricing, to be extended over the entire island. Other measures implemented in Singapore include import duties, additional registration fees, bonuses for scrapping old cars, and a quota system for the maximum number of cars that can be registered (*7*). Also worth noting, Hong Kong in 1983 became the first city to test the technical, economic, and administrative feasibility of electronic road pricing. Although found effective for reducing congestion by time of day and location, the system was abandoned after 2 years primarily because of adverse reactions by motorists (*7*). Proposals for road pricing schemes in Bangkok, Kuala Lumpur, and Jakarta were also unpopular and never implemented.

It is important to note, however, that these pricing/tax measures are introduced most successfully in conjunction with the provision of appropriate alternatives, such as public transport or safe and convenient NMT infrastructure.

ISSUE 5: NMVs AND CONGESTION

Issue Statement

In certain NMV-dependent cities, NMV congestion on city streets is itself a major concern. In Shanghai, where 87 percent of all vehicles in traffic are NMVs, bicycles are seen as a less efficient user of the city's increasingly scarce road space than buses. In Hanoi, where 64 percent of all vehicles in traffic are NMVs, local government officials have calculated the "interruption" of NMVs and certain motorized vehicles to traffic in terms of the road area taken up by one bus passenger. Although perhaps overstated, Hanoi authorities have estimated that a bicycle rider and a cycle-rickshaw (cyclo) passenger require an area 16 and 20 times larger than that required for one bus passenger, respectively. A congestion problem of a different sort is found in Tokyo, where illegal bicycle parking is a pervasive problem. Because the demand for bicycle parking at rail stations in Japan's urban areas far exceeds the supply, many people illegally park their bicycles within the vicinity of stations. In some areas, particularly on pedestrian sidewalks surrounding rail stations, the overabundance of illegally parked bicycles is a serious hindrance to pedestrian traffic flow.

Policies

Improvements in Public Transport

In NMV-dependent cities such as Shanghai and Hanoi, where a preponderance of bicycles has overwhelmed the capacity of the urban street system (particularly on main streets), public transport services should be upgraded. In terms of persons per hour per meter lane width, buses provide a capacity of 2,700 in mixed traffic and 5,200 on a busway; comparable figures for NMVs are 1,330 for a bicycle in mixed traffic, 1,800 for a bicycle on a separated facility, and only 420 to 1,200 for a cycle-rickshaw in mixed traffic and 560 to 1,600 for a cycle-rickshaw on a separated facility. In certain large cities where buses cannot provide sufficient capacity (e.g., Bangkok), an off-street public transport system may be required to provide additional capacity. Estimated capacities in terms of persons per hour per meter lane width equivalent for light rail, suburban rail, and rapid rail are 3,600, 4,000, and 9,000, respectively (*3,4*).

An alternative for addressing the problem of NMV congestion, limiting the numbers of NMVs through regulation, is not recommended. Such a policy unduly constrains NMV use. When urban transport alternatives are properly priced, free markets can most efficiently allocate resources among modes, motorized and nonmotorized.

Illegal Bicycle Parking Laws

Japan, which has the most serious illegal bicycle parking problem in the region, enacted the Law for the Promotion of Bicycle Parking Facilities in 1980 to address the problem of illegal bicycle parking. Since passage of this national law, more than a third of all local governments in Japan have enacted ordinances to address problems with illegal bicycle parking. Typically, these ordinances require landowners with property near rail stations to provide land for bicycle parking, call for the impounding of illegally parked bicycles, or both. Similar approaches could be considered in other cities in the region with serious illegal bicycle parking problems.

ISSUE 6: NMVs AND ROAD SAFETY

Issue Statement

NMVs were found to be a relatively unimportant cause of traffic accidents in each of the eight study cities for which reliable data were available. In each of these cities, the share of accidents attributable to NMVs is significantly less than the modal split of NMVs in vehicular traffic. Even though the impact of NMVs on road safety is relatively low and substantially less than that perceived by urban transport officials, there is still substantial scope for improving the safety of NMVs in Asian cities. The issue must be considered an important one, given the alarming rates of deaths from traffic accidents in Asian cities.

Policies

Traffic Management and Enforcement Improvement

As noted, traffic management and enforcement measures are required to reduce conflicts between NMVs and MVs so that traffic flows are improved and congestion is reduced. Such measures could also improve safety because they clearly allocate road space between MVs and NMVs and increase compliance with traffic regulations. Worth noting here is the case of Shanghai, which records traffic violations on bicycle driving licenses and requires repeated violators to attend a 2-day training program on safe bicycle riding. Another instructive case is that of Japan, where prefectures compete against each other to reduce the incidence of road traffic accidents and fatalities.

Better NMV Safety Equipment

NMVs in low-income cities in the region often lack basic safety devices such as rear-view mirrors, lights, and reflectors. Local governments should consider implementing policies to induce NMV owners to provide at least the most basic of safety devices, through the provision of financial incentives for doing so, through regulations requiring basic safety features (as has been implemented in George Town, for example), or through some combined "carrot and stick" approach.

Establishment of Safety Education Programs

The low educational background of NMV operators has created safety problems in certain low-income cities in the region. However, safety education programs can be beneficial, as the Japanese experience demonstrates. The bicycle law in Japan requires schools to teach children bicycle safety, which is usually done as part of "health and physical education" classes, in which the traffic police teach young children how to check a bicycle for safety and operate a bicycle in traffic. In cities where many NMV operators have limited educational backgrounds or are simply unfamiliar with urban driving conditions and levels of traffic (e.g., Phnom Penh and Kanpur), more general public education campaigns perhaps accompanied by special NMV safety "seminars" could be considered.

ISSUE 7: NMV THEFT

Issue Statement

Although there is little formal data on NMV thefts, the possible theft of NNVs was found to represent a barrier to NMV ownership in some of the study cities (e.g., Dhaka and Surabaya). Even in low-income cities in which the statistical probability of NMV thefts is not high, the perception of the risk of losing a major investment in an instant likely deters many from owning NMVs.

Policies

Secure Parking for NMVs

One approach to combating the perceived or actual problem of NMV thefts is to provide secure parking for NMVs. Japan is the world's leading nation in providing advanced NMV parking areas. The Netherlands is experimenting with the *Ficarro*, a bicycle parking carousel that is secure against bicycle theft and that reportedly can cover its own costs even with a small number of bicycles, at least under Dutch conditions. Lower-technology solutions were also found in some of the study cities (e.g., extensive guarded bicycle parking facilities in Kanpur and Shanghai).

Registration of NMVs To Reduce Theft

Another approach to addressing the NMV security issue, whether it is perceived or actual, is to implement a comprehensive system of bicycle registration. The bicycle registration system in Shanghai, which requires that registration cards be attached to bicycles at all times, has proven effective in reducing bicycle thefts in China's largest city. Also instructive is the experience of Denmark, where bicycle thefts in Copenhagen decreased by 23 percent after the introduction of a nationwide computerized bicycle theft register in June 1990 (*11*).

ISSUE 8: AFFORDABILITY OF NMVs FOR THE POOR

Issue Statement

One barrier to the purchase of NMVs in some study cities is their affordability, defined in terms of price relative to income. The price of a new standard-model bicycle consumes as much as 96 percent of the average monthly income in Phnom Penh. However, affordability tends to be a barrier to NMV ownership for those with below-average incomes, the availabilty of lower-priced economy and used models notwithstanding. Moreover, in certain countries such as Bangladesh, the affordability barrier is exacerbated by relatively high tarrifs on NMV parts, which result in higher acquisition prices. Although loans are generally available for the more affluent to purchase an automobile or motorcycle, loans are rarely available to the poor to purchase a bicycle for personal mobility or a cycle-rickshaw to establish a small transport business.

Policies

Credit and Targeted Subsidies for NMV Purchase

The affordability barrier to bicycle ownership has been addressed in three study cities. In Kanpur, private and government organizations offer low-interest loans for the purchase of bicycles. In Shanghai, employers provide commuters with subsidies of up to U.S. $3 per month, which bicyclists can apply to the purchase of a new bicycle or the maintenance of one they already own. And, in Bangladesh, credit has been issued by various government agencies to *rickshaw* cooperatives on a limited basis, with the government financing the purchase of 3,300 *rickshaws* per year countrywide.

Bicycle subsidies would seem to be justified to the extent that they result in savings in spending on transport facilities or in subsidies to public transport operators. A Dutch study found that the incremental cost of travel by bicycle is approximately one-twelfth that of travel by car, principally because of the difference in facility costs. An Indian study concluded that the operating subsidy for the bus operator in Delhi in 1985 (on the order of U.S. $150 million) would have been sufficient to provide a bicycle for every household below the poverty level (*12*).

Subsidies for the purchase of cycle-rickshaws would also seem to be easily justified given the return on investment in these vehicles; in Surabaya, for example, the return on investment in a new *becak* is significantly greater than 100 percent, which is not inconsistent with the high interest rates of 5 to 10 percent/month charged by usurers. However, to achieve their objectives, loans must be targeted at *rickshaw* drivers and not existing owners (*13*).

Tariffs Reductions on NMVs

In some countries, the affordability of NMVs is adversely affected by high tariffs, intended to benefit the local manufacturing industry. Even if high tariffs lead to increased local production, such a policy distorts free competition, resulting in unnecessarily high prices for locally produced bicycles. The price of a bicycle in Bangladesh, for example, is twice that in the neighboring Indian state of West Bengal (*14*). Because there is little evidence that such tariffs have led to increased local production of NMVs, the case for their removal is unambiguous.

ISSUE 9: NMVs AND ECONOMIC DEVELOPMENT

Issue Statement

NMVs play an important role in the local economy in many of the study cities. The *rickshaw* industry in Dhaka—including drivers, repair persons, owners, mechanics in assembly shops, and retailers in components shops—directly provides 23 percent of the city's employment. Similarly, approximately 20 percent of the jobs in Kanpur are in the NMV sector, which includes all employment related to bicycles, *rickshaws*, animal carts, and handcarts. The NMV sector is also an important employer in Shanghai and Hanoi—two large bicycle manufacturing centers. To the extent that MVs replace NMVs in these cities, local economies will drastically change with consequent dislocation effects. Nevertheless, our inventory of Asian cities found that local governments often underestimate the economic impact of the NMV sector.

Policies

Short- and Intermediate-Term Promotion of NMV Use and NMV Manufacturing

Consistent with overall economic efficiency considerations, cities with high levels of NMV ownership and use should promote NMV use and manufacturing in the short and intermediate term. NMV use can be promoted with a variety of measures specified elsewhere in this paper (e.g., improving facilities or providing potential users with access to credit). NMV manufacturing can be encouraged by providing credit and technical assitance to NMV manufacturing enterprises, identifying potential export markets for NMVs (*15*), and technology transfer between and among nations with large numbers of NMVs (*4*). However, it is not advisable to promote NMV manufacturing through high tariffs on NMV parts, a policy that merely increases prices for users. A bicycle consists of over 1,000 parts, and even in technically sophisticated Holland, large factories import two-thirds of their parts (*14*). An attempt by the government of Bangladesh to produce complete bicycles (Bangladesh Cycle Industries) has proven unsuccessful, with output only 10 percent of factory capacity (*16*).

Long-Term Easing of Transition from NMV Industries to Other Kinds of Enterprises

Realistically, the trend of increased motorization in Asian cities will lead to a reduced dependence of NMVs. However, considering the importance of NMVs in the economies of many Asian cities, ultimately it will be necessary to prepare for the conversion of some NMV industries into non-NMV industries—even into MV industries—which would be a logical step up the technological ladder. The alternative, permanently locking the region's poorest cities into an NMV-dependent economy, would hinder the technological development of local industry and block the aspirations of the many who wish to own and use motor vehicles.

ISSUE 10: NMVs AND THE ENVIRONMENT

Issue Statement

To the extent that use of NMVs reduces the number of motor vehicles-kilometers traveled, NMVs will have a positive impact on local air quality and noise environments. NMVs also can help to substantially reduce other adverse environmental impacts (e.g., visual intrusion and community severance). On the other hand, NMVs are not without adverse environmental impacts (e.g., the "bicycle pollution" problem observed in Japan, possible community severance impacts on bikeways, and animal waste).

Policy: Pricing and Tax Policies Reflective of Environmental Costs Occasioned by Vehicle Use

As recommended under Issue 4, pricing and taxing policies should reflect all costs engendered by vehicle use, including environmental costs. The problem of formulating technically defensible pricing and tax policies that would accurately reflect environmental externalities remains an obstacle to implementation. One study in the Dutch city of Groningen estimated a total environmental cost of 7.8 million guilders (U.S. $4.3 million) if the modal share of bicycles in the city were reduced from 50 percent to 5 percent (*16*); more work of this sort is required, however.

ISSUE 11: NMVs AND ENERGY

Issue Statement

The limited available data indicate that NMVs are more energy efficient than MVs. Data from 1985 show that the transport sector used only 13 percent of the oil consumed in China, where NMVs predominate for short and moderate-length trips, but 35 percent elsewhere in Asia, where mixed traffic is the norm (*4*). One study concluded that bicycles consume only 22 kcalories/passenger-km, compared with 60 for walking, 575 for bus, and 1,160 for single-occupancy automobile (*14*); however, the ratio of energy use by bus passenger to energy use by automobile occupant reported in this study seems doubtful.

Policy: Consideration of Relative Energy Impact of MVs and NMVs

Further research is required to quantify the energy impact of NMVs in Asian cities. After the conclusion of such research, decision makers choosing among alternative urban transport policies should consider the energy efficiency of NMVs relative to that of MVs, especially in countries that are large energy importers. Nevertheless, it is important for urban transport policy makers to understand that energy efficiency is but one of the many considerations and that the policy that maximizes economic efficiency and some other objectives may often be the one that favors modes that are more energy intensive than NMVs (e.g., bus).

Better-balanced transport systems with less reliance on private cars means not only less energy consumption but also low dependence on foreign exchange. The large quantity of foreign exchange now allocated in many developing countries to import fuel, automobiles, and spare parts could be reduced substantially by encouraging the use of NMVs.

ISSUE 12: NMVs AND LAND USE

Issue Statement

Road-based NMVs, which by definition are either human or livestock powered, are most competitive for short trips. However, evidence indicates that the average commuting distance in several of the study cities has been increasing as the cities become more decentralized. The 1992 World Bank technical paper, Nonmotorized Vehicles in Asian Cities, included a box featuring Kanpur as a walking and cycling city. On the basis of data from the 1970s, the box indicated an average trip length of 1.4 km (0.9 mi) in Kanpur; however, by 1987 the average trip length in Kanpur had increased to 3.6 km (2.2 mi), principally a consequence of industrial expansion radiating to the southwest of the city.

Another case is Shanghai, a city where nearly 90 percent of all trips are made by NMVs, but where changes in land use have begun to alter commuting patterns. Longer commuting distances are becoming more common in Shanghai because of the expansion of the city and relocation of industries and housing. Many households will relocate to satellite towns now under construction at a rate of 80,000 dwelling units per year. The result will be a dramatic increase in the demand for public transport, with the role of the bicycle changing from a door-to-door mode of transport to a bus-feeder mode.

Policies

Land Use Policies To Reduce Commuting Distance

A number of land use policies may be considered to address the growing trend toward decentralization and its consequent impact on commuting patterns, which will result in more travel by motorized modes. One such policy is the one traditionally followed in Shanghai, where employers have provided their employees with housing as part of the fringe benefits provided by enterprises, and the location of areas for worker housing has been based on two principles: (*a*) housing is to be located in close proximity to enterprises; and (*b*) residential areas are to be designed to minimize travel distances to shops, schools, and recreation centers (*17*). Another instructive example is Singapore, which has implemented a low-income housing program that locates residences close to workplaces, which thereby reduces trip lengths and increases the use of nonmotorized modes. A third instructive case is Karachi, where the so-called Metroville program enables individuals to build residences near their workplaces (*18*).

Promotion of Intermodal Integration Between NMVs and Public Transport

If land use policies are ineffective in reducing commuting distances and the demand for motorized transport increases, then policies to promote intermodal integration between bicycles and public transport can have positive effects. In Tokyo, one of the largest cities in the region and world, about 10 percent of all train and subway riders use the bicycle to travel to and from the station (*14*). Use of the bicycle as a feeder mode for bus is also prevalent in India; guarded bicycle parking facilities are provided at the Kanpur rail station on land rented from the city government by a private operator.

A caveat to the encouragement of the use of the bicycle as a feeder mode for public transport is the potential for the problem of pervasive illegal bicycle parking that afflicts Tokyo and other major cities throughout Japan. Since the passage of the Bicycle Law in 1980, over one-third of all local governments in Japan have enacted local ordinances to address this problem (e.g., requiring property owners near rail stations to provide land for bicycle parking and impounding illegally parked bicycles).

ISSUE 13: BIASES AGAINST NMVs AND UNBALANCED URBAN TRANSPORT PLANNING

Issue Statement

In several of the study cities it was apparent that policy makers were biased against NMVs. Hanoi, a city with an NMV mode share of 64 percent in 1992, plans to abolish NMVs by 2004 after "gradually moving all bicycles out of the city." The local government of Dhaka, a city where the NMV mode share was 52 percent in 1992, has repeatedly attempted to eliminate or reduce the number of cycle-rickshaws. Many local government officials in Manila would like to see cycle-rickshaws eliminated because of their perceived impact on congestion and safety, as well as the "degrading" nature of the work required of the operator.

The consequence of anti-NMV biases among local public officials is unbalanced transport planning, which results in accommodating the needs of motorists at the expense of NMV operators and users. Such unbalanced planning can actually lead to a deterioration of traffic conditions for both MVs and NMVs in cities where NMVs account for about one-quarter or most of all vehicles in traffic (*19*). Consequently, it is in the best interest of all road users, motorized and nonmotorized, for NMV facilities to be planned in conjunction with those for MVs.

Policies

Institutional Measures To Address Biases Against NMVs

Anti-NMV biases should be counteracted with a host of institutional measures, ranging from national-level implementation of transport pricing and credit policies that do not discourage NMV use to the training of local personnel in comprehensive urban transport planning (i.e., encompassing both MVs and NMVs) and the upgrading of local data collection on NMVs. Also, wherever possible, the views of NMV users should be taken into account in NMV planning.

Balanced Transport Planning

Urban transport planning in Asian cities has been heavily weighted toward motorized transport. This approach, whereby nearly all energies and resources have been devoted to motorized modes, must be rejected in light of the unique and vital role that NMVs play in Asia, where in many cities they account for a significant proportion of all vehicle trips, and where they contribute in important ways to achievement of nontransport goals. On the other hand, NMVs should not be promoted merely because they are NMVs. Rather, the case for NMVs, if it is to be made, must be based on careful consideration of a city's transport system (present and future, both supply and demand) and the impacts that the system has on larger systems of which it is a part. In other words, the goal should be to promote NMVs not because they are "greener" than other modes (*20*) but because they have a useful role to play in particular cities in the region.

ISSUE 14: OVERREGULATION OF NMVs

Issue Statement

There are a number of examples of how government regulatory policies have reduced the supply and use of NMVs in Asian cities:

- In Jakarta, authorities seized 100,000 cycle-rickshaws, over one-third of which were dumped into the sea. A similar policy, albeit on a lesser scale, was implemented in Delhi in the late 1980s.
- In Dhaka, NMVs have been banned from certain "VIP roads," and it is likely that NMV-restricted areas will be extended in the near future. However, no clear guidelines have been established for determining the areas in which cycle-rickshaws are to be prohibited.
- In Surabaya, the government enacted a policy of day- and night-*becaks* (i.e., cycle-rickshaws) to reduce the number operating at any given time. This regulatory system was implemented with the support of the operators and resulted in a stabilization of operator incomes. It nevertheless has resulted in a reduction in the availability of NMV transport services to local residents.
- In George Town (Malaysia), the city council in 1969 stopped issuing new cycle-rickshaw licenses and prohibited transfers except to cycle-rickshaw drivers registered before 1969. The number of cycle-rickshaw registrations has decreased 38 percent since that time, a surprisingly small decline considering that no new licenses have been issued in more than two decades.

Policy: Limitations on Regulation of NMVs

The urban transport sector in general, and NMVs in particular, would benefit by substantially less regulation by local authorities in Asian cities. Kanpur, a city with a half million bicycles and over 30,000 cycle-rickshaws, presents a good example of how NMVs can thrive in a laissez-faire environment, in which the private sector is free to respond to the travel needs of the city's residents. Of course, in Kanpur and elsewhere certain regulatory policies can play a useful role in promoting NMVs, particularly with respect to the allocation of street space, safety, and security.

ISSUE 15: SCARCITY OF FUNDS FOR NMV FACILITY IMPROVEMENT

Issue Statement

Most cities in the region devote between 15 and 25 percent of their annual expenditures to their transport systems. However, over the last decade, traffic in most Asian cities has increased at a faster rate than has investment in the urban transport infrastructure. And with developing countries already strapped for revenues, the search for financing for the urban transport infrastructure, either for MVs or NMVs, is not easy (*21*). In most cases, both national and local governments have shown neither the willingness nor the ability to address urban transport needs by generating additional revenues from the sector, from increased prices or reduced subsidies.

Policies

Consideration of Low-Cost Solutions

In light of the budgetary constraints confronting most local governments in the region, careful consideration should be given to low-cost solutions to traffic problems. As noted, traffic authorities in Kanpur are experimenting with yellow lane markings on certain main streets, effectively separating fast- and slow-moving vehicles. The success of the Kanpur experiment suggests that the prime emphasis should be on simple traffic management approaches rather than the construction of "gold-plated" facilities.

Development of NMV Facilities

Given the constraints on public finance in Asian cities, investments in NMV facilities should be made only if the benefits to society outweigh the costs. Importantly, costs should be minimized for a given level of service. To the extent that NMVs can provide a level of service comparable to that provided by motorized modes, then consideration should be given to promoting NMVs. However, promotion of NMVs on the basis of the electric utility industry's "long-term, least-cost planning methods" should be rejected (*4*) because generally NMVs will not be able to provide service levels comparable to those offered by MVs.

Adoption of Innovative Approaches to Financing

A number of innovative approaches are available for the financing of facilities of NMVs and other urban transport modes. One approach, discussed earlier, involves the proper pricing of urban transport. An instructive case is that of Shanghai, where a highway maintenance fee (a tax on vehicle use), a bicycle tax, and vehicle authorization taxes raise approximately two-thirds of the funds spent on urban transport investment (*7*). A second approach involves a combination of public-private involvement to finance NMV infrastructure. In Kanpur, as cited earlier, the city government has rented public land near rail stations to private operators of bicycle parking facilities. In Japan, many local governments have met their legally mandated responsibilities to provide bicycle parking by requiring landowners within close proximity to rail stations to contribute by dedicating a portion of their land for bicycle parking. Another innovative financing scheme involves the use of concessions and "build, operate, and transfer" schemes, in which a franchise or license agreement is negotiated with the public sector by a private group responsible for the design, finance, construction, and supervision of the facility. The approach in the urban transport sector in Asia to date has been limited to highway and mass transit projects, but could conceivably apply to revenue-generating NMV facilities such as large parking structures.

ISSUE 16: LACK OF NMV DATA, ANALYTICAL TECHNIQUES, AND ENGINEERING GUIDELINES

Issue Statement

The efforts of this recent study for the World Bank notwithstanding, there is a dearth of data on NMVs in Asian cities. Such data are required to prepare urban transportation plans that will adequately meet the needs of NMV users. Similarly, there is a lack of proper analytical techniques with which to address NMVs. The majority of analyses of urban transport problems in Asian cities rely on the "tried and trusted methods" that have been developed and tested on transport networks in metropolitan areas located in developed countries, where NMVs generally are insignificant. Finally, at least until this recent study, there has been a lack of engineering guidelines for NMV planning in Asian cities.

Policy: Improvements in Data, Analytical Techniques, and Engineering Guidelines

Additional NMV-related surveys that would need to be undertaken would include an NMV facilities inventory; an NMV traffic volume survey; an NMV speed and travel time survey; a household survey; an NMV operator's survey; a road accident inventory; an inventory of NMV transport costs and fares; an inventory of traffic regulations, enforcement, and education programs relating to NMVs; and an outer cordon survey. Regarding analytical techniques, there is an urgent need to develop a transportation network model capable of reflecting both motorized and nonmotorized transport modes by adjusting link characteristics such as link capacity and speed-volume relationships. Alternatively, in certain circumstances it may be acceptable to model motorized and nonmotorized modes separately, with explicit interacting relationships between the models to ensure consistency. Finally, it would be helpful to refine the engineering guidelines developed during the course of this recent study through pilot studies in selected cities.

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The views presented in this paper and any errors are the responsibility of the authors.

Comparative Study of Transportation Modal Choice in Asian Countries

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Major cities in developing countries in Asia are afflicted with heavy transportation problems because of an excessive concentration of people. Because the population is expected to continue to grow, the development of transport networks can have a major influence in providing more efficient and livable cities. In almost all cities, public transport modes play a major role even though the level of service is generally low. The lack of a railway system is the main deficiency of urban transportation systems. Paratransit and nonmotorized modes are used mostly to fill the travel demand. In these cities, people experience intolerable difficulties, mainly in their work trips. A graphical model to analyze the modal choice pattern of major cities in Asia with the level of economic development is developed. This model shows a consistent trend in the modal share with the change in gross national product (GNP) per capita. The country's per capita GNP will decide the zonal location of the city in the introduced graphical model together with population and city size. The mixed modes of an urban transportation system are recommended in large cities of Asia. Hence, as a starting point, densely populated major Asian cities should focus on urban mass transportation systems, including railway systems accompanied by development of infrastructure facilities for other modes.

The importance of urban transport lies fundamentally in its contribution to the economy of the country associated with urban growth. More than one-quarter of the developing world's population lives in an urban area, and more than half the national output is produced in the major cities (*1*).

Every metropolitan area in Asia is afflicted with transportation problems that will continue to grow in the future. High growth rates of population, rapid increase in urban population, and increased national products and per capita income have been the primary sources of increases in volume of person trips. This rapid increase in trips causes serious transportation problems with the unbalance between supply and demand of transportation and conflicts in land use pattern in these cities.

Urban growth rates are much higher than the national growth rates in developing countries of Asia. The availability of comparably high levels of transportation facilities and a large number of employment opportunities are encouraging migration from rural areas to cities in large scale. However, the fast-growing cities of Asia have not seen an accompanying development of transportation facilities. In this respect, the development of transport networks can have a major influence in providing more efficient and more livable cities to the enlarged populations.

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This paper intends to analyze the modal choice pattern of developing cities by reviewing the transportation behavior in Asian countries with a special concentration on the change in modal choice of person trips with economical growth. Consequently, several short-range measures are proposed to overcome the prevailing problems in the urban transportation system in Asian countries.

TRENDS IN TRANSPORTATION MODAL CHOICE

Urban Travel in Asian Cities

The modal choice of person trips is a function of economic activity distribution, socioeconomic profile of the population, and land utilization pattern of the city. Ridership of each mode varies among cities of comparable size and even in cities in the same country.

Transportation of people in the developing cities of Asia was not a problem when cities were small, both in population and size, because harmonized patterns of land use made the distances between activities short. With the introduction of motorized transportation, the size of cities expanded rapidly. As a result of unplanned growth in city size, the residential areas have spread in fringe areas, with remaining major activity centers in a small area. It necessitates large volumes of person trips with increasing travel distances.

Generally the urban transportation system in the cities of Asia consists of various modes. By reflecting the relative passenger-carrying capacity and user responsiveness the system can be clustered into three major groups: public transport (bus and railway), low-cost modes of transport (jeepney, auto-rickshaw, tonga, cycle rickshaw, motorcycle, bicycle, walking), and private transport (private car).

The work trip is the most important travel need in major cities of Asia. The pattern of work trips in cities is regular in time and space. People also travel for shopping, social activities, and recreation and between various business places, but the share of these trips is comparatively less than that of work trips. The demand for time for these other modes is irregular compared with that of work trips. Social and recreational trips are especially difficult to anticipate, but one favorable aspect of these trips is that their peak demand may be different from that of work trips.

Modal Choice of Person Trips

The use of public transport has a larger share than other modes in most cities of developing countries in Asia (Table 1), even

TABLE 1 Modal Split of Person Trips in Selected Asian Cities (*2,4–13*)

					Public Transport			Private Transport	Other Modes of Transport								
									Para-Transit Motorized								
Code No.	City	County's 1993 GNP /Capita US$	Population Density Pop./sq.km 1993	Year of Modal Split	Bus	Rail	Total	Car	Taxi	Other	Total	Non-motor -ized	Total Para Tran -sit	Motor cycle	Walk and Cycle	Any Oth -er	Total of Other Modes
1	Kuala Lumpur	2965	5328	1985	24.6	0.0	24.6	32.1	1.6	0.3	1.9	0.0	1.9	13.8	27.6	0.0	43.3
2	Bangkok (a)	1605	3954	1989	38.9	0.0	38.9	32.7	9.9	18.5	28.4	0.0	28.4	0.0	0.0	0.0	28.4
3	Chiang Mai	1605	1053	1977	7.0	0.0	7.0	7.0	0.0	80.0	80.0	6.0	86.0	0.0	0.0	0.0	86.0
4	Manila (b)	725	12315	1989	16.0	1.0	17.0	16.0	2.0	58.0	60.0	0.0	60.0	0.0	0.0	7.0	67.0
5	Cebu (c)	725	1625	1992	0.3	0.0	0.3	4.3	38.3	57.1	95.4	0.0	95.4	0.0	0.0	0.0	95.4
6	Jakarta (d)	605	12590	1990	50.0	0.3	50.3	25.2	3.0	4.7	7.7	0.0	7.7	16.8	0.0	0.0	24.5
7	Bandung	605	-	1991	17.7	0.0	17.7	5.6	0.0	9.7	9.7	0.0	9.7	17.3	49.7	0.0	76.7
8	Surabaya	605	-	1982	9.0	0.0	9.0	2.0	0.0	18.0	18.0	13.0	31.0	45.0	13.0	0.0	89.0
9	Colombo	510	2760	1992	69.0	3.0	72.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.0	18.0
10	Karachi (e)	400	5923	1988	52.0	6.0	58.0	18.0	3.0	15.0	18.0	0.0	18.0	6.0	0.0	0.0	24.0
11	Shanghai (f)	325	2013	1986	24.7	0.0	24.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72.1	3.2	75.3
12	Beijing (g)	325	3652	1987	32.1	0.0	32.1	0.0	0.6	0.0	0.6	0.0	0.6	0.0	64.1	3.2	67.9
13	Delhi (h)	310	15669	1981	48.8	11.0	59.8	16.7	0.0	6.2	6.2	0.0	6.2	0.0	17.3	0.0	23.5
14	Calcutta	310	23438	1985	67.0	10.0	77.0	0.0	2.0	14.0	16.0	7.0	23.0	0.0	0.0	0.0	23.0
15	Bombay	310	16450	1985	34.0	34.0	68.0	8.0	10.0	14.0	24.0	0.0	24.0	0.0	0.0	0.0	24.0
16	Kanpur (i)	310	5141	1977	7.0	0.0	7.0	0.0	0.0	5.0	5.0	88.0	93.0	0.0	0.0	0.0	93.0
17	Jaipur (j)	310	243	1985	6.0	0.0	6.0	3.0	0.0	7.0	7.0	22.0	29.0	18.0	44.0	0.0	91.0
18	Hyderabad	310	10418	1977	39.0	0.0	39.0	0.0	0.0	29.0	29.0	32.0	61.0	0.0	0.0	0.0	61.0
19	Kathmandu (k)	170	1266	1992	16.0	0.0	16.0	0.0	0.0	9.0	9.0	0.0	9.0	0.0	61.0	14.0	84.0
	Average of Asia				31.1	3.6	34.7	10.0	3.9	19.2	23.1	9.3	32.4	6.5	19.4	2.5	60.8

Notes: 0.0 = None or negligible
(a) Taxi=Incl.Silor & Samlor; Other=Hired Mcycle
(b) Rail=LRT; Other=Jeepney
(c) Taxi=Incl.Tricycle,MCycle,etc.;Other=Jeepney
(d) Car=incl.pickups;Otherl=Bajaj, Bemo, etc.
(e) Other=Autorickshaw
(f) Walk=40.3%,BCycle=31.8%;Taxi=Incl.MCycle,Truck,etc.
(g) Walk=13.8%,BCycle=50.3%
(h) Bus=Incl.Rail;Car=Car,Scoooter;Taxi=Incl.Autorickshaw
(i) Non-motorized=Cycle Rickshaw
(j) Taxi=All Motorized;Non-Motor.=Cyclerickshaw
(k) Walk=56%;Other=Cycle-rickshaw,Tempo,Metertempo,MiniBus

though the levels of service and area served are inadequate. The bus system is the most typical example of all deficiencies. Although constituting a small percentage in the total vehicle composition on the roads, buses typically account for more than one-third of person trips in most developing cities, such as Bangkok, Jakarta, Colombo, Karachi, Beijing, Delhi, Calcutta, and Bombay.

Urban rail services have importance in few cities. In Bombay, for example, railways carry 34 percent of total trips. In most cities, urban railways suffer from antiquated rolling stock that is often more than 50 years old, with poor track conditions and a poor signaling system.

The deficiencies of bus and rail services are being alleviated by paratransit modes that act as an intermediate mode of transport in most Asian cities. Paratransit modes are of two forms: motorized and nonmotorized. Auto-rickshaws, silors, samlors, jeepneys, bajajs (three-wheelers), scooter rickshaws, motorcycle rickshaws (motorized) and becaks, tongas, cycle-rickshaws, and tricycles (nonmotorized) are some paratransit modes in use in Asian cities. In Manila and Cebu, one-half of trips are made by jeepneys. Nonmotorized vehicles are used extensively in most Asian countries. For example, cycle-rickshaws are dominant in Kanpur because they carry 88 percent of total person trips of the city.

A large percentage of trips in most developing countries, including trips to work, are made on foot or cycles; for example, in Shanghai and Beijing trips are made by cycling and in Kathmandu by walking. In all developing cities in Asia the facilities for pedestrians are poor. Conditions for cyclists are worse than they are for pedestrians. In Shanghai and Beijing the number of bicycles [7.20 million and 7.26 million bicycles in 1990, respectively (*2*)] is more than or equal to one-half its population, and in many other cities bicycles outnumber automobiles. Even in Beijing and Shanghai, where bicycle lanes are provided, the other related infrastructures such as lane dividers, railway, road crossings, and flyovers are not sufficient.

The low usage rate of public transport may reflect either high levels of private automobile ownership or too low an income to afford the fare. In cities such as Kuala Lumpur and Bangkok, because of increased car ownership, the modal share by private car has been increased from the last decade. The degree of motorization is closely related to the levels of income together with taxation policy and import quotas. On the other hand, low-income cities will use nonmotorized modes, as in Beijing and Shanghai (bicycle), Kanpur and Jaipur (cycle-rickshaw), and Kathmandu (walking).

Automobile ownership in Asia lags far behind that in the developed countries, and in general most of the cars are in cities. In Thailand, 70 percent of the cars are in Bangkok (*3*). In Bangkok, 47 percent of the vehicles registered were private cars in 1991, whereas for the whole country only 15 percent of the total registered vehicles are private cars (*3*).

From the available data on modal split in different cities of Asia, the following deductions may be drawn.

1. The growth in gross national product (GNP) per capita reduces the upper limit of public transport usage, whereas private care use increases when GNP per capita grows (Figure 1).

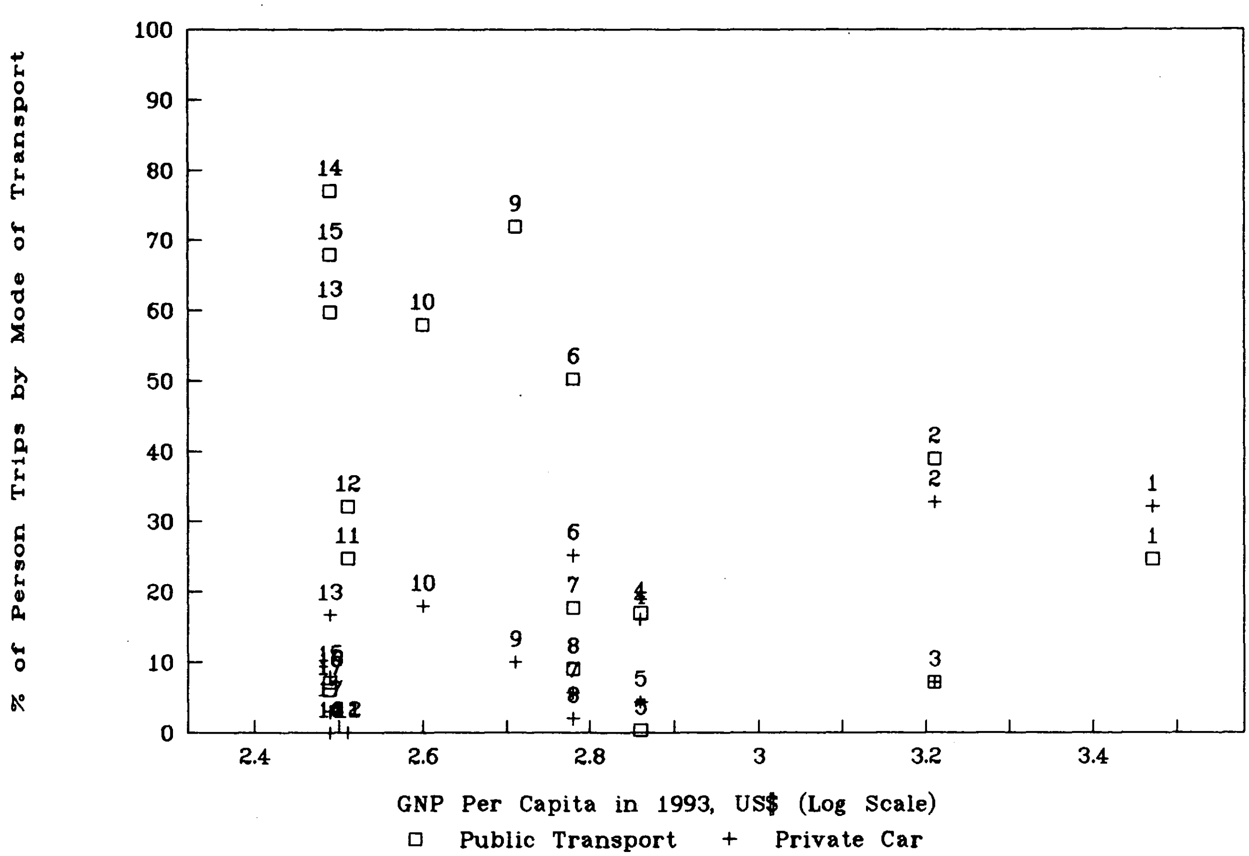

FIGURE 1 Variation in modal share by public transport and private car with per capita GNP.

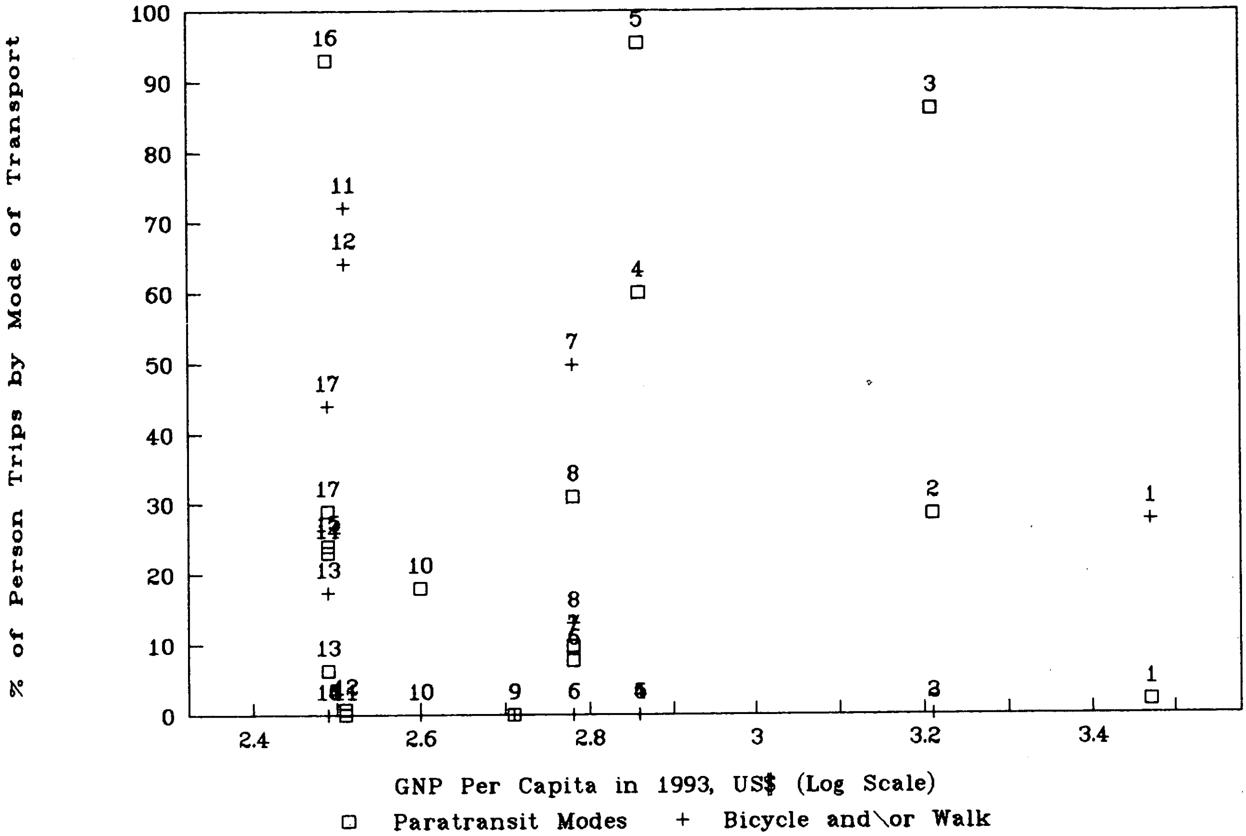

FIGURE 2 Variation in modal share by paratransit, bicycle, and walking with per capita GNP.

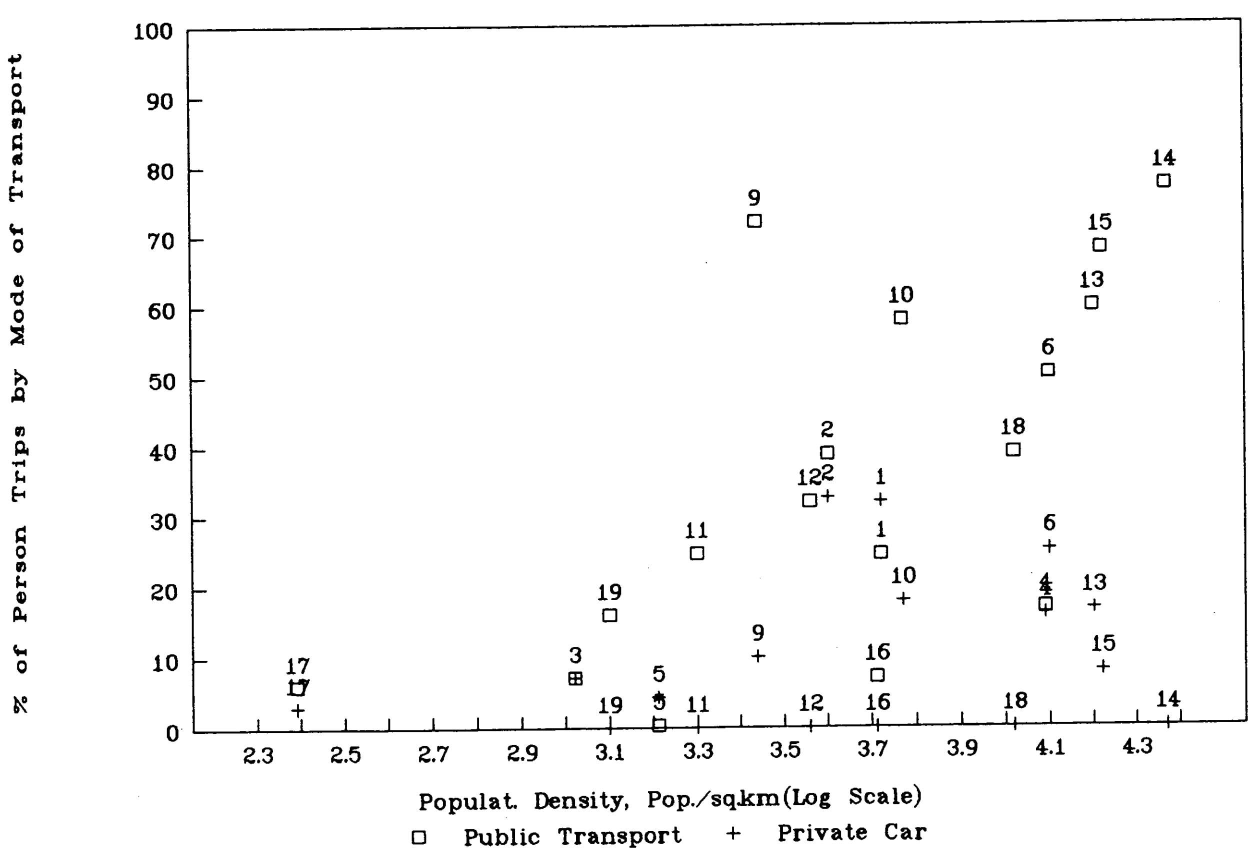

FIGURE 3 Variation in modal share by public transport and private car with population density.

2. Figure 2 shows the reduction in the share of paratransit modes with an increase in per capita GNP. The poor, who cannot afford any motorized transport and who walk and use bicycles, will increase the use of paratransit modes with the growth of income. As a result, the share of walking and cycle trips will decrease.

3. In cities of large population densities, a larger share of person trips by public transport modes can be seen (Figure 3). It may be possible to operate public transport services profitably in densely populated cities because of the attraction of more passengers as a result of its cheap fare. This results in lower usage of private automobiles.

4. When cities become more dense and major activity centers remain concentrated in the city center, people need to make more short-distance than long-distance trips because all daily activity centers can be located in the vicinity of the residential area. Therefore, people are inclined toward walking and cycling for their short-distance trips in densely populated cities of developing countries (Figure 4).

Modal Choice by Trip Purpose

The separation of residential areas from workplaces with rapid growth in urban areas has created a pendulum movement between home and work during peak periods. This accounts for a larger volume of person trips than any other type of trips. The shopping trip is the second most frequent type of urban travel. The length of shopping trips, on the average, is shorter than that of work trips.

In general, the work trips generated in all the cities make up more than 25 percent and in some cities more than 50 percent of total trips (Table 2). When the share of national products in the major or capital city is comparably larger, the city provides a larger number of employment opportunities and contains most of the industries of the country, which in turn generates larger volumes of work trips.

Figure 5 shows that with the increase in the per capita GNP of countries, the percentage of trips to work is possibly reduced. This is because fewer people may need to work and other activities may become dominant. Meanwhile, a high percentage of nonworking people generate more trips to shopping, recreation, social, and religious locations and in turn trips for other purposes increase.

Table 3 shows that more trips for work and school are made than for public and bicycle/walk trips.

COMPARATIVE ANALYSIS OF MODAL CHOICE AND TRIP CHARACTERISTICS

The population densities, GNP per capita, level of motorization, number of motorized and nonmotorized trips, and each country's modal split pattern of person trips are analyzed by developing a graphical model. In spite of few available data, there are indications of sufficient consistency in the result to warrant further

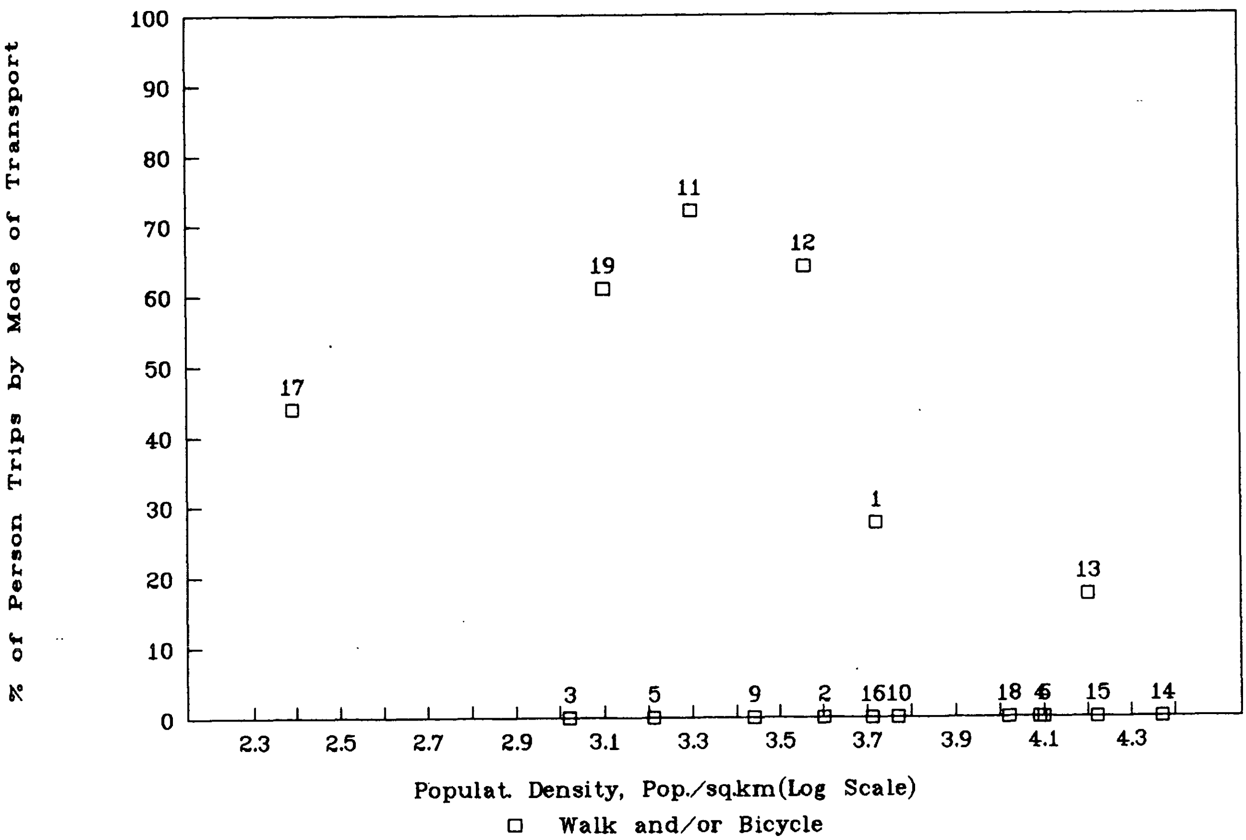

FIGURE 4 Variation in modal share by walking and bicycle with population density.

TABLE 2 Modal Split by Trip Purpose in Asian Cities (*4–7,10–12*)

Code No.	City	GNP Per Capita US$	Population Density Pop. per sq.km	Year of Modal Split	Trip Purpose Work	Schl.	Total	Shop.	Busi.	Total	Recr.	Priv.	Total	Home	Othe.	Total	Work + Home
1	Kuala Lumpur	2965	5328	1985	14.6	10.6	25.2	-	6.3	6.3	-	26.5	26.5	42.0	-	42.0	56.6
2	Bangkok	1605	3954	1989	19.7	10.4	30.1	-	13.0	13.0	-	15.1	15.1	41.8	-	41.8	61.5
3	Chiang Mai	1605	1053	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	Manila	725	12315	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	Cebu	725	1625	1992	12.3	12.0	24.3	-	5.1	5.1	-	-	0.0	48.6	22.0	70.6	60.9
6	Jakarta	605	12590	1990	22.6	11.5	34.1	4.3	7.0	11.3	-	12.4	12.4	42.2	-	42.2	64.8
7	Bandung	605	-	1991	23.5	8.5	32.0	8.6	-	8.6	-	-	-	43.4	16.0	59.4	66.9
8	Surabaya	605	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	Colombo	510	2760	1992	-	-	68.4	-	-	12.2	-	-	11.6	-	7.8	7.8	68.4
10	Karachi	400	5923	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	Shanghai	325	2013	1986	76.3	3.9	80.2	13.6	-	13.6	3.9	-	3.9	-	2.3	2.3	76.3
12	Beijing	325	595	1990	26.2	5.8	32.0	6.0	2.4	8.4	3.3	-	3.3	45.8	10.5	56.3	72.0
13	Delhi	310	15669	1981	52.6	16.2	68.8	3.5	6.2	9.7	14.6	1.1	15.7	-	5.8	5.8	52.6
14	Calcutta	310	23438	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	Bombay	310	16450	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	Kanpur	310	5141	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	Jaipur	310	243	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	Hyderabad	310	10418	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	Kathmandu	170	1266	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes: - = Data not available
Schl. = School
Shop. = Shopping
Busi. = Business
Recr. = Recreation
Priv. = Private
Othe. = Other

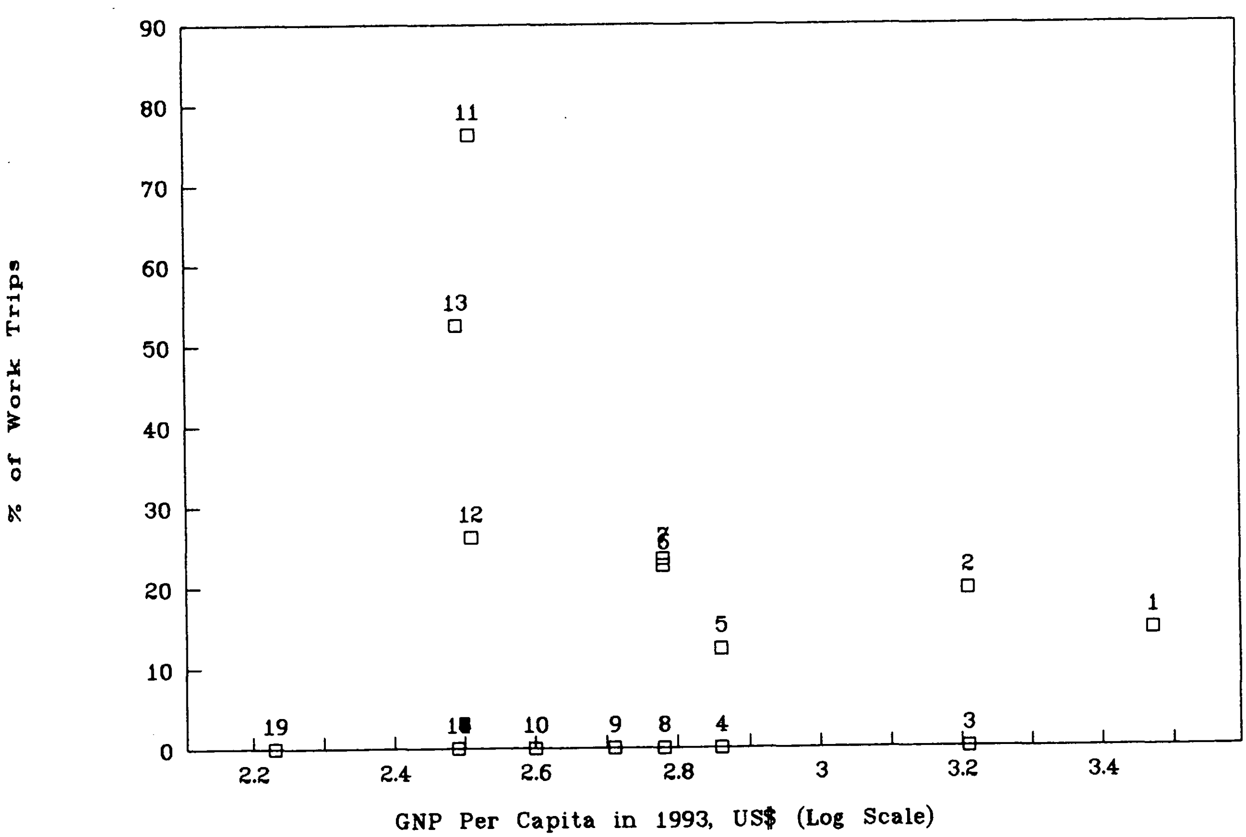

FIGURE 5 Variation in work trips with per capita GNP.

TABLE 3 Percentage Distribution of Work and School Trips by Mode (*4–7,10,11,14*)

City	Purpose	Public	Private	Para-transit	MCycle	Cycle & Walk
Tokyo	Work	52	25	0	12	11
	School	25	5	0	7	63
Bangkok	Work	59	37	2	2	-
Jakarta	Work	34	20	-	19	27
	School	26	7.5	-	3.5	63
Bandung	Work	14	5	10	18	53
	School	22	3	10	27	38
Delhi	Work	37	4	2	10	47
	School	17	0	2	0	81
Shanghai	Work	36	-	-	-	64
	School	31	-	-	-	69

TABLE 4 Modal Split Data of Selected Cities the Developed World (*14,15*)

Code Number	City	GNP Per Capita of Country US$ (1993)	Modal Split (1982-1988) Public %	Private %	Other %
A1	Tokyo	27,326	67	32	1
B	USA-country	22,550	5	89	6
B1	New York	22,550	86	12	2
C	Stockholm	22,391	52	48	0
D	Stuttgart	21,475	33	44	23
E	Paris	21,188	29	56	15
F	London	17,738	35	61	4
G	Hong Kong	14,102	79	8	13
I	Wellington	11,875	31	56	13

TABLE 5 Change in Modal Split in Selected Asian Cities *(16,17)*

Code No.	City	Mode	1955	1960	1965	1970	1975	1980	1985	1990
A1	Tokyo	Public	93	92	91	75	76	71	75	65
		Private	0	0	0	18	19	23	24	30
		Other	7	8	9	7	5	6	1	5
A2	Nagoya	Public	94	92	91	60	49	39	37	33
		Private	0	0	0	32	45	55	59	64
		Other	6	8	9	8	6	6	4	3
A3	Osaka	Public	94	93	90	75	71	65	64	60
		Private	0	0	0	17	23	29	31	36
		Other	6	7	10	8	6	6	5	4
1	Kuala Lumpur *a*	Public	-	-	-	35	-	-	25	-
		Private	-	-	-	47	-	-	32	-
		Other	-	-	-	18	-	-	43	-
2	Bangkok *a*	Public	-	-	-	59	-	-	39	-
		Private	-	-	-	29	-	-	33	-
		Other	-	-	-	12	-	-	28	-
6	Jakarta *a*	Public	-	-	-	61	-	-	50	-
		Private	-	-	-	24	-	-	25	-
		Other	-	-	-	15	-	-	25	-
10	Karachi *a*	Public	-	-	-	63	-	-	58	-
		Private	-	-	-	16	-	-	18	-
		Other	-	-	-	21	-	-	24	-
13	Delhi *a*	Public	-	-	-	41	-	-	59	-
		Private	-	-	-	13	-	-	17	-
		Other	-	-	-	46	-	-	24	-
14	Calcutta *a*	Public	-	-	-	34	-	-	77	-
		Private	-	-	-	8	-	-	0	-
		Other	-	-	-	58	-	-	23	-
15	Bombay *a*	Public	-	-	-	41	-	-	68	-
		Private	-	-	-	11	-	-	8	-
		Other	-	-	-	48	-	-	24	-

Notes: - = Data unavailable.

a Data corresponding to 1985 were collected during 1980-1988.

development of the model. The constructed model has been validated by comparing the present modal split of Asian developing cities (Table 1) with some cities in the developed world (Table 4) and by testing historical data sets of some cities of Asia (Table 5).

Modes of transport in Asian countries are categorized into three main groups, as follows, to apply in the suggested graphical model.

1. Public transport: bus, rail, subway, street car;
2. Private transport: private car;
3. Low-cost (other modes): motorized paratransit (silor and samlor in Bangkok, jeepney in Manila and Cebu, and bajaj in Jakarta); nonmotorized paratransit (cycle-rickshaw in Kanpur and Jaipur); motorcycle; and bicycle and walk.

Because the percentage of trips by taxi is very small in any country under analysis, such as Kuala Lumpur (1.6 percent), Bangkok (9.9 percent), Jakarta (3 percent), and Bombay (4 percent), it is included here under low-cost modes of transport group for statistical convenience.

The modal choice pattern of cities in Asian developing countries and some selected cities of developed countries is plotted in the proposed trilinear graphical model in Figure 6 on the basis of the data presented in Tables 1 and 4.

Past and present modal split data of some cities in Japan and Asia (Table 6) are plotted in Figure 7 to illustrate the change in modal choice with the level of economic development of countries of those cities.

Figures 6 and 7 reveal that the trilinear graphical model can be divided into four zones, which gives the dominating mode of transport of the city by its zonal location in the model. Following are the four zones that derived from the model.

1. Low-cost modes of transport;
2. Public transport;
3. Mixed transport, divided into the following subzones: (a) public and low-cost modes, (b) public and private car, (c) low cost modes and private car; and
4. Private car.

Figure 8 shows the pattern of change in modal choice with the economic development of the country based on historical data. The trend in the urban tansportation system is from low-cost modes, especially nonmotorized modes, to mixed (i.e., low-cost and public), and then to public transport dependent (bus and rail mainly) as the country changes from being an underdeveloped country to a developed country. Then, as the economy continues to grow, the tendency of urban transport is toward private car dependent and, therefore, the location of the city in the model will move upwards, to the uppermost triangle by passing mixed-zone modes (public, private car, and low-cost modes). Also, there are some cases that heap their positions on the left axis, such as New York, Tokyo, Nagoya, and Osaka, where subways and urban trains play a major role. Still, in those cities the change pattern of modal choice moves upwards with the development of the economy (Figure 7).

The analysis done in this study by the trilinear graphical model is based on the available historical facts. Therefore, the derived change pattern of modal choice is not necessarily a preferable pattern with the city development level.

POSSIBLE SOLUTIONS TO PROBLEMS IN URBAN TRANSPORTATION SYSTEM

Urban Transportation System with Mixed Modes of Transport

The most preferable pattern of modal choice of person trips in Asian countries would be mixed modes (the middle rectangular

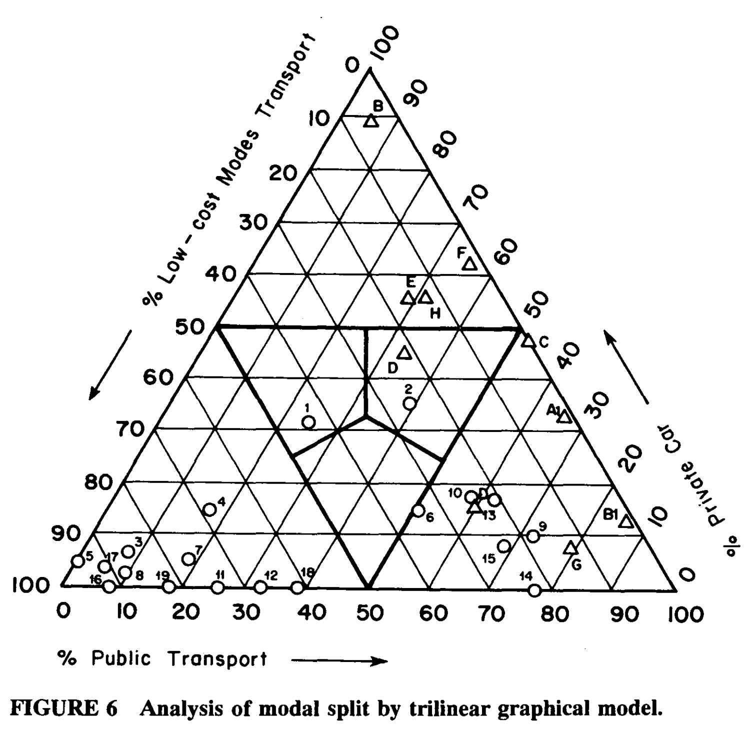

FIGURE 6 Analysis of modal split by trilinear graphical model.

TABLE 6 Classification of Developing Cities in Asia on the Basis of Modal Choice by Trilinear Graphical Model, 1993

Dominating Type of Mode	Country/City	GNP Per Capita US $	Population Density Pop./sq.km
1. Low Cost Modes of Transport Dependent	Chiang Mai	1605	1053
	Manila	725	12315
	Cebu	725	1625
	Bandung	605	-
	Surabaya	605	-
	Shanghai	325	2013
	Beijing	325	3652
	Kanpur	310	4141
	Jaipur	310	243*a*
	Hyderabad	310	10418
	Kathmandu	170	1266
2. Public Transport Dependent	Colombo	510	2760
	Karachi	400	5923
	Delhi	310	15669
	Calcutta	310	23438
	Bombay	310	16450
3. Mixed Mode Dependent			
a. Low Cost Mode & Public Transport	None		
b. Pubic Transport & Private Car	Bangkok	1605	3954
	Jakarta	605	12590
c. Private Car & Low Cost Modes	Kuala Lumpur	2965	5328
4. Private Car Dependent	None		

a Metropolitan/municipality area is not known and total area was used here.

\- Data not available.

Note: Only those cities which were mentioned in TABLE 1 are classified here.

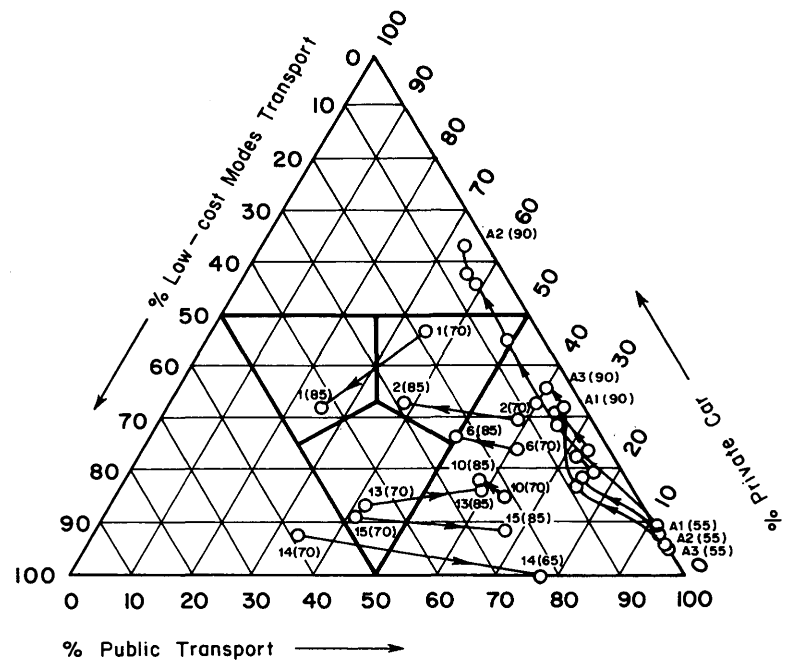

FIGURE 7 Change in modal choice in selected Asian cities.

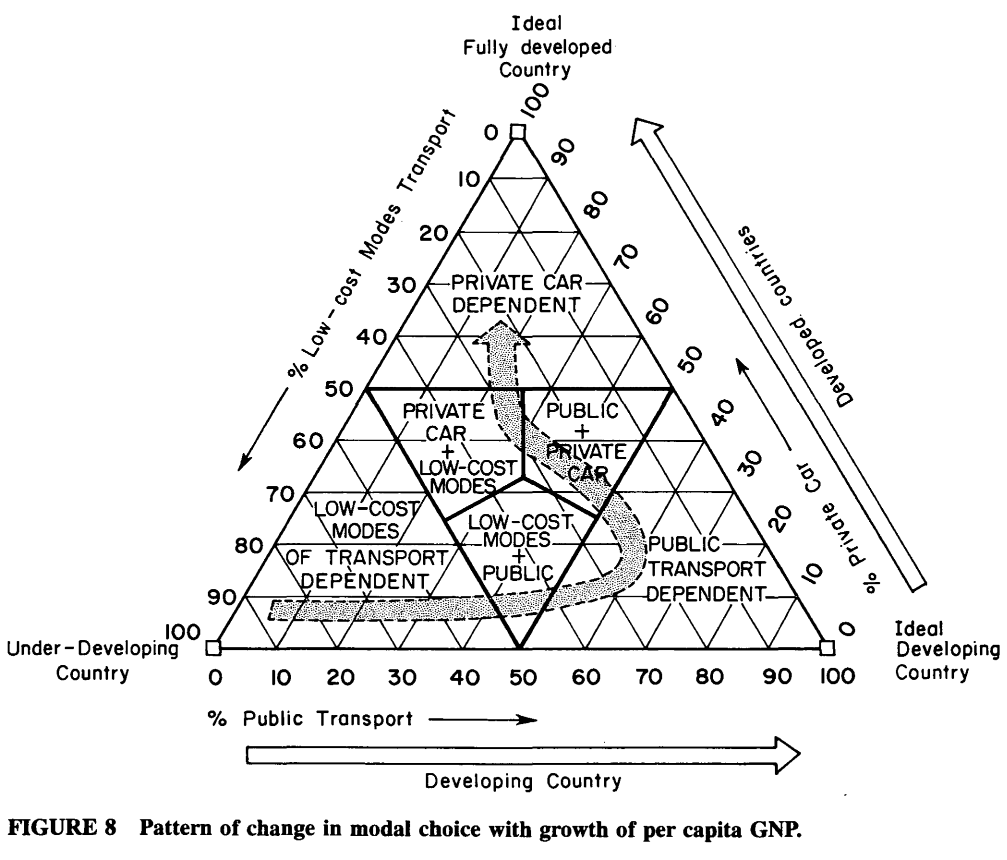

FIGURE 8 Pattern of change in modal choice with growth of per capita GNP.

zone in the model), where people have a variety of modes to choose from on the basis of their willingness, affordability, and travel need. The precise position in the middle triangle should be decided on the basis of such factors as city size, population, and GNP per capita. To approach this stage, all the developing cities in Asia would have to provide infrastructures for all types of modes. In most developing cities, railway is lacking. Hence, as a starting point, the railway system needs to be developed to complement the development of infrastructures for all modes, such as pedestrian facilities, bicycle lanes, and bus lanes. After such development, the public transport system could be used in the crowded urban areas with paratransit modes to provide feeder service. In the later stages, these cities could consider a supplementary improvement with various levels of service and comfort by mixed modes to fill the demand created by people from different income levels.

At present a railway system is being developed in Los Angeles, and a bicycle way is being developed in Holland. These projects may show that even developed cities try to go back to the middle triangle of the above-described trilinear model.

Possibility of Mass Transit

Commuter traffic in large cities by necessity is predominantly serviced by mass transport systems. A reliable mass transport system has been drawing attention recently in most of the large cities.

Bangkok, where the traffic congestion is considered to be among the world's worst (Table 7), remains as one of the major cities in Southeast Asia still without a mass transit system.

Many different forms of bus-based and rail-based mass transit systems are considered to be suitable in developing cities of Asia; these include the guided-bus way, the subway system, the skytrain, and metropolitan rapid transit. Of these mass transit systems, the most appropriate system should be selected on the basis of the type, fare structure, coordination with existing public transport systems, and finally economic and financial feasibility of the system as a first step.

Because of the availability of bus systems in all the cities of Asia, it is more appropriate to improve the present bus system as an immediate way to solve the transportation problem to some extent. Improvements can be made by providing specific require-

TABLE 7 Available Mass Transit Systems in Asian Cities (*2,4,7,8,10,11,15*)

City	Type of Mass Transit System	Status
Singapore	Mass Rail Transit (MRT)	In operation
Kuala Lumpur	Light Rail Transit and Mono Rail	----ditto---
Bangkok	Train Service	*a*
	Sky Train, Subway and Rapid Transit	Under consideration
Metro Manila	Light Rail Transit (LRT)	In operation
Jakarta	Elevated Railway	
Colombo	Train Service	*a*
Karachi	Train Service	*a*
Beijing	Subway	In operation
Shanghai	Subway	Under construction
Delhi	Train Service	*a*
Calcutta	Train Service	*a*
Bombay	Train Service	*a*

a Generally provides long distance service and not adequate with rolling stock and infrastructure to cater for the existing demand in urban transportation system.

ments such as exclusive bus lanes, improved level of service, and increased area of service. These improvements may be used when it would be possible to implement an urban mass transit system in these cities in coming years.

CONCLUSIONS AND RECOMMENDATIONS

Rapid urbanization and motorization combined with a shortage of resources are the major cause of the current urban traffic problems of most developing countries in Asia. These resource limitations in developing countries seriously impede the possibilities of increasing transport capacity in a metropolis. A shortage of surface space in central city areas remains as another limiting factor that obstructs extensive improvements in the road/railway network.

For most cities in Asia and the great majority of their populations, the choice of mode is between regular bus (31.1 percent average) and very cheap walking and cycling (19.4 percent average). Excluding taxi, paratransit (motorized) modes play a significant role in the urban transport system of developing countries, accounting for approximately 19.2 percent average users in all countries in Asia under consideration in this study. Taxis are not affordable in almost all countries. Railway accounts for only 3.6 percent average of the total because of the nonavailability of rail service in most Asian countries. Among considered countries in Asia, railway service is used for commuter trips only in a few cities such as Bombay, Calcutta, Colombo, and Karachi.

The developed trilinear graphical model shows a consistent trend in modal share change with the changed GNP per capita. Each city should find the desirable zonal location in the diagram, depending on per capita GNP as well as population, size of the city, and other secondary facts related to the level of city development.

A mixed mode of transportation system is recommended for large cities because it enables the system to cater to the person-trip demand with different levels of affordability and travel needs generated by large and dense cities of Asia. Improvement of the present bus system would be a prompt remedial action to ease the prevailing situation in these cities. Further, as a first step, it is suggested that urban mass transit systems be developed to include a railway system along with development of the infrastructure facilities that are required by all types of modes.

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Moving Toward Integrated Transport Planning: Energy, Environment, and Mobility in Four Asian Cities

P. CHRISTOPHER ZEGRAS AND MIA LAYNE BIRK

Around the world today, cities face serious problems of congestion, air pollution, and energy consumption that are directly related to transport system growth. To meet growing transport needs, cities require new solutions that will allow them to simultaneously develop economically and minimize the negative effects of transport system growth. The experiences of four very different Asian cities—Bangkok, Thailand; Surabaya, Indonesia; Islamabad, Pakistan; and Varanasi, India—demonstrate the clear need for a new planning approach that allows consideration of all available options. This new approach—integrated transport planning—emphasizes as the primary goal accessibility for citizens rather than mobility for individual vehicles. The integrated approach considers environmental, social, and energy use costs of transport systems to be inherent to the planning process and values projects that provide multiple positive benefits and complement a city's urban development goals. Finally, the integrated approach seeks to develop long-term, proactive solutions that make the best use of scarce investment dollars. The worldwide use of the integrated transport planning approach will lead to a network of efficient, economically viable, environmentally sustainable cities.

A complex web of interrelated human needs and activities makes up an urban area. To ensure the efficient commerce of goods and services, the fulfillment of residents' needs, and sustained long-term economic growth, urban areas require an efficient transportation system. To endure over time, such a system must therefore be sustainable—meeting the basic transportation needs of all citizens without depleting the economic and natural resource base. A well-developed transport system promotes economic growth by allowing efficient commerce, attracting new business activity, and providing access to fulfill residents' daily requirements. Indeed, like any other urban public service—sewage, clean water, electricity—expansion of transport services must accompany development to ensure healthy growth.

Today the transportation systems of many cities are not accomplishing their basic tasks; instead they inefficiently clog space, pollute air, consume large quantities of petroleum products, inadequately provide for residents, require large portions of financial resources for operation and maintenance, and hamper economic growth. Traditionally, most cities and lending agencies have responded to transport shortfalls and inefficiency by expanding the road network. Although the development of road networks is important, roads are only one part of the entire transport system. Focusing only on a single system component rather than the system as a whole leads to piecemeal solutions, and system growth easily overwhelms individual component progress. Such approaches—relying on a nonrenewable natural resource base, polluting the environment, devouring financial resources, and inadequately servicing all residents' needs—have led many cities to their present congested state.

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LINKS BETWEEN TRANSPORTATION, CONGESTION, OIL USE PROBLEMS, AND ENVIRONMENTAL DEGRADATION

Historically, motorization and its accompanying congestion, oil dependency, and air pollution have plagued the cities of the industrialized world. Today, however, motor vehicles and the adverse effects of their intensive use have spread worldwide.

Motor Vehicle Fleet Growth

Much of the future growth in motorization will occur outside the industrialized world. Motor vehicle growth rates in many of the developing and newly industrialized countries of Asia, Africa, and Latin America far outpaced those of the Organization for Economic Cooperation and Development (OECD) countries (which include the United States, Canada, most European countries, and Japan) during the 1980s. Between 1988 and 1995, the motor vehicle fleet in the Asia-Pacific region (excluding Japan) is projected to grow 96 percent, compared with a projected 12 percent growth in Western Europe during the same period (*1*). If present trends continue, the global motor vehicle fleet will double in the next 20 to 30 years (*2*).

Economic Strain of Petroleum Consumption Growth

Increased motor vehicle use comes at an economic cost, particularly because of the consumption of petroleum necessary to fuel fleets. Rising transportation petroleum consumption—already accounting for over half of petroleum consumption in most developing countries (*3*)—requires depletion of foreign capital reserves to import oil. Many of these countries already spend as much as 15 percent of their export earnings on oil and some actually spend over 50 percent of export earnings (*4*).

Furthermore, rising oil consumption in one country implies rising global oil demand—and prices—felt in all countries, jeopardizing the stability of the global economic climate. History shows the economic and social ramifications of overdependence on oil—seen during the Arab oil embargo of 1973, the Iranian revolution of 1979, and the 1990 Persian Gulf crisis.

Effects of Congestion

The rising worldwide demand for oil is aggravated by traffic congestion, which squanders millions of barrels of oil annually. For example, in Bangkok (Thailand), an estimated U.S. $1.4 million worth of fuel is wasted every day by vehicles idling in traffic. In addition, a study by the engineering office of the Bangkok Metropolitan Administration estimates that had the person-hours lost from the average 44 working days spent in traffic each year been put to productive use, Thailand's gross domestic product would have grown another 10 percent (*5*).

Environmental and Social Impacts of Transport

Congestion also intensifies motor vehicle emissions, contributing to rapidly deteriorating air quality. In some cities—including Mexico City (Mexico), São Paulo (Brazil), Manila (the Philippines), and Kuala Lumpur (Malaysia)—between 70 percent and 86 percent of total airborne pollutants can be attributed to road transport (*6*,p.196). Transport vehicles burning fossil fuels emit lead, hydrocarbons (HC), nitrogen oxides (NO_x), carbon monoxide, sulfur oxides, and suspended particulate matter—all health hazards. The combination of HC and NO_x in the presence of sunlight forms ozone, a key ingredient of urban smog and a danger to health and local vegetation. The noise from intense traffic leads to hearing loss and the stress of dealing with traffic is linked to many psychological disorders.

Other negative effects of congestion and related pollution include loss of potential investors who stay away to avoid the inefficiency—as is occurring in Bangkok, Thailand, and San Francisco, California, and harm to the tourism industry, which many countries rely on for foreign exchange earnings.

Motor vehicle emissions also threaten the global ecosystem by emitting greenhouse gases, implicated in potential global warming. Worldwide, the transport sector accounts for 14 percent of the world's carbon dioxide (CO_2) emissions—the most significant greenhouse gas (*7*).

EXPERIENCES IN FOUR ASIAN CITIES

To minimize the negative impacts of traditional transportation development, developing countries require new solutions that enable them to meet transport needs within energy, environmental, and economic constraints simultaneously. To address this need, in November 1990 the International Institute for Energy Conservation (IIEC) initiated a project entitled "Assessment of Transportation Growth in Asia and Its Effects on Energy Use, the Environment, and Traffic Congestion." The goal of the assessment was to identify options for cities of various levels of infrastructure development that would enable them to meet transport needs while minimizing environmental degradation, oil consumption, and traffic congestion.

Four cities were selected as case study sites for the assessment. The four cities—Bangkok, Thailand; Surabaya, Indonesia; Varanasi, India; and Islamabad, Pakistan—were selected because each represents a different level of infrastructure development. Bangkok typifies those cities that have highly developed road transport systems and are experiencing crises in their transportation sectors with regard to energy use, pollution, and congestion. Surabaya typifies those urban regions that are growing rapidly in transport infrastructure; although they have not yet reached the pollution and congestion levels of a city such as Bangkok, they are proceeding rapidly along this path. Varanasi is representative of smaller cities whose transport sectors are still dominated by traditional, nonmotorized transport modes but are expected to increasingly use motorized modes in the future. Because these cities are in their transportation infrastructure infancy, implementation of long-term planning strategies can help them avoid the transport-related problems now suffered by highly motorized cities. Finally, Islamabad—a small city whose development has been carefully planned and managed—provides a comparison between its careful development planning and the unmanaged growth of the other cities.

City Descriptions

Information about each city is drawn from case studies published by IIEC (*8–11*), Washington, D.C. Each of the four cities represents distinctly different phases of demographic, economic, cultural, and historical development. Bangkok, the capital of Thailand, was founded 200 years ago and has grown into one of the world's major metropolitan areas, serving as the economic, administrative, and spiritual hub of a rapidly growing country. It is home to about 8.5 million people—14 percent of the country's population—and accounts for almost half of the nation's annual economic growth. Surabaya, the capital of Indonesia's East Java Province, has historical roots tracing back to at least the 13th century and traditionally has served as a bustling trading port. It has a population of about 2.5 million and continues to thrive as an important regional and international port, an administrative center, and a focus of industry and education. In contrast, Islamabad, the capital of Pakistan, is only 30 years old and represents just 0.5 percent of the nation's population—about 600,000 people. Islamabad plays a relatively small role in the domestic economy and serves primarily administrative, diplomatic, cultural, and religious purposes. Varanasi, with historical roots leading back at least 3,000 years, is a revered spiritual center for Hindus and Buddhists, home to some of India's most important temples and mosques, and a center of higher education and art. Varanasi has just over 1 million inhabitants.

Just as the four cities contrast greatly in historical development and in their respective roles in regional and national activity, they also differ in their transportation systems and levels of urban infrastructure development.

Bangkok

In Bangkok private motor vehicles such as cars, pickup trucks, and motorcycles account for the majority of daily motorized trips taken by residents. Bangkok's transport system is severely congested for up to 16 hr/day, and the city suffers tremendous air and noise pollution, oil wastage, and economic problems as a result. Significant contributors to Bangkok's reliance on private motorized transport include its sprawling urban development, infrastructure investment emphasis on large road-building projects, and congestion-constrained public bus system.

Because its transportation-related problems are so great, Bangkok requires short-term solutions to stem the current crisis and long-term solutions that prevent such a critical situation from occurring in the future. Such solutions run the gamut of transportation options, such as improvements in fuel quality, vehicle technology, maintenance, and driver handling improvements; mass transit options; traffic management; measures that decrease the need and desire to operate vehicles; and long-range land-use planning. Because Bangkok is central to the Thai economy, policies created in Bangkok for such items as individual vehicle emissions or fuel economy will set a positive standard for the country as a whole.

Surabaya

Surabaya provides a major economic growth center for Indonesia's East Java province and is experiencing the initial stages of problems resulting from rapid transportation system growth. Although its congestion problems are nowhere near the crisis levels of Bangkok's, its problems will become much more acute within the next decade if present trends are not aggressively reversed. Surabaya's transport system, characterized by short discontinuous road links, a winding one-way network on many of the main roads, and a few major north-south transport corridors traversing the city, has been constrained by existing city structures and natural physical barriers. Private motorized transport is dominated by a relatively high population of motorcycles and a smaller number of automobiles. Buses and minibuses provide most of the public transport services with auxiliary service from taxi and taxi-like services.

To steer the city's transport system development away from the path of Bangkok, Surabaya requires options that are forward thinking to put in place a system that can handle future dynamic growth. Surabaya's best available options include policies to ensure priority to public and nonmotorized transport, land use planning to manage development in a transport-oriented manner that discourages urban sprawl, and better traffic control. Improvements in vehicle and fuel quality will require national and provincial level leadership; thus Surabaya can play a model role in pushing for these changes.

Varanasi

In Varanasi, nonmotorized transport modes and two-wheeled motorized vehicles dominate the city's vehicle population, with few buses and cars on the city's streets. The diverse vehicle types crowding Varanasi's streets, the almost complete lack of a formal public transport system, absence of traffic management, and traditional, narrow center-city roads contribute to long periods of peak traffic.

Because it is an ancient city now facing the advent of modern transport vehicles and needs, Varanasi's challenge is to create a system that addresses tourist and resident needs while preserving its historic and religious character. Its solutions must be long-range in focus, concentrating on providing public transport and nonmotorized and pedestrian access for the majority of residents who neither can afford to drive a car nor would be able to drive effectively in the large portion of the city not designed for four-wheeled vehicle traffic.

Islamabad

Finally, Islamabad, a city designed on a grid road network, benefits from wide, relatively well maintained streets designed with future vehicle population growth levels in mind. No visible traffic or pollution problems exist, although residents notice that traffic volumes have increased over the years. Private motorized vehicles such as cars and, to a lesser extent, motorcycles dominate 44 percent of Islamabad's passenger travel, with buses satisfying only 28 percent of residents' demand for mobility.

Islamabad enjoys the unique position of a city having effectively controlled growth; thus it has time to examine its options. To meet the transport needs of Islamabad's citizens in the most environmentally sustainable manner, it must consider whether its current system allows for the most efficient movement of people and goods. Although its transport emissions and energy use problems are relatively minor, Islamabad has an opportunity to argue for progressive improvements in vehicle maintenance and technology, reduction of lead in gasoline and sulfur in diesel fuel, a better pedestrian and bicycle travel environment, and an attractive bus system for both school children and workers.

City Commonalities

Despite their differences, the cities' transport systems share common characteristics that point to general trends within urban areas in developing countries. First, the cities have rapidly growing urban populations, with annual growth rates over the past decade ranging from 2.2 percent in Bangkok to 6.6 percent in Islamabad.

Second, three of the cities—Varanasi, Bangkok, and Surabaya—have high central area densities, ranging from 300 people per hectare in Bangkok to approximately 700 people per hectare in Varanasi. Moving away from the city centers, population densities slowly decline. As shown in Figure 1, per capita energy use in the four cities tends to increase when density declines. [The apparent negative correlation between per capita energy use and urban area density is consistent with a similar correlation from an international 32-city study by Newman and Kenworthy (*12*).] At the same time, center city dwellers are increasingly fleeing to less congested suburbs. Bangkok and Surabaya already display urban sprawl characteristics, developing uncontrolled in all directions

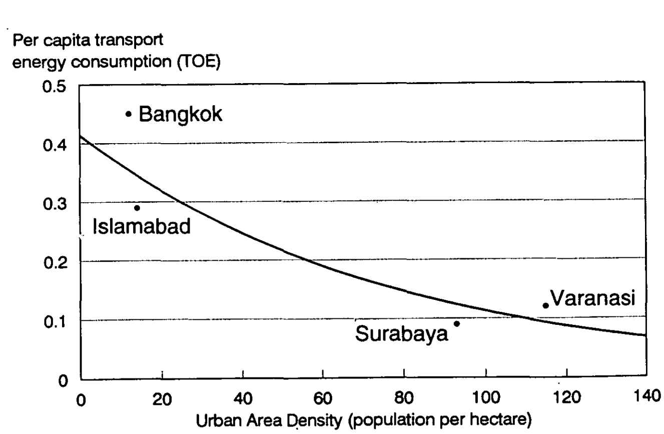


FIGURE 1 Per capita transport energy consumption and urban area density.

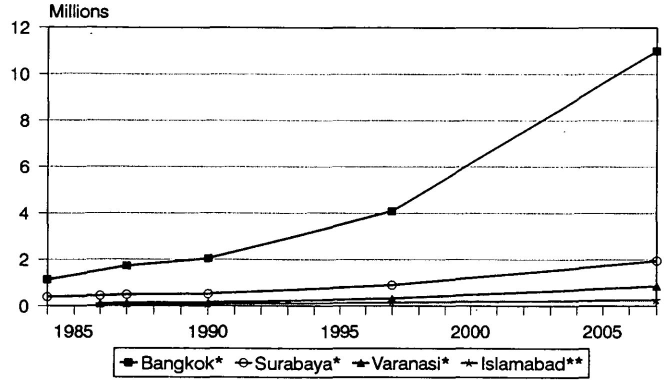


FIGURE 2 Comparison of vehicle fleet growth: 1984 to 2007.

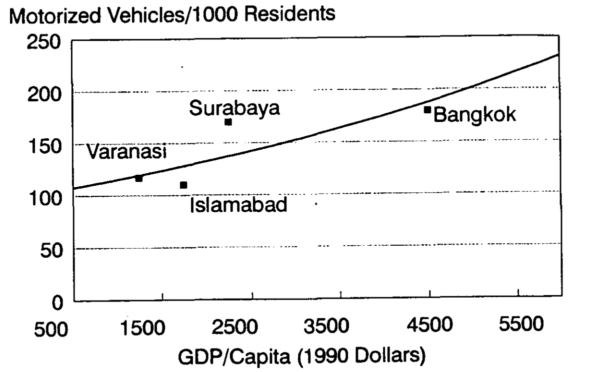


FIGURE 4 Motorization rates and income levels.

with many areas not reached by public transport, forcing residents to rely on private vehicles for daily travel, and thereby increasing per capita transport energy demand.

Third, public transport (referring to transportation available to the general public rather than to publicly owned transport) in the case study cities is often insufficient and poorly equipped to handle future transport needs. Consequently, residents without access to private vehicles turn to paratransit modes such as cycle rickshaws, privately owned minivans, and three- and four-wheeled taxis. Compared with overall motor vehicle fleet growth, the bus fleet growth in all four cities has been insignificant, with the share of bus travel to meet overall travel demand declining.

Fourth, each city has consistently registered high motor vehicle fleet growth rates because of increased economic and population growth, urban sprawl, and lack of mass transport alternatives. In Varanasi in recent years, the motor vehicle fleet grew by an average 13 percent per year, in Islamabad, 8.5 percent, in Bangkok, 11.5 percent, and in Surabaya, 5 percent (Figure 2). In contrast, vehicle fleet growth rates in many industrialized countries during recent years (motor vehicle fleet growth from 1984 to 1989 for the United States, United Kingdom, Sweden, Japan, Italy, West Germany, France, Canada, Belgium, and Australia) have averaged only 3.7 percent per year (*13*). The high relative growth registered in these cities will likely continue as a result of currently low levels of per capita vehicle ownership (see Figure 3), rising personal incomes (Figure 4 correlates income with vehicle ownership), and growing domestic motor vehicle manufacturing industries.

Fifth, all four cities face rapid growth in road energy consumption and average annual emissions in large part because of growing transport systems.

Sixth, each city has relatively high levels of lead and sulfur in its petroleum fuels (see Figure 5) and relatively poor levels of vehicle technology and maintenance. These characteristics lead to serious emissions problems that can be reversed by raising fuel quality, vehicle technology levels, and maintenance requirements.

Finally, each city has created urban development plans, which, with the exception of Islamabad, they have had difficulty implementing. All have failed thus far to integrate urban development plans with transport plans. The lack of clear authority in Bangkok,

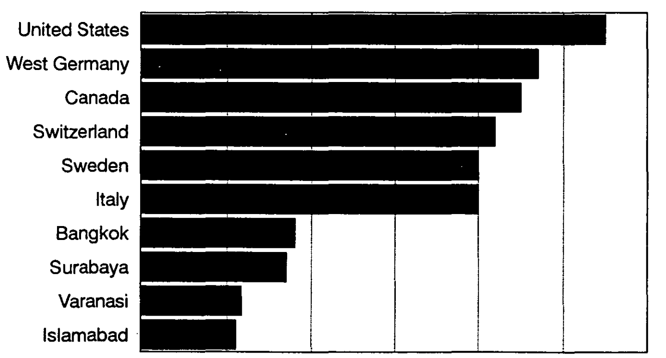
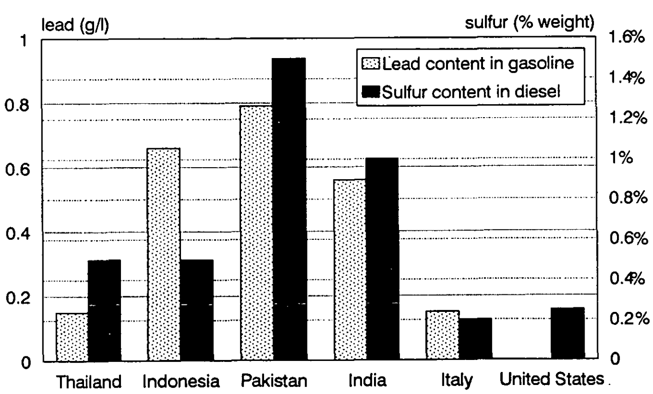


FIGURE 3 Per capita vehicle population (*9–11;18*,p.280).



NOTE: The fuel specifications for Thailand are as of January 1992; the fuel specifications for Italy are as of 1991; in the U.S., leaded fuel is unavailable at nearly all retail outlets; presently in the U.S. sulfur content of diesel is an estimated average 0.25%, as of October 1993, the U.S. government will mandate a maximum sulfur content in diesel of 0.05%.

FIGURE 5 International comparison of lead in gasoline and sulfur in diesel.

Surabaya, and Islamabad for designing and implementing comprehensive plans is a major cause of this failure.

OPTIONS FOR REDUCING TRANSPORT ENERGY CONSUMPTION, EMISSIONS, AND CONGESTION

Because of these commonalities, similar types of options can be applied to their very dissimilar situations and still achieve results. Implementation of the right combination of these will lead to urban transport systems that are efficient, clean, and highly accessible, thus satisfying the citizens' needs while boosting the economy and leaving a minimal impact on the environment. Options for improving urban transport services range from raising the efficiency of individual vehicles to enacting policies that encourage more transit-oriented urban development. Generally, transport system improvements fall into six categories:

- *Urban land use planning.* Urban land use planning is a crucial element of development, as it can often dictate travel patterns and modal choice. Land use planning must be coupled with transport planning decisions to maximize citizens' access to transport services. For example, the city of Curitiba, Brazil, requires that much development occurs along express, exclusive bus routes, thus increasing densities to support public transport use. More than 70 percent of Curitiba's residents use the bus system for daily mobility. The Netherlands has similar land use planning principles guiding its development toward compact, nonmotorized, and public transport–friendly cities.
- *Encouraging more energy-efficient modes of transport.* The highest priority for transport development in a city is to promote modes that satisfy the needs of citizens, rather than vehicles. Thus, cities should develop and encourage use of modes such as buses, subways, trolleys, and heavy rail, moving people at the lowest pollution and fuel consumption per person (see Table 1). Similarly, nonmotorized transport modes, such as bicycling and walking—moving people at little societal cost—must play a major role in transport system development.
- *Managing the transport system.* Transport system management measures aim to manage traffic and vehicle speeds by working within the existing infrastructure, typically requiring little or no expansion of the present infrastructure supply. Such measures can be advanced technologies, such as computer-synchronized traffic lights, or strict policies, such as vehicle bans in city centers. Other measures include implementing pricing mechanisms that discourage driving, improving telecommunications systems to decrease the number of urban trips, reducing the availability of parking, and using parts of the existing infrastructure exclusively for buses and high-occupancy vehicles.
- *Expanding the transport infrastructure.* Many cities require considerable expansion of the existing transport infrastructure to accommodate growth in transportation demand. Transportation infrastructure expansion measures can provide citizens with access to previously inaccessible areas. Such measures include construction of roads to divert traffic from city centers and construction of exclusive mass transit facilities.
- *Improving the efficiency of individual vehicles.* Energy-efficient vehicles use less fuel and generally discharge fewer pol-

TABLE 1 Comparison of Emissions, Energy Use, Space Use, and Cost of Different Modes of Transport (per passenger-km) (*2,17*)

Mode of Transport	Persons per Hour per Lane	Energy Consumption per Seat-km (kWh) (2)	Total Cost per Person-km (US cents) (1)	Total Emissions per Passenger-km (Grams) (3)
Walking	1,800	0.04	NEGLIGIBLE	NONE
Bicycling	1,500	0.06	0.2	NONE
Motorcycle	1,100	NA	NA	27.497
Car	440-800	0.29	8.6	18.965
Bus:				
Mixed Traffic	10,000	0.12	1.4	1.02
Busway	19,000	0.09	0.9	0.89
Light RailTransit	18,000	NA	NA	Coal: 4.3520
				Gas: 0.1876
				Fuel Oil: 0.6261
Rapid Rail Transit	54,000	0.15	2.4	Coal: 4.9651
				Gas: 0.2307
				Fuel Oil: 0.7102

Notes: 1. Total Cost in US cents includes track capital and maintenance costs, and vehicle operating costs. 2. Energy Consumption in kWh includes energy needed to construct guideways, manufacture vehicles and operate the system. Calculated values assume full occupancy of vehicles with no standees. 3. Total Emissions includes CO, HC, NOx, SOx, Aldehydes, and SPM.

lutants than less efficient ones. Technical measures to improve the efficiency of vehicles include reducing aerodynamic drag and the rolling resistance of tires through design changes, substituting lightweight materials, and reducing the amount of energy lost to friction in the engine, transmission, and drive train. Vehicle maintenance and energy-efficient driving techniques also are crucial to efficient operation.

- *Switching to cleaner and alternative fuels.* Decreasing the lead content of gasoline and the sulfur content of diesel will significantly reduce emissions of those pollutants. Switching to cleaner-burning fuels—such as compressed natural gas, liquid petroleum gas, ethanol, methanol, and electricity—can decrease pollution and the dependence on gasoline and diesel and, in some cases, increase the efficiency of fuel use.

Many measures that might improve transport conditions in the short run may, in fact, exacerbate long-term urban transport conditions. For example, the new roads under construction in Bangkok worth hundreds of billions of dollars will likely reduce congestion, emissions, and energy use only in the very short term because of the high demand for road space. In fact, studies (*14*) suggest that the new roads will have no net impact on congestion. Placing priority on the motor vehicle as the primary means of delivering transport services—through enhanced roadways, parking facilities, and traffic flow programs—not only improves the motor vehicle-based transport system but often degrades other transport options, such as bicycle use, mass transit, and pedestrian facilities.

Once cities are developed to service the automobile, it is very difficult to change travel habits and growth patterns. Consequently, cities must consider the long-term effects of all the available options before considering one over another. None of the options will succeed individually; each must be viewed as part of a system and each should be considered for integration into a comprehensive transport system improvement plan. Because each urban area is unique in layout, transport modes, design, and size, each requires a program of options for its own situation and demands.

SHIFTING GEARS: TOWARD AN INTEGRATED TRANSPORT PLANNING PARADIGM

Despite the wide range of options available to help cities meet their citizens' transport needs, little progress has been made toward accomplishing this goal. The problems of today's transport systems—rising motor vehicle fleets, increasing congestion, increasing air and noise pollution, and dangerous reliance on fossil fuels—were identified decades ago, yet the situation has worsened. Although the four Asian cities examined for this report vary widely in level of development and infrastructure, they share one critical need: to develop new methods of transport planning and implement the options available to help.

Envisioning a New Paradigm

To ensure that cities do not follow an unsustainable path in developing urban transport systems, a new development paradigm needs to be created. Cities in developing countries, many of which have not yet sunk substantial investments into transport infrastructure, have the opportunity to lead the way in devising this new transport planning paradigm. By preparing now for a transport system that promotes thorough evaluation of a diverse range of traveling modes, developing countries can create new pathways to achieve lower-cost transport sustainability.

Integration of Options

The first step in developing a new transport paradigm entails the integration of transport options into comprehensive plans. In the four cities studied for this report, each case study team developed action plans to correct short- and medium-term transport system problems. Each team also developed long-range strategies to examine options to resolve the city's recurrent problems or prevent traditional problems from occurring. Each team first analyzed the city's urban development trends, transport system components, fuel consumption, and transport emissions and used this information to develop a comprehensive matrix of transport options, ranging from traditional infrastructure supply options, such as road-building and maintenance, to public transportation development, traffic management, vehicle maintenance, and land use planning.

Although the various measures were compiled in option-oriented action plans, the Asia case study teams found great need for a comparative methodology to allow them to decide which transport options would produce the most effective services for the money invested. Such a methodology, an integrated transportation planning (ITP) process, would enable planners to compare the costs of road building with other available options, such as enhancing an existing mass transit system, for achieving the goal of moving people or goods. In comparing these options, transport planners also would have a mechanism to incorporate the value of environmental costs, security costs of increasing dependence on imported oil, and the costs of rising congestion, into estimated project costs of building additional roads, mass transit infrastructure and improvements, or other transport options.

Conditions for ITP

To begin building an ITP process, causes and effects of transport planning not explicitly considered in the past will need to be considered in the cities.

Enhanced Accessibility

Cities must first consider options that ensure that each citizen has access to the daily needs and wants of urban life. Because most people need to travel to work, take the children to school, and accomplish daily errands, a menu of options should be considered by the city as the best way to provide these services. The most efficient option would be to eliminate the travel need entirely by creating a compact multifunction zone with the person's home, place of work, school, and shops within easy walking or biking distance. Another option would be to design an effective bus, rail, or car pooling system allowing for efficient travel between these destinations. The most energy-intensive, cost-intensive, and polluting option possible would be to spread the destinations out, providing a network of roads without mass transit options, and compelling the person to drive a private vehicle to fulfill the desired need. A transport policy must work to ensure all citizens accessibility, whether by walking, biking, taking a bus or other mass transit, or driving, to the key elements in the complex economic and social processes that make a city thrive.

With enhanced accessibility as the major transport goal, planners, together with city officials and concerned residents, can develop a set of criteria by which cities can judge whether a given project or program of options is the least-cost path toward providing services. Such a list of criteria would replace the traditional cost-benefit analysis that analyzes a project's value solely on its short-term monetary merit, without considering long-term economic, social, and ecological sustainability.

Social Sustainability

Cities must judge whether a proposed transport program utilizes space in the most equitable way for all residents. As such, the transport system as a whole should be oriented to value people transported rather than vehicles moved. As can be seen in Table 1, the persons moved per meter-width of lane per hour greatly vary depending on the mode of travel. Not surprisingly, mass transit, pedestrian, and bicycle traffic come out far ahead of automobiles in the efficient use of road space while contributing the least to air pollution and energy consumption.

Equity plays a crucial role in maintaining social sustainability, particularly in developing countries. Current transport policies tend to favor car ownership for the elite, with a disproportionate amount of public money going to imports of fuels, vehicle components, and vehicles themselves. The majority of developing country citizens do not, however, own cars; hence they remain immobilized without access to the economic and social fabric of the city. In Surabaya, for example, only about 27 percent of residents use private motorized vehicles for daily travel, whereas the rest walk, bicycle, take cycle rickshaws, or use public transport. In Varanasi, nearly 50 percent of travelers use nonmotorized modes or motorized three-wheeled taxis, and in Bangkok about 50 percent of motor vehicle trips are taken by bus or paratransit. Despite the large number of people in each city that do not own or use a private motorized vehicle daily, the bulk of transport funding goes toward building and maintaining roads designed for private motor vehicles. A more equitable system would allocate transport funding to services that mobilize the whole population, rather than just a small portion of it.

Cities should also consider the potential impacts, such as displacement of communities, reduction of public recreational facilities, increased traffic noise in neighborhoods, and detraction of aesthetic quality in affected areas, of the proposed transport projects.

Ecological Sustainability

Every potential transport project should be evaluated according to its ecological sustainability. As is occurring in all four cities, pollutant emissions tend to increase in parallel with the growth of road-based transportation. Present environmental impact statements—when and if they are carried out—are limited usually to short-term impacts, thus ignoring whether short-term environmental gains will likely erode over time. A new road, for example, will improve emissions in the short term as traffic flows faster, but in the long term the road will likely generate more traffic and reach gridlock once again. Impact assessments should quantify a road's future effects on air quality. Transport projects should also undergo rigorous environmental impact analysis on such aspects as lost watersheds and other land.

Energy Use Analysis Each environmental impact assessment should project future energy consumption levels that will result from a given project or plan. The projection should be drawn out to 10, 20, and 30 years to account for population growth and motor vehicle fleet growth. Similar to emissions, a new road may have a positive energy consumption gain in the short term (smooth traffic flow means lower-energy consumption; congested conditions decrease vehicle efficiency), but after 5 or 10 years may be overwhelmed by traffic, thus causing a significant energy consumption increase. A monetary value for the additional energy costs should be calculated and a determination made as to how much energy (likely to be petroleum) will need to be imported to satisfy the demand. Those projects demonstrating a lower energy consumption impact should receive preferential value because of their lower long-term cost. Such rankings help ensure economic and political security by minimizing vulnerability to energy supply disruptions while benefiting local and global environments by minimizing energy-related pollutants, including greenhouse gases.

Internalizing Costs The key to determining ecological and social sustainability is quantifying the long-term environmental costs or benefits, thereby "internalizing" those costs that are left out of a traditional cost-benefit analysis. Transport decision making generally does not fully consider the economic, environmental, health, and social costs of passenger and freight transport options; instead, only the direct costs of the option (i.e., building a road) are considered. Failing to consider these costs constitutes a public subsidy to road-based transport. In the United States, according to the World Resources Institute in Washington, D.C., road transportation subsidies approach $300 billion per year, including

- $174 billion in highway construction, repair, and services (police, fire, etc.) and parking not borne by drivers;
- $10 billion in health costs from air pollution;
- $27 billion for reducing national CO_2 emissions from motor vehicles;
- Over $25 billion in military expenditures to protect the Middle Eastern oil flow;
- $55 billion in accident costs not borne directly by drivers; and
- $9 billion in noise damage to property in urban areas from cars and trucks (*15*).

The quantification of environmental externalities is a subject of great research and debate, although all agree that the value of such externalities is more than zero. Despite the lack of consensus on how to value such costs, they are being incorporated, albeit cautiously, into other sectors such as power generation. Assigning values, no matter how rudimentary, to social, environmental, and energy use impacts would begin establishing a level playing field so that a variety of options to provide transport services can be considered equally.

Multiple Impacts

Cities must give priority to those projects with multiple positive effects over those with a single effect. For example, designating part of a city center as a nonmotorized zone, as has been done in Vienna, Austria, and Curitiba, Brazil, minimizes vehicle pollution and petroleum consumption in that area. Nonmotorized zones can increase revenue for merchants who have more visible store fronts unencumbered by parked vehicles, more space outdoor to set up tables or attractive sales mechanisms, easier access for loading and delivery, and increased clientele from the additional people accommodated in the areas. Nonmotorized zones provide an incentive for residents to use public transport, if it is available, rather than individual cars, allowing all residents equal access to the system. In contrast, the Third Stage Expressway in Bangkok, currently under construction, will have minimal impact on congestion, air pollution, and fuel consumption and will mostly help city residents who own cars or motorcycles.

Adherence to Urban Development Plan

Projects must also be evaluated for their compatibility with overall urban development goals, which are inextricably linked with transport provision. The cities studied all created 5-year urban development plans, and some created longer-term plans as well. However, transport projects are rarely analyzed as to whether they complement or detract from urban development plan intentions. When analyzing current and future transport projects, planners must consider how transport decisions will affect land uses and urban development. Because development hinges on the efficient exchange of goods and services and the accessibility to urban necessities, both land use and transport planning should be viewed as the means by which a city's functions are available to all citizens (*16*).

Long-Range Planning

Project selection should be based on the long-term goal of providing transport services at the least total cost to society. The present system of 5-year urban development plans does not adequately serve cities' growth. Although projects with short-term impacts alleviate transport crises, the key to establishing a comprehensive transport planning process is to decrease the need for a short-term, reactive decision-making process and to put in place a long-term, proactive decision-making process. The establishment of exclusive bus lanes, for example, improves bus services in the short term, which will improve ridership, establish mass transit as a viable travel mode, induce land uses favorable to mass transit, and pave a long-term path for future conversion to higher-capacity transit modes such as rail.

Authority

The case studies demonstrate that cities must first define transportation services and accessibility as the goals to meet citizens' needs. Second, cities must integrate all transport options into a program addressing short-, medium-, and long-term objectives. Finally, cities must judge projects by new criteria, including social sustainability, ecological sustainability, and multiple benefits. Once a city begins to operate under these precepts, a government institution must have the authority to implement the decisions made that will affect the city's transport system development. By integrating energy, transportation, and land use planning within an institution at the local level, the city can ensure that all policies will form an integral part of all urban planning. This institution must work with, but have authority over, all departments working on transport so that decisions can be integrated among the differing policy makers.

In Curitiba, Brazil, for example, the Instituto de Pesquisa e Planejamento Urbano de Curitiba (IPPUC, or Research and Urban Planning Institute of Curitiba) since the 1970s has held the reigns in designing and implementing a wide range of ideas, many of them cutting across several government departments. The bus system, for example, was implemented by IPPUC, which coordinated agencies involved in highway and road design, bus companies and the regulating bodies, emissions control agencies, and eventually, because the old buses were taken out of service because of emissions violations and used for mobile classrooms, the education authorities and the private sector. The authority given to IPPUC, as well as its abilities in coordinating the differing agencies, has fueled Curitiba's success.

In three of the four cities—Bangkok, Varanasi, and Surabaya—no implementing body has the authority to control and coordinate the various aspects of transport planning, even within the context of their 5-year urban development plans. The result, particularly in Bangkok, has been ongoing planning with few positive results. Each 5-year plan reacts to the developments that occurred since the last plan, with each subsequent plan pointing out the planning deficiencies in the previous plan. Very few aspects of the actual plans have been implemented.

In Islamabad, on the other hand, the Capital Development Authority (CDA) is the authority charged with implementing the city master plan and coordinating the various agencies involved in urban development aspects such as transport, sewage, education, and energy supply. Much of Islamabad's success in adherence to the master plan can be attributed to the CDA's clear responsibility and power to act out its role. Most problems in Islamabad's development path relate to the plan content and policies themselves.

THE LAST WORD

By redeveloping the goals and objectives of transportation, cities in the region and around the world could

- Improve citizens' mobility, safety, and health;
- Minimize economic costs by reducing oil payments, congestion costs, and infrastructure investments;
- Stimulate urban economies by creating jobs in local industries such as mass transit;
- Improve other aspects of urban life by promoting city revitalization and urban livability; and
- Improve local and global environmental conditions by minimizing pollutants.

All cities must establish responsibility at the local level for a process that will guide future transport while balancing different modes, minimizing travel demand, and reducing the costs of urban land development. Only then can they effectively identify financially and ecologically sustainable principles as guidelines for development of urban environments. An integrated approach to transport planning will help reverse the negative trends experienced by cities around the world. The integrated approach will thus guide cities toward a brighter future—a future in which the transport system boosts and benefits the health and economic welfare of all citizens.

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Nonmotorized Vehicles in Hanoi and Phnom Penh: Existing Situation and Options for Improvement

DEREK DYLAN BELL AND CHIAKI KURANAMI

Vietnam and Cambodia, two of the poorest countries in Asia, are currently undergoing accelerated changes in their domestic economies. Vietnam has been moving toward a free-market system since the collapse of communism in the former Soviet Union, and Cambodia experienced an economic surge from the recent presence of 22,000 United Nations personnel involved in a comprehensive peacekeeping mission. A rapid increase in the number and use of motor vehicles (MVs), especially motorbikes, has accompanied these developments and contributed to significant deterioration in traffic safety and congestion. The capital cities of Hanoi and Phnom Penh are major activity centers whose residents traditionally have depended on nonmotorized vehicles (NMVs), especially bicycles and *cyclos* (pedicabs), for performing functions vital to maintaining their livelihoods. Although economic conditions in these countries have encouraged rapid motorization, roadside traffic counts in mid-1992 showed that NMVs still accounted for 50 to 70 percent of all vehicle volumes in these two cities. Local government officials, however, have expressed views hostile toward NMVs, and in Hanoi plans have been made to abolish all NMVs from operating within the city by the year 2004. Officials in Hanoi and Phnom Penh should take a more balanced approach to transport planning by including needs of NMV users with those of MV users. Not only would affordable NMV facility improvements, such as the provision of spatial and temporal separation measures, ensure that all residents, including the poor, maintain reasonable access, but they would probably improve citywide traffic safety and congestion as well.

Vietnam is undergoing significant changes in its economic policies as it moves toward a free-market system, largely encouraged by the collapse of communism in the former Soviet Union and the drastic cuts in aid and subsidized goods that followed. In the case of Hanoi, the capital city of Vietnam, this situation has encouraged the widespread use of nonmotorized vehicles (NMVs) and the recent advent of motorbikes (i.e., small, lightweight motorcycles with typical engine displacements of 50 to 90 cc). Because automobiles are out of the price range of most residents and because services provided by motorized mass transit (e.g., bus, tram) are either inferior or absent, Hanoi residents move around by riding bicycles, cyclos, and motorbikes. *Cyclo*, pronounced "seek-low," is the term for pedicab in Hanoi and Phnom Penh (Figures 1 and 2).

Phnom Penh, the capital city of Cambodia, has been experiencing drastic changes since early June 1993 when a 120-member constituent assembly was elected to draft a new constitution; this election was the culmination of a comprehensive peacemaking operation of the United Nations. During the Khmer Rouge regime under Pol Pot during the 1970s, much of Cambodia's formally educated workforce died from overwork, malnutrition, disease, or execution. This tragedy affects every aspect of Cambodian life, including a shortage of skilled professionals in government agencies, especially those related to city planning. Urban transport planning, policy, and services in Phnom Penh have suffered as a result. NMVs, a source of employment for unskilled workers, are a significant part of the current transport system, and they will likely remain so for many years as the nation recovers and rebuilds.

Although NMVs are an important part of the urban transport system and economy in both cities, government officials are planning to limit NMV use in the near future, with the presumption that traffic safety and congestion will improve as a result. In Hanoi, traffic authorities intend to prohibit NMVs from operating by 2004. Similarly, in Phnom Penh officials plan to forbid cyclo operations.

The rationale behind these proposed restrictions is understandable when considering that (*a*) NMVs are commonly misperceived as being responsible for most traffic accidents, (*b*) NMVs are relatively slow vehicles, and (*c*) NMVs outnumber motor vehicles (MVs) on the city streets. However, plans to prohibit NMV operations may not resolve traffic safety or congestion problems; in fact, they may be self-defeating. NMVs are well suited for short trips, and they can be more efficient than MVs in terms of productive passenger capacity (e.g., passengers per hour per meter of lane width) (*1*). NMVs also effectively use local technologies and play an important role in providing job opportunities for many people. Consequently, NMV facility planning should be integrated into the urban transport planning process.

SOCIOECONOMIC CHARACTERISTICS

Hanoi had a 1992 urban population of 1.1 million and a population density of 25,600 residents per square kilometer (66,300 per square mile). Although the proportion of Vietnam's workforce in agriculture is a relatively high 72 percent, rural migration to Hanoi is estimated at fewer than 10,000 persons a year (*2*,p.7). Vietnam had an annual gross nation product (GNP) per capita of U.S. $200 in 1990 (*3*,p.241).

The 1992 urban population of Phnom Penh was approximately 745,000, corresponding to a population density of 16,200 inhabitants per square kilometer (42,000 per square mile). In contrast to Hanoi, the population of Phnom Penh increases by an additional 100,000 during the dry season as farm workers migrate to the city to seek temporary employment. With 81 percent of Cambodia's work force in agriculture, this trend may continue for

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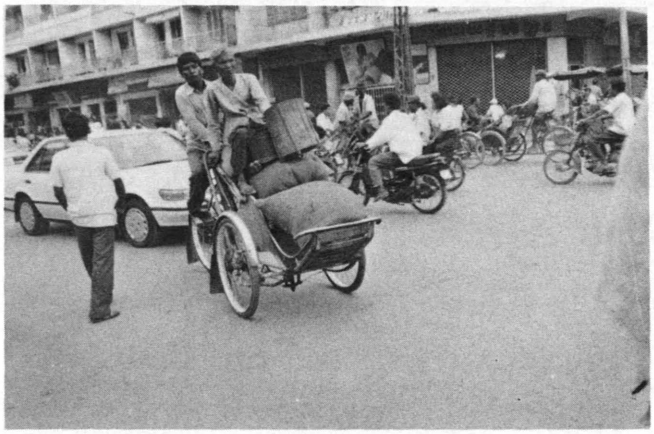

FIGURE 1 Cyclo used for passenger and goods movement in Phnom Penh (*photograph courtesy of D.D. Bell*).

many years (*2*). In 1991, Cambodia had an annual GNP per capita of U.S. $200, the same as that of Vietnam (*4*,p.18).

TRANSPORT INFRASTRUCTURE

In general, the transportation infrastructure is poor throughout Vietnam but especially in the north. Of 105 000 km (65,200 mi) of roads nationwide, about 12 000 km (7,500 mi), or 11 percent, is paved (*5*,p.84). Many of the roads and bridges were damaged during the country's past three wars (i.e., with China, Cambodia, and the United States) and have yet to be repaired or reconstructed. Hanoi has 385 streets, of which most are paved and 75 percent are 7 to 11 m (23 to 36 ft) wide. The total length of paved streets in the urban area of Hanoi is estimated to be 1790 km (1,112 mi). There is one main ring road that surrounds the city, but it can carry only one lane of traffic in each direction. Bus operations are rather difficult given the narrow width of Hanoi's roads and the extensive use of two-wheeled vehicles.

FIGURE 2 Congested street in Hanoi filled with bicycles and cyclos (note bicycle tire maintenance hawker on the sidewalk) (*photograph courtesy of C. Kuranami*).

Roads throughout Cambodia and within Phnom Penh are in desperate need of repair. All of Cambodia's national roads were originally paved with asphalt materials but suffered serious damage during the 1970s and 1980s. Today only 2600 km (1,620 mi)—8 percent of all roads in the country—is paved, and widths range from 4 to 7 m (13 to 23 feet). In Phnom Penh, 188 km (117 mi) out of the city's 488 km (303 mi) of roads is paved. Many of these unpaved roads are in poor condition, and some are impassable for large MVs. This creates an advantage for NMVs and motorbikes, which can be maneuvered more easily than automobiles, trucks, and buses on damaged streets.

Interestingly, Hanoi and Phnom Penh have nearly the same urbanized area and paved road length. However, the paved road supply per population is quite different: 1.7 km (1.1 mi) per 10,000 population in Hanoi, and 2.5 km (1.6 mi) per 10,000 population in Phnom Penh.

VEHICLE OWNERSHIP

Hanoi

Although bicycles have not been registered in Hanoi since 1975, estimates by various government officials place their number at about 1 million (Table 1), equivalent to a bicycle ownership level of 0.91 per person. Consequently, bicycles make up about 85 percent of all vehicles in the city, and, after combining them with motorbikes, the number of two-wheeled vehicles represents over 95 percent of all vehicles.

Although some motorbikes in Hanoi are used for public transit services, most units are privately owned for personal use. The motorbike ownership level is 0.12 vehicle per person. Because a significant portion of the number of automobiles are owned by the government for official use, Hanoi's nongovernment automobile ownership level is likely below the calculated 0.03 vehicle per person. Hanoi does not have any metered taxicabs.

Cyclos, used for passenger or freight transport, or both, account for less than 0.5 percent of all vehicles. Oxcarts, prohibited within the city of Hanoi, are produced and used in the surrounding rural areas for goods movement.

Xelams (which are three-wheeled motorized taxis) account for the majority of motor vehicle public transit trips in Hanoi. Xelams resemble the tuk-tuks of Thailand except that the passenger area of the xelam is slightly larger, with two longitudinal bench seats capable of holding 6 to 10 passengers, who must enter from the rear of the vehicle.

Only 160 buses out of 480 units in Hanoi are operational, corresponding to one bus for every 7,000 residents. Most of the buses are not in working condition because there is a shortage of parts to repair them. This situation contributes to the general perception that bus service is poor and unreliable. Tram service was recently terminated because of a lack of spare parts.

Phnom Penh

In Phnom Penh, bicycles account for 47 percent of all vehicles in the city. Although their number is considered to be increasing, bicycle ownership is a low 0.17 unit per person. There are still a few hundred bicycles being used for public transport in Phnom Penh, but they are quickly disappearing. Bicycles and motorbikes

TABLE 1 Vehicles by Type in Hanoi and Phnom Penh

	Hanoi[a]		Phnom Penh[b]	
Vehicle Type	Number	Percent	Number	Percent
Bicycle	1,000,000	84.6	125,000	47.1
Cyclo	5,100	0.4	11,136	4.2
Oxcart	0	–	500	0.2
Motorbike	128,000	10.8	115,775	43.6
Xelam	1,667	0.1	0	–
Auto Rickshaw	0	–	100	0.0
Automobile	35,000	3.0	11,049	8.6
Truck	11,800	1.0	1,937	0.7
Bus	160	0.0	23	0.0
Total	1,180,860	100.0	265,520	100.0

[a]As of June 30, 1991, according to the Ministry of Transport, Communication, and Post.
[b]As of May 31, 1992, according to the Department of Roads and Bridges.

combined make up more than 90 percent of all vehicles. The number of cyclos is slightly higher than that of automobiles, but trucks outnumber oxcarts by about 4 to 1.

With only one bus for every 32,000 people, Phnom Penh is essentially a city without bus service. Consequently, the city's public transport system is largely based on the cyclo, which outnumbers all other forms of public transit in the city with one for every 70 residents. Most cyclos are found in poor residential areas of Phnom Penh and near work places. Very few can be seen in agricultural areas where population densities are low. Motorbike taxis are the most popular form of motorized public transit. Like Hanoi, there are no automobile taxis.

When Phnom Penh, like all of the Cambodia, was closed to the rest of the world (except China) during the late 1970s, MV use basically disappeared. Although firm data are unavailable, casual observations over the past few years indicate that MV ownership and use, especially that pertaining to motorbikes, has rapidly expanded in Phnom Penh. The city's traffic environment, previously dominated by bicycles and cyclos with fewer motor vehicles, will soon be inundated with motorbikes. As of June 1992, the numbers of motorbikes and automobiles in Phnom Penh were nearly even with the number of bicycles and cyclos, respectively.

Phnom Penh has a small number of three-wheeled motor vehicles called auto rickshaws. Interestingly, these vehicles have two wheels and a wooden cart in front of the driver (single wheel in rear), and a small engine between the driver and the wooden cart powers the front axle. These auto rickshaws are produced locally and used to transport freight.

NMV USE

Modal Split

In Hanoi, bicycles are the main mode of transport during the peak period and clearly dominate all other forms of transport (Table 2). However, it is important to note that the 36 percent MV share observed in a 1991 survey (not including pedestrians) in Hanoi's

TABLE 2 Pedestrian and Vehicle Volumes in Hanoi and Phnom Penh

	Hanoi[a]		Phnom Penh[b]	
Mode	Number	Percent	Number	Percent
Pedestrian	582	7.1	242	5.1
Handcart	0	–	6	0.1
Bicycle	4,578	55.8	1,237	25.9
Cyclo	321	3.9	1,116	23.4
Motorbike	2,377	29.0	1,721	36.1
Xelam	49	0.6	0	–
Auto Rickshaw	0	–	9	0.2
Automobile and Truck	230	2.8	434	9.1
Bus	66	0.8	8	0.2
Total	8,203	100.0	4,773	100.0

[a]Survey was conducted by the principal author at two locations on a major thoroughfare during the evening peak hour (4:15 p.m. to 5:15 p.m.) on June 30, 1992.
[b]Survey was performed by a local consultant on a major thoroughfare during the morning peak hour (6:30 a.m. to 7:30 a.m.) on May 24 and 25, 1992.

Ba Dinh and Dong Da districts (one location in each district) is greater than the 27 percent share observed from average daily traffic counts of 1 year before in the same two districts (four locations in the Ba Dinh District and five locations in the Dong Da District) (*6*,p.21). This finding suggests that MVs, namely motorbikes, have been increasing in number and use in Hanoi, although such a comparison between the two surveys may be influenced by the various time segments involved (i.e., the 1992 survey was a peak-hour count and the 1991 survey was a daily count). Cyclos, which represent less than 0.5 percent of all vehicles in Hanoi, accounted for 4 percent of all vehicles observed in the roadside peak-hour traffic counts. This corresponds to a very high cyclo utilization rate.

Although the bicycle ownership level in Phnom Penh is higher than that for motorbikes, roadside traffic counts indicate that there are more motorbikes than bicycles on the city's streets today (Table 2). As shown earlier, 47 and 44 percent of all vehicles in Phnom Penh are bicycles and motorbikes, respectively. Yet recent roadside traffic counts during the morning peak hour demonstrate that bicycles made up 27 percent of vehicular traffic and motorbikes accounted for 38 percent. Although cyclos make up only 4 percent of the total number of vehicles in Phnom Penh, they are the most highly used vehicles, accounting for 25 percent of all observed vehicular traffic.

Impact of Rainy Weather

During brief yet heavy rainstorms, many streets in Hanoi and Phnom Penh become flooded. However, traffic continues and people still ride bicycles, cyclos, and motorbikes during the rain showers. In terms of travel behavior, rainy weather has little impact. Pedestrians walk in the rain at a normal pace without umbrellas. One can sometimes observe a cyclo carrying a passenger with his or her stalled motorbike, presumably because the spark plugs became wet and the engine could not refire. This is an ironic situation in which the NMV performs better than the MV—a motorbike in this case—in terms of performance and reliability.

NMVs and Tourism

NMVs are considered important for the development of tourism in Hanoi and Phnom Penh because many tourists prefer to rent bicycles or hire cyclos in which they then travel around the city. This is true except during the peak periods when riding a bicycle in heavily congested conditions can be dangerous for inexperienced riders. Advantages of cyclos are that they can operate on narrow streets where cars and buses may not be able to go, they move slowly and allow one to view one's surroundings more easily than in a speeding car, and they enable one to easily keep one's bearings and know where one is in the city. With an increase in tourism, there is great potential for the increased use of cyclos by tourists visiting Hanoi or Phnom Penh.

SAFETY AND ACCIDENTS

Although most government officials in Hanoi complain that bicyclists account for 50 to 90 percent of all traffic accidents, statistics gathered from the Hanoi Bureau of Traffic Police (Table 3) suggest otherwise. According to these figures, bicycles and cyclos combined were responsible for only 11 percent of all reported traffic accidents in 1991 even though they make up about 60 percent of all vehicles plus pedestrians observed in traffic. Motorbikes were the leading cause of accidents, responsible for 61 percent of the total, far exceeding their traffic composition rate of 29 percent.

The figures shown for Phnom Penh are the number of vehicles by type damaged in traffic accidents, according to the Phnom Penh Police Commissariat. Bicycles and cyclos combined represented fewer than 10 percent of all damaged (involved) vehicles even though they make up slightly more than 49 percent of all vehicles plus pedestrians observed in traffic. As in Hanoi, motorbikes accounted for the majority of involved vehicles at 71 percent, much higher than their traffic share of 36 percent.

According to these figures, NMVs perform significantly better than MVs in terms of accident avoidance and safety in Hanoi and Phnom Penh. Although the number of responsible or damaged

TABLE 3 Vehicles Responsible for or Involved in Traffic Accidents in Hanoi and Phnom Penh, 1991

	Hanoi[a]		Phnom Penh[b]	
Vehicle	Number	Percent	Number	Percent
Bicycle	48	11.0	20	7.5
Cyclo	0[c]	–	5	1.9
Motorbike	265	60.6	190	71.4
Xelam	21	4.8	0	–
Automobile	13	3.0	51	6.7
Truck and Bus	90	20.6	0	–
Total	437	100.0	266	100.0

[a]These figures correspond to vehicles deemed responsible for traffic accidents in 1991, according to the Hanoi Bureau of Traffic Police.
[b]These figures correspond to vehicles reported damaged from traffic accidents in 1991, according to the Traffic Police Direction of the Phnom Penh Police Commissariat.
[c]The 48 accidents listed above for bicycles include those for *cyclos*.

vehicles reported in these tables is probably far lower than the total number of accidents that actually occurred in these cities in 1991, there is no reason to believe that any one of these modes should be singled out as having a different share of responsibility for unreported accidents, which most likely involve minor or no injuries. Usually traffic police in these cities report an accident only if injuries are considered serious or if the parties involved cannot agree on a settlement.

One important issue regarding traffic safety in Phnom Penh is that many of the current residents migrated to the city from rural areas in recent years and still do not understand the dangers associated with high-volume traffic. Many have little knowledge about or little regard for traffic safety. Although some attempts have been made to educate the public, such as a traffic safety campaign with weekly announcements on TV and other uses of mass media, people generally ignore them.

COSTS

Acquisition Prices

NMVs in Hanoi and Phnom Penh are, for the most part, produced locally and are very inexpensive compared with MVs. Although the average price for a new bicycle in Hanoi is 400,000 dong (U.S. $36, according to the exchange rate in June 1992), a secondhand one costs about 100,000 dong (U.S. $9). The average costs for new and secondhand bicycles in Phnom Penh are about 48,000 and 30,000 riel (U.S. $38 and $24), respectively.

In contrast, new motorbikes and automobiles are imported and subject to import duties, which average 100 percent. New motorbikes cost about 18,500,000 dong (U.S. $1,680) in Hanoi and 1,435,000 riel (U.S. $1,150) in Phnom Penh. Secondhand motorbikes cost about half in both cities. Automobiles are far beyond the range of affordability for the majority.

Annual Registration Fees

In Hanoi, so-called traffic fees were introduced in November 1991. Although bicycles are exempt, cyclo owners are required to pay 4,000 dong/month (U.S. $0.36), equivalent to U.S. $4.36/year. This is more than twice the fee imposed on a 50-cc motorbike, 1,500 dong/month (U.S. $0.14), or only U.S. $1.64/year. It appears that the authorities are discouraging cyclo use and encouraging motorbike use through discriminatory pricing methods. Likewise, oxcarts in the urban periphery are charged a relatively high 10,000 dong/month (U.S. $0.91) or nearly U.S. $11/year. The rate for automobiles is exactly twice this.

Vehicle registration fees were also introduced in Cambodia in 1991. Bicycles and oxcarts are exempt, but cyclo owners are required to pay 500 riel/year (U.S. $0.40), almost equal to the monthly rate in Hanoi. Motorbike owners pay two to four times this fee, depending on engine displacement, and car owners pay about 20 times as much. It appears that the registration fees in Phnom Penh are based on the ability of owners to pay, not on the desired side effects as in Hanoi.

Rental Fees

In Hanoi, cyclo drivers typically owns their vehicles. One exception is if they work for a hotel, from which they then rent the hotel-owned cyclo; however this is uncommon. On average, a cyclo driver earns about 10,000 to 50,000 dong/day (U.S. $1 to $5).

Most cyclo drivers in Phnom Penh rent their vehicles for about 400 riel/day (U.S. $0.32), and their average daily incomes are about 2,500 to 3,750 riel (U.S. $2 to $3). Considering that the annual GNP per capita in Vietnam and Cambodia is U.S. $200, cyclo drivers in Hanoi and Phnom Penh earn above-average incomes. In fact, in 1992 cyclo drivers in Phnom Penh made about 10 times the fixed monthly salary of government employees. From this perspective, it is evident that cyclos are an important part of the local economy.

FARES

Public Transport

In Hanoi, all passenger transport options for a 2-km (1.2-mi) trip cost about 2,000 dong (U.S. $0.18). For trip lengths less than 1.5 km (0.9 mi), cyclos and xelams are cheapest, charging about 1,000 dong/km (U.S. $0.15/mi). When trip lengths exceed 2 km (1.2 mi), the 50- to 70-cc motorbike and bus have the least expensive fares—1,500 dong (U.S. $0.14) and 2,000 dong (U.S. $0.18), respectively—because they have flat rates controlled by the city government. Motorbikes or motorcycles with engine displacements greater than 70 cc charge a flat rate of 2,000 dong (U.S. $0.18). Because the availability of motorbikes for public transit is far greater than that for buses, motorbikes are widely patronized.

In Phnom Penh, buses are the cheapest form of public transit at 5 riel/km (U.S. $0.006/mi), but because of their usual unavailability people must choose other modes. Cyclos, in some cases capable of carrying up to six or more passengers and always readily accessible, are the most frequently used public transit vehicle, charging at least 10 times the bus fare. This fare increases according to the number of passengers, but as with all forms of informal public transit in Phnom Penh (and Hanoi), rates are negotiable. Motorbike tax fares average 70 riel/km (U.S. $0.09/mi), slightly higher than those for cyclos.

Freight Transport

In Hanoi, freight transport is handled mainly by bicycles, cyclos, small tractors, and trucks. Occasionally xelams are used. Bicycles hauling goods are a common sight in Hanoi, but usually the bicyclists are hauling their own goods to and from the market. Most bicycles are equipped with a flat metal brace anchored above the rear fender. This brace can be used as a platform to support large straw baskets and other vessels for transporting goods. People carry all sorts of cargo, mostly agricultural products, in these containers. Specially reinforced bicycles can carry loads of up to 250 kg (550 lb).

Cyclos are used in Hanoi for transporting agricultural products in addition to carrying much heavier loads, especially when distributing goods between warehouses and retail outlets. One can observe cyclos transporting as many as five full metal kegs, a dozen coat racks, two or three rolls of carpet, a few bed mattresses, or long pieces of timber. In transporting these heavier loads, which can amount to as much as 350 kg (770 lb), cyclos compete with small tractors and sometimes with xelams. Government officials estimate that cyclos charge about 10,000 dong/ton-km (U.S. $1.33/ton-mi). Trucks normally handle loads that exceed the capacities of cyclos, small tractors, and xelams.

Besides carrying passengers, cyclos in Phnom Penh are also used to deliver goods to stores and from the river port to distribution points such as shops, markets, and warehouses. Traffic authorities estimate that cyclos charge about 5,000 riel/ton-km (U.S. $5.85/ton-mi). In many cases, people employ bicycles or handcarts to deliver goods over relatively short distances. Bicycles are commonly utilized to transport agricultural products whereas handcarts carry mainly firewood and other bulky objects. The use of oxcarts can be observed in the urban periphery, seldom within the city itself. As with passenger transport fares, fees for goods movement in Phnom Penh and Hanoi are negotiable.

NMV REGULATIONS

As mentioned earlier, oxcarts are prohibited from operating within the city of Hanoi. Occasionally they can be seen on the main ring road, but they do not penetrate the city. Some streets in Hanoi do not allow truck, bus, or tractor traffic, but all roads are open to bicycles and cyclos, both of which are expected to follow the same basic traffic rules as MVs.

In Phnom Penh, 62 traffic regulations were approved by the local government on August 31, 1991 (*7*,p.1). One of these regulations calls for NMVs to operate on the far righthand side of the road with motorbikes and not to occupy the lanes near the centerline (as in Vietnam, vehicles in Cambodia travel on the righthand side of the road). The lefthand lanes are supposed to be used only by automobiles, trucks, and buses. However, like all other traffic regulations, there is little enforcement and very little public knowledge or understanding of the restriction. Therefore, this and other traffic rules constantly are being violated.

NMV FACILITIES

Two relatively wide streets in Hanoi have physically separated lanes for motorized and nonmotorized traffic in both directions for a total length of about 2 km (1.2 mi). These lanes are separated by a raised curb, with MVs to occupy the center lanes and NMVs to travel in the righthand lanes. While motorized traffic stays in its designated area, NMVs can be found operating in both lanes. This is the case even when traffic in the NMV lanes is light. There is no enforcement of these lanes to ensure that traffic remains separated.

In Phnom Penh, all vehicles share the same roadways. As mentioned earlier, a regulation requires all NMVs to occupy the far righthand lane, but this does not occur in practice. Currently there are no physical distinctions between these lanes, and often there is no striping on the streets. As a result, many vehicles make weaving movements when overtaking and passing slower-moving vehicles.

LOCAL GOVERNMENT ATTITUDES AND POLICIES

Hanoi

Government officials in Hanoi are now trying to transform the traffic system from nonmotorized to motorized, namely, from bicycle and cyclo to bus and xelam. The most frequent argument is that high bicycle and cyclo use slows down motorized traffic and results in an underutilization of the capacity of Hanoi's streets. Motorized transport other than motorbikes cannot develop in line with its potential capacity, and this actually serves to reinforce NMV and motorbike use.

Officials at the Hanoi Office of Transport and Urban Public Works have calculated the "interruption" of NMVs and certain MVs to traffic in terms of the road area taken up by one bus passenger. On the basis of these figures, officials argue that greater bus and xelam patronage, through a change in mode choice, would reduce the number of vehicles on the streets and consequently reduce traffic congestion. Currently, city government officials are appealing to the national government to allow a competitive policy for buses. Since the local government does not have funds to compensate for city bus operating losses, it is constantly losing money and thereby fueling inflation.

Officials expect the speedy development of MVs to displace NMVs by the end of 1997. At that time they expect bus and xelam service to be superior to that of NMVs, and subsequently they plan to abolish all NMVs within the city of Hanoi by 2004 after "gradually moving all bicycles out of the city." With these future changes in mind, government officials want to inform the public that NMVs are limited in their activities and should be required to obey certain traffic rules and regulations; for example, operators of NMVs used for passenger transport should be organized and belong to an association or cooperative.

Phnom Penh

In Phnom Penh, government authorities would like to phase out the use of cyclos over the next few years. Their rationale is that cyclos are unsafe for passengers because they sit in front of the driver and the driving behavior of the operator is generally poor. However, exposed to the possibility of a different cyclo design, such as that found in Bangladesh, India, and parts of Thailand, where pedicab passengers are seated behind the driver, the same government officials said that such an option would require consideration and may be acceptable.

Passenger safety, however, is not the only issue. Some officials argue, like those in Hanoi, that cyclos slow down motorized traffic and that cyclo drivers do not obey traffic rules. Other disadvantages cited by government officials include the disorganization of cyclo drivers, incidents in which cyclo drivers are intoxicated or discourteous, and the difficulty in controlling fares. However, in December 1993, the Cambodian Conductors' Association (CCA) was established with private donations to provide drivers of cyclos and motorbike taxis with cheap meals and accommodations if homeless; the CCA also aims to educate its member drivers about traffic regulations (*8*,p.4). Clearly, this is a step in the right direction.

OPTIONS FOR IMPROVEMENT

General

Although bus service in Hanoi needs to be improved, abolishing NMVs from operating in the city may not be the answer. Such a declaration would likely cause many social problems because people who could not afford motorbikes would suddenly be dependent on transit with all the associated limitations and inconveniences. For example, how would someone carry a large basket of fruit or live fowl on board a crowded bus or xelam, or while hanging onto the back of a motorbike? All of these situations are very difficult, thus requiring a change in distribution methods that could better be achieved through the implementation of a comprehensive long-term transport plan that considers NMVs and MVs. Any rule prohibiting NMVs would also have to be strictly enforced if it is to be followed.

Officials in Phnom Penh also want to encourage bus use, but many residents of Phnom Penh also carry bulky commodities with them when they travel, making bus transport particularly inconvenient. Furthermore, the general population does not understand the purpose of urban mass transit, which has a bad reputation because its users generally are considered to have low status in the community.

Instead of discouraging and abolishing NMVs from the streets of Hanoi and Phnom Penh, government officials should consider a plan that would both improve bus service and meet the needs of NMV users. This could be accomplished by incorporating NMV facility planning into the conventional urban transport planning process, thereby providing a framework to supply basic NMV facilities. Early action is required to protect the interests of NMV users and ensure improvement of the overall urban transport system.

NMV Facility Planning

It is recognized that motorization is both a by-product of and an impetus for economic development and growth, but burdening NMV users, who are disproportionately represented by the poor, by restricting their mobility through NMV regulations seems counterproductive. The needs of both MV and NMV users should be met, and this requires the simultaneous planning of both MV and NMV facilities. Such comprehensive planning enables close integration between transport services, such as bicycle- or cyclo-to-bus, as well as an understanding of the patronage each mode receives and the dynamics of competition and complementarity among modes.

NMV Network and Routing

Just as NMV planning should be performed in conjunction with the planning for other transport modes, the NMV network should be prepared in conjunction with design of the overall transport network. This NMV network should consist of continuous NMV routes that are consistent with NMV operators/users' origin-destination pairs. Similarly, these routes should provide a relatively direct and convenient path between trip ends and not be circuitous or "spotty" in nature. When generating an NMV plan, the responsible agency should consider both spatial and temporal separation measures.

Spatial Separation Measures

The two types of NMV facilities recommended here are NMV lanes (a) delineated by pavement markings and (b) designated by barriers. With the first type, NMVs and MVs are provided separate lanes of travel, but there is no physical barrier to prevent an MV from encroaching in the NMV lane or vice versa. As a result, the use of NMV lanes with pavement markings will be effective if motorists and NMV operators are well disciplined and stay within their respective lanes.

The simplest pavement marking is a single, solid line of bright color, and it should be used consistently throughout the city for this purpose; the color (e.g., white or yellow) should be determined by local authorities, consistent with prevailing color schemes used in traffic control. It is recommended that road paint be used for lane markings and repainting be performed whenever necessary and financially feasible. This type of lane striping has been successfully implemented in the Indian city of Kanpur, with NMVs and MVs naturally separating along this inherently perceived boundary (*9*).

However, if traffic violation rates significantly reduce the practical capacity or safety, or both, of such lanes, it may be necessary to upgrade the facility by installing steel railing, vertical posts, raised curb, or another form of physical barrier. This technique of NMV facility planning, to initially designate NMV lanes with pavement markings, ensures that the potentially most cost-effective solution is implemented, and if indeed effective, these NMV lanes should satisfy the transport needs of NMV operators or users and improve traffic flow and road safety.

With the second type of NMV lane, MVs are physically prevented from encroaching on the NMV facility. These NMV lanes should perform better in terms of traffic flow because of the reduction in friction from physically separating slow- and fast-moving vehicles. However well-designed NMV lanes delineated by pavement markings may outperform poorly designed NMV lanes designated by barriers.

The major drawback with physically separated lanes is that generally they are more expensive to provide initially than striped NMV lanes. However, they may be more cost-effective when considering the potentially lower maintenance costs, fewer accidents, and improved traffic flow. Furthermore, the installation of barriers, such as steel railing, is a low-technology solution that can utilize local labor and materials.

As mentioned earlier, the physically separated NMV facility on a section of road in Hanoi does not effectively prevent NMVs from occupying MV lanes. This failure should be interpreted not as an example demonstrating the difficulty of accommodating NMVs, but as a good example of poor planning (and poor enforcement). Often NMV facilities are implemented where there is space available and in disjointed segments, not where they are needed. This practice should be discontinued in favor of the comprehensive planning process described herein.

Temporal Separation Measures

Temporal separation measures, such as access restrictions, can be very effective in improving overall traffic safety and congestion in the city. Access restrictions can vary by vehicle and by time of day for any given road facility.

In Shanghai, vehicle access restrictions have been successfully implemented to prohibit MV access to certain roads during morning and afternoon peak periods of travel (*10*). Such roadways become temporary NMV paths during MV-prohibited hours and are likely to function more effectively and efficiently than spatially separated lanes.

This type of separation is recommended for corridors with high NMV use where MVs can travel adjacent streets without major inconvenience. If adopted, access restrictions must be well defined and made known to NMV and MV operators through the installation of visible and legible road signs. Movable barriers, such as drums or concrete blocks, may also be utilized to prevent MV access from side streets or driveways.

CONCLUSIONS

NMVs, which account for a majority of the vehicles observed on the streets of Hanoi and Phnom Penh, are important not only in meeting travel needs, but also in contributing to the livelihoods of many of the cities' residents. However, prevailing biases of local governments toward NMVs may result in the prohibition of NMV use in the near future. Consequently, this conflict should be resolved through an emphasis on balanced transport planning, which includes the needs of MV and NMV users when drafting an urban transport plan. NMVs, in fact, often perform better than MVs in terms of traffic safety and efficiency.

It is important to also recognize that a critical issue concerning transport improvements in Hanoi and Phnom Penh is that funding constraints have severely limited action to date. This could be remedied with appropriate transport infrastructure planning and development projects funded by international aid organizations. When providing funds for such projects, these organizations should take appropriate measures to remedy anti-NMV biases and thereby promote balanced transport planning.

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Any errors in fact or judgment are the responsibility of the authors.

A Tale of Two Cultures: Ethnicity and Cycling Behavior in Urban Ghana

MARGARET GRIECO, JEFF TURNER, AND E. A. KWAYKE

A preliminary study of attitudes towards cycling in Accra, Ghana, showed that significant differences have been found to exist between cycling practice and attitudes toward cycling in two areas of the city that share low-income characteristics but have a different ethnic social base. Three key propositions were explored: (a) riding is commonplace in Nima, where it appears an everyday part of childhood and an accepted means of transport, but in Jamestown it is seen as dangerous and the behavior of rebellious, deviant school-age males; (b) there is an established network of bicycle hiring traders who facilitate access to bicycles at a higher level than that suggested by ownership figures; and (c) women riders and women hiring traders act as role models for other women of all ages to ride bicycles. Then the policy consequences of these findings in the context of the promotion of nonmotorized means of transport were considered.

Recently attention has been focused on the development of nonmotorized transport options as an appropriate and sustainable strategy for the Third World (*1–3*). Transport policy research has identified substantial differences in the extent to which various developing areas of the world have taken up the cycling option; dramatic differences between Asia and Africa have been identified. In China, more than half of the inhabitants own a bicycle; in Asia as a whole, the figure is near 40 percent. Sixteen percent of Latin Americans own a bicycle, but only 3.5 percent of Africans do. Furthermore, within Africa itself significant differences are found between French-speaking and English-speaking West Africa (*4*). It is this established pattern of differences that formed the rationale for our research into attitudes toward and patterns of cycling in Ghana. The research was conducted as part of a joint project between the Transport Research Laboratory (TRL) and the Ministry of Transport and Communications, Ghana, with linkages to the World Bank's Sub-Saharan Africa Program.

A less remarked upon but equally distinctive difference between regions is found in Ghana itself (*5*), where, in the 1980s, of the national stock of 200,000 cycles, 34.2 percent were to be found in the northern region, 43.8 percent in the two upper regions, and only 0.7 percent in greater Accra (Figure 1). In the three uppermost regions of Ghana, cycle ownership was about 53 per 1,000 persons, some 65 times higher than that of Accra. Cycling in Ghana has been primarily a northern practice. Recent figures indicate an expansion of this stock with imports of bicycles estimated at 67,000 for 1992, 225,000 for 1991, and 158,000 for 1990 (*4*).

Currently, there is considerable policy activity, not least on the part of the World Bank, to diffuse cycling practice to the large urban centers of the south (*6*). There is some evidence of a suppressed demand for bicycle use in Accra (*6*). It has been estimated that in certain low-income areas, 62 percent of households own a bicycle (*7*), but this figure does not hold true for all or most low-income areas of Accra. Even where households own a cycle, conditions for cycling on the main thoroughfares are so poor that most cycling takes place only within local areas. Even causal observation indicates that cycle use is not evenly distributed among the low-income districts of urban Accra. In this context, it was decided to investigate differences in attitudes toward cycling and cycling practice itself within urban Accra. Personal observations, contacts with local transport experts, and information provided by interviewers engaged in other transport research projects all indicated that the level of cycle use by the residents of Nima was higher than that in other areas.

Nima, a low-income, densely populated urban district, has traditionally been and remains a major reception area for migrants from the north. Because cycling is a more common practice in the north, this migration link provides a path for the transference of the northern culture of cycling into the urban south. Migrants are carriers of a nonmotorized transport culture. Moving from this analysis, which was largely shaped by local expert knowledge, an investigation of cycling attitudes and practices was conducted in the low-income area inhabited by northerners (Hausa, Fra-Fra, Kusasi, Dagomba, Busanga, etc.) and in a low-income area (Jamestown) inhabited by indigenous social groups (Ga) (Figure 2). Preliminary evidence indicates that there are variations in transport culture within the city, variations that correspond with patterns of migration linkage to areas of greater nonmotorized transport use.

Understanding these differences in transport culture has important policy implications. Substantially different patterns of childhood socialization were found with regard to cycling in Nima and in Jamestown. In Nima, adults encouraged boys to learn to cycle, although attitudes toward girls and cycling were more problematic; in Jamestown, both boys and girls were strongly discouraged and frequently punished by their parents for cycling. These differences in patterns of socialization have their consequences for subsequent use of the bicycle and thus for the viability of the bicycle as a mass means of nonmotorized transport. A clear policy implication of such differences in transport cultures within a city is that where policy makers intend to install cycling infrastructure, the positioning of the initial parts of the network should be anchored on the existing areas of high usage. Locating facilities where the user population has poor access may very well lead to implementation failures.

The work reported here is the outcome of three pilot surveys and a conventional travel diary survey. The first survey on the household activity patterns of low-income households was of 14 households. The survey attempted to capture a number of types

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of households (nuclear, large extended male headed, female headed). As a consequence of the inclusion of large extended households, the survey contains information on many persons (245), albeit of a preliminary form. Questions about the use of cycles and the ability to ride were included in the semistructured interview format used for the household activity research. On the second survey, which was explicitly concerned with cycling, 16 individuals were interviewed, 8 of whom came from Nima, 8 of whom came from Jamestown. Of the eight from Nima, four were cyclists, four were not; patterns were similar with Jamestown. Within their interviews, these 16 individuals made reference to the cycling/noncycling experiences of 216 other persons. The third survey was concerned with the transportation needs and experiences of women petty traders; included in this category of women traders were those women who sold their own services as human transport (*kayayo*—head load carriers who carry goods from the market to the bus station or truck parks). In this survey, there was no prompt on cycle ownership or opportunities for riding. None of these 12 economically active low-income women made any mention of bicycle use or ownership. Although further ethno-

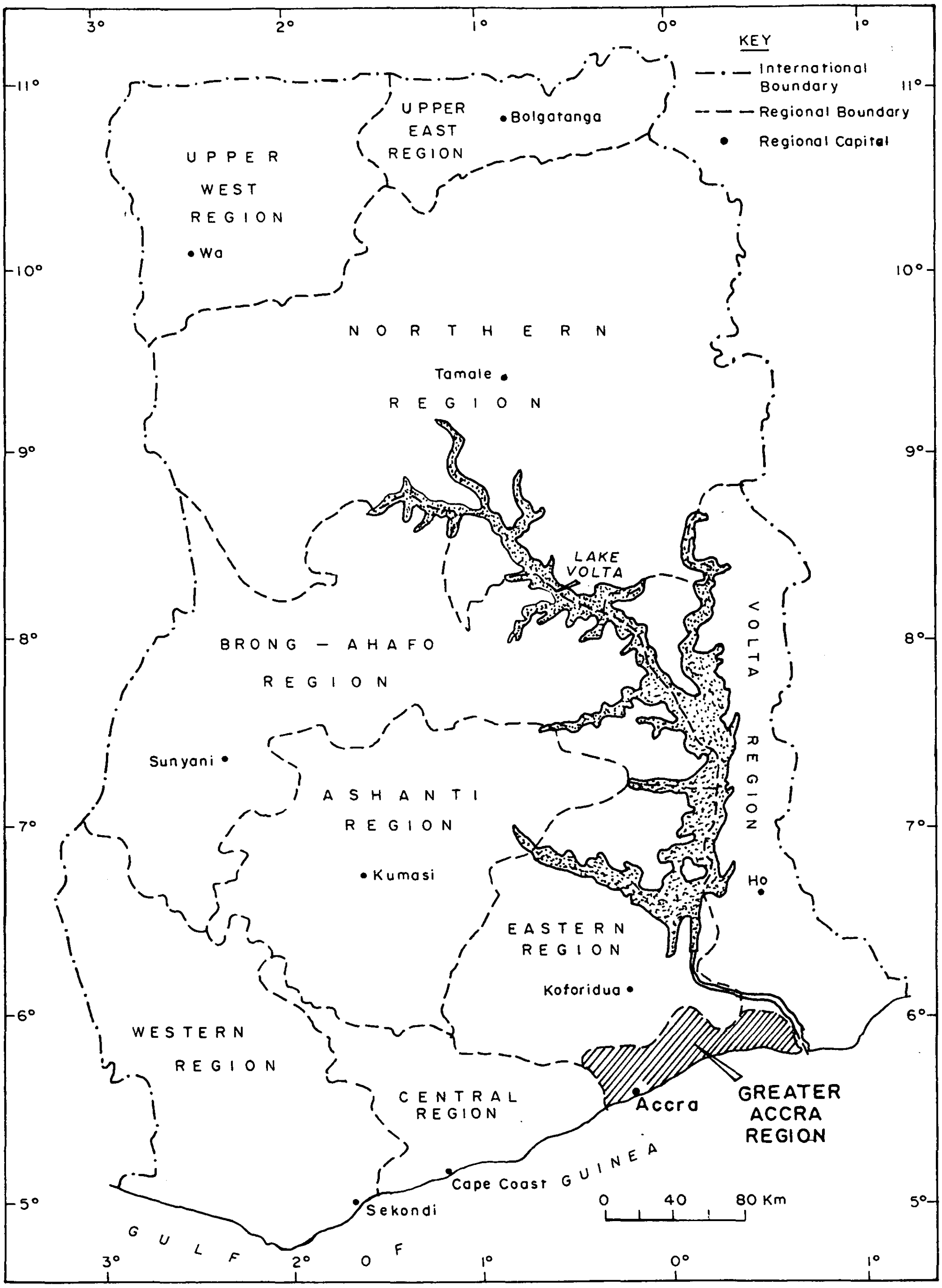

FIGURE 1 Map of Ghana.

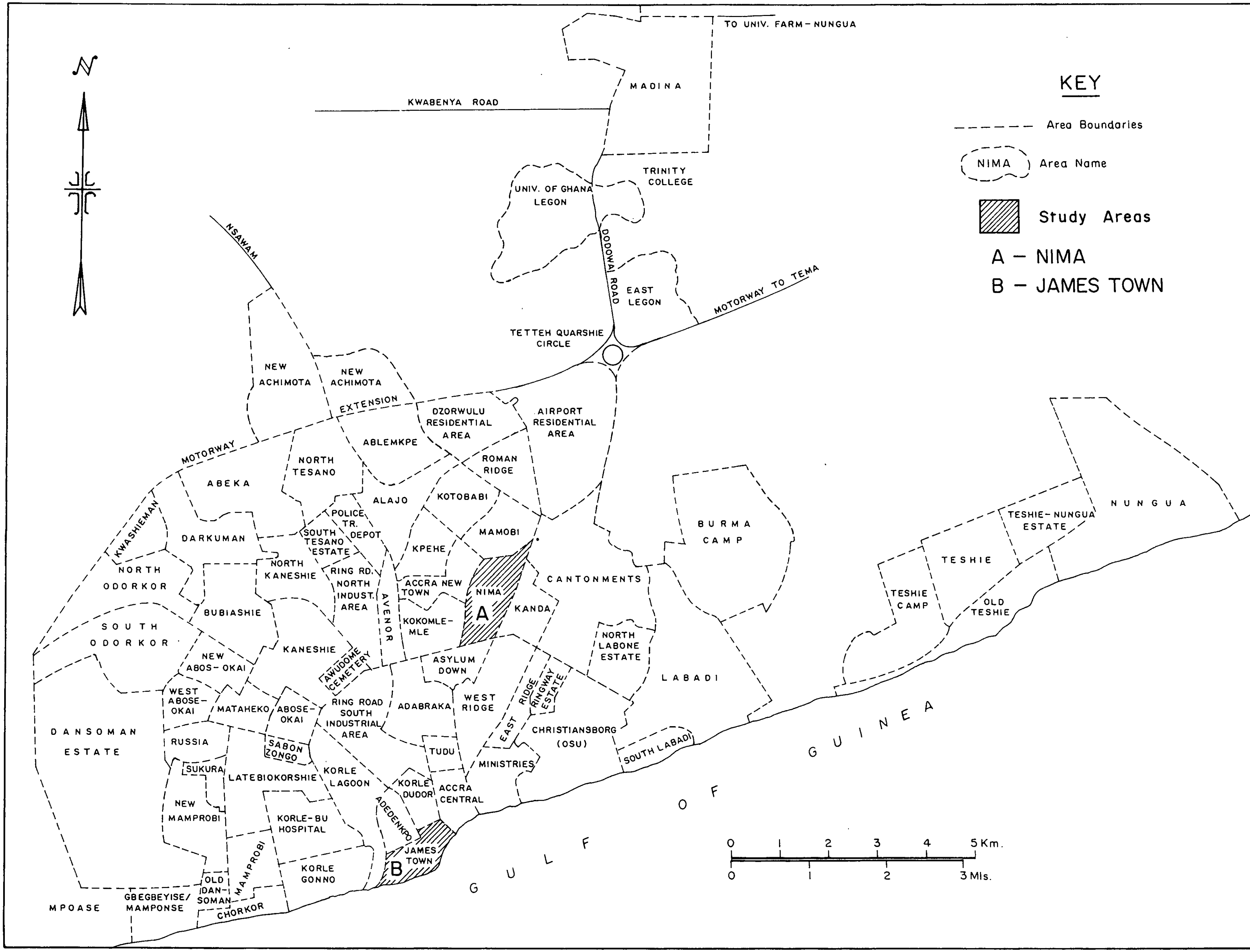

FIGURE 2 Map of Accra.

graphic and survey work is planned on these issues, for the moment our evidential base is confined to these 42 interviews that span the personal travel experiences of 473 low-income persons. Of these, 290 persons are based in Nima, 116 in Jamestown, and the rest in other low-income areas of Accra (Russia and Madina).

This paper is divided into five sections. In the introduction, the concept of transport culture and its significance for policy decision making has been discussed. The second section explores the various socialization processes with respect to cycling in Nima and Jamestown. The third section examines the importance of hiring arrangements as opposed to ownership rates in the transmission of cycling skills and identifies the obstacles such hiring arrangements pose for the use of cycles for economic or occupational purposes. The fourth section examines the opportunities and contraints surrounding women cycling in a Third World location. The final section and conclusion provide some concrete policy implications of this analysis.

PERMISSION OR PUNISHMENT: AREA DIFFERENCES IN PARENTAL ATTITUDES TO CHILD CYCLING

As a consequence of nation building dynamics, the ethnic composition of local areas has rarely been an explicit focus of official statistical research. As a consequence, it is difficult to provide a definitive estimate of the social composition of the Nima and Jamestown areas. Local knowledge (*8*) and dissertations conducted at the University of Ghana (*9,10*) indicate the strongly migrant and northern composition of Nima and the indigenous, coastal social composition of Jamestown.

From the qualitative materials that have been collected, a clear distinction in attitudes toward cycle use exists between these two locations. In Nima cycle use was widespread among men; such cycle use has a strong economic and occupational component. In Jamestown, reports of adult cycle use were substantially less; cycling in Jamestown appears to be primarily a leisure activity for young men. Respondents' reports on the "cycling culture" of these two areas were congruent with the on-street observations of our local interviewing and research team.

Both in Nima and Jamestown, young men enjoy the freedom of mobility provided by the bicycle. In Nima such riding activities on the part of such youths typically occur with parental encouragement; however, in Jamestown, our respondents, both adults and chidlren, reported parental resistance toward and prohibition of cycling activity on the part of children. Thus, children who cycle in Jamestown typically are doing so without parental consent and in opposition to parental authority. It may very well be that part of the pleasure of cycling in Jamestown is derived from this flouting of authority. Whether or not this is the case, it is certainly clear that cycling in Jamestown was seen as a deviant, male, school-age behavior. Cycling in this context was the equivalent of hooliganism, a negative behavior for which children would be punished when parents became aware that they had been engaged in such an activity. A nonriding man in Jamestown recounts the following:

> On the question of whether his parents knew he was cycling, since he rode in the community, he said they knew and saw him on several occasions on a bicycle. The question as to how was their reactions towards his riding, he said, "My parents did not take kindly to it all; each time I was reported, I was beaten and denied from food for that day." It was not a good experience at the time, because it was always tempting to ride.

The language that both children and adults, reflecting on their childhood cycling experiences, use to describe the way in which their parents became aware of their cycling activities is that of being "reported." Where children were reported to their parents for their involvement in cycling activities, punishments often extended to being beaten. That such negative attitudes toward children cycling were not simply parental attitudes but were communal attitudes is indicated by the involvement of other persons in reporting the child to the parent.

The involvement of the wider community in the social control of children provides a social surveillance capability that extends beyond the immediate residential area; if surveillance were viewed as the responsibility of parents alone, the chances of detecting such "wayward" behavior would be significantly lower; communal surveillance, on the other hand, increases the probability that children cycling will be detected and reported. A girl from Jamestown explained that her parents learned that she could ride when "someone went and reported [her] to them." When her parents realized that she could ride, "they advised [her] to stop immediately because [she] could easily be hit by a moving vehicle."

Although these attitudes necessarily generated substantial barriers to cycling as a routine activity on the part of children, the thrill of cycling clearly exceeded the fear of punishment for most young men, and although parental and community attitudes militated against ownership and routine use of cycles by children, the episodic bouts of riding by risk-taking children resulted in a wider diffusion of cycling skills than ownership statistics suggest. To finance their deviant behavior, children frequently used their "feeding money" to hire bikes for periods as short as 15 to 30 min. The availability of very short-term cycle hire permitted Jamestown youth to circumvent the prohibitions placed on riding by their parents. No doubt when children redirected their financial resources reserved for food toward leisure activity, it further alienated Jamestown parents from cycling.

In Nima, community acceptance of bike riding meant that boys almost without exception learned to ride bicycles. It also meant that girls also commonly learned to ride, although community acceptance did not extend to women riding bicycles much beyond puberty, and those who did ride were comparatively rare. The respondents in Nima commonly reported pleasant feelings and experiences while riding bicycles. These included both feelings of superiority over friends and peers when they were children, because they could ride and others could not, to feelings of independence in their movement when they were older. The problems of learning to ride reported by Nima respondents were mostly about the physical problems of riding. "For children, I feel it is part of childhood activities to learn to ride bicycles especially for most children like these in our Nima community," according to one Nima women who is a noncyclist.

By contrast, in Jamestown, community acceptance of bicycle riding did not exist and although it was still common among boys of school age, a number of children did not learn to ride, especially girls. The learning problems cited by Jamestown respondents were not confined to the physical dangers of learning to ride on busy inner-city streets without the provision of safe play areas but also explicitly included the moral penalites of detection and punishment by parents or indirectly by means of other members of the family or neighborhood. Whereas cycling in Nima was an open and esteemed activity for children, cycling in Jamestown was a furtive if thrilling experience.

Nima culture encourages children to acquire cycling skills, whereas Jamestown culture discourages children from doing so. Nevertheless, the boys of Jamestwon typically overcome such social barriers and learn how to ride. However, the negative culture surrounding cycing in Jamestown militates against youth viewing cycling instrumentally, that is, as a major means of transport as opposed to a mode of leisure. By contrast, children in Nima tended often to cycle purposefully to places such as school and marketplaces. They also reported the use of bicycles when running errands for parents; this was even cited sometimes as a method of winning parents' consent to more playful bike riding—a girl from Nima reported, "I use the bicycle to run errands for my parents and myself. I also use it to derive my sparkling pleasure."

Before leaving this discussion of the cultural differences toward childhood cycling, it is important to note that there are good reasons that parents in Jamestown might seek to influence their children against pursuing cycling activities. The mixed road use patterns of developing contexts generate many dangers for the young cyclist. The interactions between cyclists and pedestrians (many of whom may be operating as human transport bearing head loads and children on the back) and cyclists and motor vehicles in contexts where road surfaces are in poor repair and roadside gutters crumbling and broken do not provide a safe environment in which children can learn and practice cycling. Nevertheless, what remains interesting is why the parents of Jamestown, which enjoys more or less the same traffic and infrastructural conditions as Nima, discourge their children from riding whereas the parents of Nima do not.

NONMOTORIZED TRANSPORT IN A DEVELOPING CONTEXT: CYCLE-HIRE IN A PETTY TRADING ENVIRONMENT

The low cycle ownership levels found in urban Accra disguise how widely spread is the ability to cycle. Clearly, the extensiveness of hiring facilities in a context where ownership statistics are low is very important in providing low-income youths with the opportunities to learn these skills. However, it is not simply a question of the extensiveness of such hiring provision; rather the explanation of such widespread diffusion is to be found in the special character of hiring arrangements in the developing urban context.

Some special features of cycle hiring arrangements enhance the opportunities of youth to make use of the service. First, much of the hiring is undertaken on the basis of very small time units or hiring by small specified distances (popularly known as "*kobo-kobo*"—pole to pole). These can be seen as the transport equivalent of other petty trading arrangements in developing countries. Petty trading arrangements typically mean that the poor are paying more for a commodity than are the wealthy. The consequence of small time unit hire and small distance unit hire in transport is no different, as the information in the following table indicates:

Hiring Duration	*Nima (cedis)*	*Jamestown (cedis)*
15 min	50	
30 min	100	60–100
1 hr	200–300	120
Pole to pole	20–40	20

The cost of a new bike was given by one respondent as 27,000 cedis. At the rate of 200 cedis an hour, the cost of a bike to a hirer/trader could be recovered in 135 hr of hiring. Rates appear to be lower in Jamestown; perhaps this is explained by the low levels of adult patronage.

These petty trading arrangements around cycling appear to be primarily used for learning to cycle and thereafter for leisure cycling by youth. Among all categories of respondents, the first use of cycles predominantly occurred during childhood with most respondents having ridden a cycle at some stage of their life. Many first had access to bicycles through the cycle-hire traders that existed within their communities. "The boys who hire or rent the bicycle out on commercial basis taught me how to ride," said a girl in Nima. "I used to give them some extra money after I have hired and paid for the time or distance I use for cycling and asked them to push me around. They did this for a couple of days and number of occasions before I became finally perfect and started riding on my own." Another respondent began riding bicycles with schoolmates at a bicycle hiring unit at Jamestown. According to him, groups of peers go to this pool to hire bicycles at break time, which would last for an hour.

Petty hiring arrangements, although overall an expensive means of gaining access to riding opportunities, are offered at sufficiently small units of income to permit children to be the major purchasers of the service. These traders offer, from a child's perspective, the additional benefit that bicycle access can be obtained without the presence of overbearing parental supervision. Respondents from both communities reported that often hirers restricted learners to riding between two posts (kobo-kobo) that were within sight of the hirer so that they could oversee any damage being done to their bikes. This arrangement, of course, transfers the burden of supervising the child's safety in learning to cycle from the parent to the trader; preventing damage to the bike cannot be ensured without preventing damage to the child. Given the youthful character of this market for cycle-hire, it is in the interest of the trader to ensure that hirers have achieved sufficient proficiency before letting them loose on the wider road network. The involvement of traders in generating cycling proficiency for chlidren has its counterpart in the lack of parental involvement; parents were not reported as being involved in the teaching of bike riding.

The financing of bicycle riding among those that were riding as boys appeared predominantly to be from allowances given to them for other purposes. Money given to them to buy food while at school was commonly siphoned off to pay for bicycle hiring fees. It was noticeable that, in general, girls were using means of being able to afford to ride that were different from those of boys, either by using other sources of funding, such as trading activities, or by borrowing bicycles from relatives for free. A girl in Nima described it like this:

> As part of my labour activities after school, I sell Nido powdered milk in bits to children in the neighbourhood and makes a profit of about 300.00 cedis on each container. It is out of this amount of profit, I set aside 20.00 cedis to hire the bicycle to learn to ride. This is how I initially financed my riding.

Through such hiring arrangements, and despite vehement parental opposition, the cycling skills necessary to support sustainable mass nonmotorized urban transport policies may be present in areas such as Jamestown; however, childhood socialization processes that define cycling as a dangerous form of leisure may work against the adoption of the nonmotorized transport option by the adult. Existing short-term/distance hire arrangements neither permit the opportunity for the development of childhood routines of purposeful cycle journeying nor provide the necessary motivation for the acquisition of maintenance skills or even the necessary acquaintance with the techniques and procedures involved. The time/distance constraints of petty hiring mean that the cyclist never moves beyond the hirer's local area and thus is never out of the range where maintenance becomes the user's and not the hirer's responsibility.

Much of the attention on promoting the cycling option as a sustainable transport strategy has focused on the need to establish more flexible purchasing arrangements and to reduce import taxes and tariffs that place the bicycle out of the financial range of low-income households. Although this policy impulse is undoubtedly correct, there is mileage to be gained in considering a reorganization of existing hiring arrangements toward a longer leasing period for cycle-hire. Similarly, it may be useful to consider purposely reshaping the character of the hiring market. Currently, the market is largely a youth leisure market; however, the promotion of cycle-trailers on a hiring basis has the potential for converting these existing cycling facilities into more economic and occupationally useful services. There is evidence that in northern Ghana women traders have begun to use such cycle trailers (*1*), whereas there is not yet any evidence of such activity on the part of women traders in Accra. Purchasing such transport equipment may prove a substantial barrier to adoption on the part of low-income women—certainly in urban centers where relatively cheap motorized transport is available; the hiring or long leasing option on such enhanced load-bearing facilities may have the capability of altering existing preferences.

MAVERICK RIDERS? BARRIERS AND OPPORTUNITIES IN WOMEN'S CYCLING

In both Jamestown and Nima, there was clear evidence of a prejudice against adult women who cycled: adult women learning to cycle in Nima did so late at night when social and traffic activity had decreased substantially. The comments of cyclists themselves reflected the negative attitudes of the community around them toward women cycling. Men, cyclists and noncyclists alike, appear to consider cycling not suitable for women, although in Nima riding by girls is somewhat accepted. When asked what type of people ride bicycles in his community, a nonrider in Nima responded, "a few workers, few school children, and many children have taken to bicycle riding from hiring."

In Jamestown, bicycle riding even by girls is treated with some suspicion, and girls who ride are considered of "questionable sexuality." The most common justification for why women should not ride bicycles is the apparent danger of the activity on the main roads. Such attitudes also are often held by women noncyclists. Other explanations also demonstrated an apparent unwillingness to allow girls an ability to "play"; their role, from a very early age, is to assist in reproduction within the household, be it social, or at a later stage in life, biological. "It is not safe at all to see women riding, our roads are very bad, with many potholes and woman riders often run into children and people's wares by the road side," said a riding man in Jamestown. Asked whether he knows some women riders, the respondent explained that he knew a few and that those women behaved like men, that they even play football with men.

By contrast, the attitude of cycling women in both communities is often one of support to other riders, particularly other women. They themselves derive encouragement from greater numbers of woman riders and try and support other women who want to ride. One of our Nima respondents was a female cycle-hire trader. By her account the presence of woman hirers increased the likelihood of women learning to ride or hiring bikes to practice as there was reduced embarrassment and social pressure. When a girl cyclist from Nima was asked about her feelings about women riding bicycles, and why, she said,

> I admire females who can ride perfectly well. When they ride, I always have the urge also to go on a bicycle and ride. With adult female cyclists, I see them as role models and a source of encouragement to develop and advance in cycling activity. Why because as many females cycle, they help to change our attitudes towards female cycling and more females would join in the activity.

Respondents drew attention to the problems that women's dress posed for modesty if they were to cycle. The arrival of the bicycle in Western culture produced exactly the same concerns, with the consequence that a specific cycling dress designed to ensure the appropriate level of modesty was initially adopted by female cyclists. Although such concerns over dress are not confined to the Muslim community alone, the Muslim male community represents a substantial part of the cycling community and such concerns about modesty operate, given present dress code, against the diffusion of adult cycling activity to the adult female sector of this community.

Any policy concerned with promoting cycle adoption by women must engage this problem at some stage. There is, however, a practical solution that might be incorporated in any promotional activity. In a number of Muslim communities, most particularly those in which women are heavily engaged in field agriculture, women wear trousers and tunic dresses. Such dress is highly suitable for cycling activity and could be promoted in conjunction with cycle use; in such circumstances, its Muslim pedigree could usefully be emphasized.

Concerns about the environmental damage caused by motorized transport and constraints imposed by global financial problems have resulted in the reassessment of motorized developments as the appropriate transport policies for the Third World. However, the pilot research already has indicated that women face difficulties in gaining community acceptance as cyclists. If environmentally friendly policies are promoted without attention to such gender differences in the social acceptability of cycling, then a situation will occur in which environmentally friendly policies can hurt the economic activities of women. The promotion of fair transport policies must ensure that if the cycle option is adopted where motorized transport would previously have been the appropriate policy candidate—motorized transport being socially acceptable for women, albeit as passengers—active promotional measures must be taken to ensure that cycling by women is not socially discouraged.

This research indicated that a number of changes could be made that would be likely to encourage higher levels of cycling by women. First, the poor design of the existing infrastructure exposes women cyclists to ridicule, harassment, and injury from other road users; an improved infrastructure could do much to make cycling less risky for women and thus more socially acceptable because exposure to danger is regarded as an unfitting experience for women. (A program to construct segregated cycle ways in Accra was scheduled to commence in January 1994 under the auspices of the World Bank.) Second, alterations in the design of cycles and cycle accessories could do much to change the bicycle from a transport mode for the solitary individual into a facility for transporting occupational loads. The promotion of trailers and substantial front load carrying baskets to women petty traders would, if successful, generate a substantial market for cycling. Currently, the only visible use of such technology is by the males who sell Fan ice cream from cold boxes built into the front of their vehicles—the Fan boys. Any such promotion campaign would have to focus on providing safe locations for parking vehicles. Women who currently use cycles to make purchases at markets encounter major problems in finding secure parking facilities for their bikes. If cycle trailers do indeed become adopted in the urban trading context, then this problem will be greatly magnified.

PROMOTING NONMOTORIZED TRANSPORT IN DEVELOPING COUNTRIES: POLICY IMPLICATIONS

It has been argued that cycle ownership and use are not evenly distributed across the low-income areas of Accra. Instead, the clear focal hub of low-income cycling activity is located in Nima. Consequently, any program of cycleway infrastructural provision in the city would do well to consider the benefits of centering the initial stages of such a development in this area of high usage. Locating cycleways in areas of low cycle usage would enable their invasion by other road users.

Much of the focus around the promotion of cycling as a sustainable transport option has fallen upon the purely technical infrastructural requirements; however, for implementation to be successful in developing such cycleways, special features of the developing context need to be considered. Given the existing patterns of mixed road use, even where segregated facilities are provided, the danger remains of the spillover of road-side trading into these newly provided areas. Consideration should therefore be given to establishing strong visual signing, which indicates and helps enforce the moral rights and entitlements of cyclists at least to priority in such locations. As has been noted, there are particular problems of interaction between cyclists and human transport (head load carriers). Given the importance of human transport in Africa, policies designed to promote cycling will also need to be sensitive to the highway requirements of this particular social group.

Although the extensiveness and petty renting character of current hiring arrangements enable the development of the technical skill of cycling, such arrangements do little to promote the ready economic or occupational use of cycles. Such hiring arrangements can contribute little toward the mass adoption of sustainable nonmotorized transport options, apart from providing the conditions for the wide diffusion of cycling skills. Clearly, the provision of infrastructure has to be accompanied by arrangements that enable the financing and purchasing of vehicles.

It is apparent that anticycle childhood socialization processes are in play in certain African low-income areas and that road use conditions may play some considerable part in explaining the pattern of such "prejudice." Policy makers can, according to respondents of this study, usefully think about providing safer learning environments for child cyclists. In this way the negative attitudes of parents in such areas may be encouraged to change in the more positive and sustainable direction.

It also has been noted that there are clear cultural barriers to women cycling. This is a matter of some considerable importance because if policy intentions are to favor the bicycle as a transport mode in developing contexts, where women have key economic and transport roles and there are cultural barriers to women and cycling, then any such transport policy will be likely to increase gender inequity. Specific attention is thus required to promoting such infrastructural, vehicle design, dress, and social adjustments that will facilitate the development of women's cycling.

To summarize, there are cultural factors that condition transport behavior—in this case, cycling behavior. Unless transport policy takes explicit account of such factors, there are likely to be real and substantial policy failures.

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Role of Nonmotorized Transportation and Public Transport in Japan's Economic Success

WALTER HOOK

The public policies in Japan that enabled the development of an urban transportation system dominated by nonmotorized transport and rail-based mass transit were studied. The key role played by public policies that discouraged automobile use, encouraged bicycle use, channeled investment into rail, and drove up the cost of land is highlighted. It is argued that this urban transportation system contributed to rapid economic growth in Japan since World War II by constraining consumption, encouraging savings, and reducing labor costs. Finally, it is argued that the Japanese experience could serve as a better guide to developing countries than does past U.S. policy.

The extensive use of nonmotorized modes of transportation, such as bicycling, pedicabs, and walking, is often associated with a lower level of economic development. Writing in 1960, Rostow (*1*) equated the automobile-dependent post-World War II United States with the highest stage of economic development:

> What were those leading sectors in the American age of high consumption? They were, once again, the automobile, suburban home building, road-building, and the progressive extension of the automobile and other durable consumers' goods to more and more families.

From the perspective of 1990, however, it appears that the achievements of the post-war Japanese economy are far more impressive than those of the United States, with Japan having the fastest rate of economic growth and the fastest increase in its productivity of all the countries of the Organization for Economic Cooperation and Development (OECD). Yet Japan is also the least dependent on the private automobile of all the OECD countries, and the most dependent on rail, mass transit, the bicycle, and walking.

Japan industrialized later than the other OECD countries and thus had to break into already highly competitive international markets. As a result, it faced problems similar to those of developing countries today, such as how to promote its own indigenous industries in the face of highly cost-competitive foreign imports.

High urban density and a transportation system heavily reliant on nonmotorized transportation and its linkages with rail-based mass transit have been critical to Japan's economic success. By minimizing aggregate transportation costs, Japan has been able to minimize its production costs, making its goods more competitive in international markets. Further, by discouraging the consumption of private automobiles and encouraging savings, a larger pool of potential investment capital was created, also critical to rapid economic growth. Japan was able to achieve this transportation-land use system in part as a result of conscious public policies discouraging the use of the private automobile and in part as the indirect result of policies that drove up the price of land.

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Japan's initial decision to discourage the use of the private automobile was in large measure because the industry was dominated by foreign firms. Investments into road infrastructure comparable with those of U.S. levels did not emerge until the mid-1970s when the strength of the Japanese automobile industry was firmly established.

As the result of a historical pattern of investment favoring rail, Japan was able to encourage a high-density settlement pattern centered on its rail network, which also made walking and bicycling convenient. Not being dependent on the automobile for commuting, Japan was able to minimize total transportation costs, albeit with a decided lack of attention to passenger comfort. Because people did not have to buy automobiles to get to work, they were encouraged to save this money instead, which lowered the cost of capital in Japan. This, among other factors, explains why Japan has had one of the highest savings rates among the OECD countries since 1950, saving and investing an average of 30 percent of its annual national income, compared with only 18 percent in the United States (*2*). The high savings rate in turn encouraged investment into modern technology.

The automobile, far from being a symbol of economic prowess, is more a symbol of economic assets being wasted on consumption instead of on job-creating and productivity-increasing investment. Meanwhile, the bicycle and other nonmotorized vehicles, far from being a symbol of economic backwardness, are more a symbol of a society able to meet its passenger transportation needs in the most cost-effective and least environmentally damaging way, allowing scarce economic resources to be invested elsewhere.

COMPARISON OF EFFICIENCY OF JAPANESE AND U.S. TRANSPORTATION SYSTEMS

The relative efficiency of the Japanese and U.S. transportation systems can be assessed by comparing the percentage of gross national product (GNP) that each country spends on its transportation system. In 1960 the United States spent 20.7 percent of its GNP on transportation, a figure that has fallen slightly to 17.9 percent in 1990 (*3*). By contrast, Japan in 1985 spent only 10.79 percent of its GNP on transportation (*4*). This gap of 7 percent has alarming implications for the relative costs of Japanese and U.S. products in international markets. Transportation costs are an input into every good produced, both directly in terms of shipping the good and indirectly because the wage rate must cover the commuting costs of the labor force. The differences in aggregate transportation costs are considerably wider than the gap between the percentage of GNP spent on health care that has so alarmed economists. The United States spends roughly 12 percent of its GNP on health care, relative to about 9 percent in Japan, a difference of only 3 percent.

From the disaggregated GNP figures, it is clear that the domination of the U.S. passenger transportation system by the private automobile is the key reason for the cost differences. In the United States, of the total 17.9 percent of GNP spent on transport, fully 9.5 percent is consumed by private automobile and taxi transportation, and 5 percent is consumed by truck transportation. Rail-based modes for both freight and passengers account for only 0.7 percent of GNP. In Japan, by contrast, only 2.37 percent of its GNP is consumed by private passenger vehicles and small pickup trucks, whereas only 2.25 percent is spent on road freight. Rail, at 1.4 percent, accounts for a considerably greater share of GNP than in the United States. In both cases the share of GNP spent on bicycle transportation was negligible.

These differences are also reflected in household expenditure data. The Japanese household sector consumed 9.4 percent of their income on transportation and telecommunications in 1985, whereas the U.S. household sector consumed 15.2 percent on transportation and telecommunications (*5*). Other sources indicate that automobile related expenses account for between 18.6 and 22 percent of total household expenditures in the United States (*6*). Figures for Britain and West Germany were only slightly lower than those for the United States, with 16.6 and 15 percent respectively, whereas that for France was only 12.9 percent.

The enormous differences in the cost of transportation for society as a whole are primarily a result of the fact that Japan has been able to transport its work force much more cheaply than the United States. This is clearly reflected in the mode share data.

In Los Angeles in 1980 the private automobile accounted for 88 percent of work trips, whereas public transport (buses) accounted for only 7.7 percent and walking and cycling accounted for only 4.2 percent. However, private motor vehicle travel is dominant even in the New York City tri-state region, which is the most transit-oriented metropolis in the United States, accounting for more than 25 percent of all mass transit miles traveled nationally. In New York in 1990 the private vehicle accounted for 71 percent of all work trips, whereas public transit accounted for only 10 percent and walking and cycling only 6 percent—a sharp decline even from 1980, when only 63.6 percent of work trips were made by automobile, 28.3 percent by mass transit, and 8.1 percent by walking and bicycling (*7*).

These figures differ radically from those in Japanese cities. In the Tokyo metropolitan area, bicycling and walking accounted for 25.8 percent of all commuting trips in 1968 and fell only slightly to 21.7 percent of all commuting trips by 1988. Rail accounted for 51.9 percent of all commuting trips in 1968 and still accounted for 46 percent in 1988. The automobile accounted for only 12.9 percent of all commuting trips in 1968 and now accounts for some 29.4 percent of all commuting trips, still exceedingly low by OECD standards (*8*).

Thus, the transportation needs of at least half of the Japanese population are met by the 1.4 percent of GNP spent on rail transport and the negligible amount spent on nonmotorized transportation. It is in its role of minimizing the costs of the entire transportation system and increasing the catchment area and hence the viability of the rail-based mass transit system that nonmotorized transportation has played a critical role in the competitiveness of the Japanese economy.

Nonmotorized transportation has not only played a key role in Japan's transportation system historically; its role is actually increasing in several key areas. Over the past few decades the role of nonmotorized vehicles in Japan has changed slightly. As people are moving farther from urban centers, the use of the bicycle and walking for an entire commute has fallen slightly. However, the use of the bicycle to commute to rail stations has increased rapidly since the 1970s. In 1975 there were only 300,000 bicycles parked at commuter rail stations throughout the country. By 1981 this figure had risen to 1.25 million, and it is now well above 3 million, with 1 million of them in Tokyo. In suburban areas around major cities between 15 and 45 percent of rail station access is by bicycle. For Tokyo as a whole the percentage of people who use the bicycle to reach rail stations rose from 4 percent in 1975 to 11 percent in 1980 to 13 percent in 1985 to closer to 15 percent today. This growth in bicycle use has not been exclusively in the lower-income areas but has been at least as prevalent in higher-income neighborhoods (*8*).

This massive increase in bicycle commuting to rail stations has been facilitated by the rapid improvement of bicycle parking facilities near stations. Increasing numbers of bicycles illegally parked in front of rail stations began to be a serious problem for pedestrians in the late 1970s, prompting government action. The Bicycle Law, passed in 1977, provided public funding and tax incentives for the construction of bicycle parking facilities. Japan's 1980 Bicycle Law provides that newly constructed or enlarged department stores, supermarkets, and banks must provide bicycle parking. Japan has spent more than $10 billion on bicycle-related infrastructure over the past two decades, which led to the construction of some 8,952 parking facilities holding some 3 million bicycles, of which 3,250 are in Tokyo. Each year another 237,000 new bicycle parking spaces are constructed, an increase of over 10 percent a year. About 73 percent of these are controlled by provincial or local governments, 13 percent by public authorities such as the railroad, and 13 percent by the private sector. Roughly 66 percent of these parking spaces were within 100 m of a rail station entrance, and most hold from 500 to 1,000 bicycles. Land for these parking facilities is usually donated to the government by a railroad company or a large business during a "land readjustment," a process similar to urban renewal. One-half to one-third of the capital costs for construction can be paid for from public subsidies, and tax benefits and subsidized financing are available to the private sector for bicycle parking provision (*8,9*).

There are about 60 million bicycles in Japan—roughly double the number of motor vehicles—and since 1986 the increase in the number of nonmotorized vehicles has kept pace with the increase in car ownership (*9,10*). They are assuming an increasingly important role in providing cheap, pollution-free, and convenient access to suburban commuter rail stations.

The rapid increase in the role of the bicycle as a way of reaching commuter rail stations has considerable economic and environmental advantages over automobile park-and-ride facilities. The provision of parking for private motor vehicles is far more expensive than the provision of parking for bicycles. It costs some $3,500 to $5,000 to provide surface-level parking for a single motor vehicle and closer to $20,000 for a single parking space in a parking garage. Meanwhile, it costs only $100 for a bicycle in a rack, and only $1,000 per bicycle for a state-of-the-art, fully automated and secure bicycle storage facility. This does not include the relative difference in the cost of land, which in Japan is the determining factor. A single bicycle requires some 6 to 12 ft^2 of ground-level storage space, compared with a minimum of 330 ft^2 for a single automobile parking space (*11*).

Automobile park-and-ride facilities also do little to control the increase in emissions that are causing global warming and severe health problems. Most emissions come from cold starts and cold-running engines, whereas only a minimal amount of extra emissions are generated once the engine is warm and running. Thus, if passengers first drive to a park-and-ride facility the number of cold starts is not reduced at all. Bicycle and walking trips, of course, generate minimal air pollution.

Several factors have led to the growth in combined bicycle-rail commuting in Japan. First, with housing extremely expensive and cramped in Japan, housing development is expanding farther and farther away from commuter rail stations. The bicycle expands the catchment area of a rail station from about 1 km^2 for walking to about 25 km^2 for a commuter with a bicycle. Thus, bicycles are replacing some trips that otherwise would have been walking trips. Second, as traffic congestion continues to worsen on Japanese streets, the travel speed of buses has fallen dramatically. Average travel speeds on the Tokyo Metropolitan Region roads have slowed from an average of 9 mph in 1960 to 7 mph in 1983, and the slowing trend continues (*12*). This pace has particularly hurt the popularity of buses, which travel even more slowly. As a result, people who used to ride the bus to commuter rail stations are increasingly switching to faster bicycles. Finally, the increase in road congestion and the lack of parking continue to discourage people from using their private automobiles.

With passenger transportation relying on bicycles and mass transit, Japan has been able to dedicate its available road infrastructure primarily to trucking. Trucks account for nearly every other vehicle on Japanese roads and take up more than half of the total road space (*13,14*).

Automobiles are an important form of consumption. Every dollar spent on them is a dollar that could have been saved and thus invested into increasing economic growth. If this consumption were entirely "luxury" consumption, at least one could claim that this is how Americans are choosing to spend their surplus wealth. Being able to own a car is a luxury that most people in an affluent society should be able to enjoy. However, being dependent on the automobile to take care of basic commuting needs is not liberating. It means that families have no other option than to sit in traffic jams. This imposes significant costs on the American family, which could be avoided if bicycling, walking, and public transportation alternatives were more viable.

Because it has become necessary for commuting, the automobile has become an indirect cost of production. In the United States each employee must be paid some $5,000/year for the purchase and maintenance of their automobile to get back and forth to work each day (*6*). Furthermore, taxes have to be collected to pay the estimated $2,400 per passenger car of public subsidy to make automobile transportation viable (*15*). This $7,400/worker is reflected in the costs of all goods produced in the United States, albeit indirectly.

In Japan, by contrast, a one-time purchase of a $100.00 bicycle and a $500.00/year rail pass can take care of a person's annual commuting costs. Japanese workers therefore need only to be paid about $600.00/year to cover their commuting costs. These are significant cost differences that are undermining the competitiveness of U.S. products in international markets.

The automobile-based U.S. transportation system also led to the development of very low density suburbanization, whereas the rail-based Japanese transportation system led to the development of higher-density clusters around rail stations. The low-density U.S. pattern imposes important inefficiencies in the provision of many other forms of infrastructure and public service, such as telecommunications, electricity, water, sewerage, postal service and drainage. Several studies (*16,17*) indicate that the cost of providing housing in low-density unplanned suburban areas is at least 60 percent higher than providing the same number of units in planned, higher-density areas. More than half of these costs are underwritten by the tax payers. In low-density sprawling human settlements the costs of providing roads and streets are 4 to 15 times higher than in high-density areas, the costs of copper pipe and utility pipe for water supply 5 times higher, the costs of providing postal delivery 300 times more expensive, the costs of heating 5 times higher, and the amount of water and electricity consumed are double (*16*). Because of the ability to rely on walking, bicycling, and commuter rail, residents in Tokyo use $^1/_7$ the gasoline consumed by residents in large U.S. cities. The macroeconomic implications of these cost differences, which are reflected ultimately in the costs of U.S. products, are disturbing.

U.S. dependence on the automobile is also exacerbating the trade deficit. In 1989 Japan produced 9,052,000 passenger cars while consuming only 4,404,000 cars. In the same year the United States produced only 6,823,000 passenger cars while consuming 9,853,000 cars (*18*). If each one of these important cars cost $10,000, then $30 billion of the U.S. annual trade deficit at 1990 levels, or roughly 15 percent, can be directly attributed to the deficit in automobiles. If oil imports are also considered, automobile-related imports account for closer to 45 percent of the U.S. trade deficit.

Although many scholars have asked why the United States has lost the competitive edge in the production of automobiles, fewer have asked why it consumes so many. It is telling that in Toyota City most employees live in company housing near their factories and are picked up each morning by a company bus to minimize the worker's transportation costs (*19*). In the United States, automobile plants in Detroit are located in distant suburbs that are accessible only by private automobile to ensure that their employees are also customers.

HISTORICAL AND PUBLIC POLICY CAUSES OF JAPAN'S URBAN TRANSPORTATION SYSTEM

The radical differences between the transportation systems of Japan and the United States have developed in part as the result of historical processes, in part as a result of conscious public policy decisions, and in part as a result of the relative roles of Japan and the United States in the global economy.

Since World War II the Japanese government has pursued a set of public policies known as the "Maruyu system," which aimed at constraining private consumption. For example, interest earned on savings in the Postal Savings Bank was not taxed up to the first $13,000 before 1989, whereas there were a host of consumption taxes, with the automobile being a major target (*20,21*). With domestic demand weak after the war, and wanting to increase the pool of savings available for investment, Japan had to focus on selling its products in international markets. To make their products competitive the Japanese had to minimize their production costs, including their transport costs.

Total transport costs in Japan were minimized by several public policies. First, before 1975 Japan had a relatively low level of public investment into roads and highways and a relatively high level of public investment into rail-based transportation. Japanese investment into rails was actually higher than its investment into roads in absolute terms before 1964 [Figure 1 (*22–24*)]. Japanese investment into road infrastructure (as a percentage of GNP) was considerably below investment levels in the United States, but only before 1975 ([Figure 2 (*3,24*)]. Japanese investment into rail has been considerably higher than that in the United States throughout the post-war period [Figure 3 (*3*)]. In part as a result of these differences the amount of urban land dedicated to road traffic circulation is much lower in Japanese cities (5 to 15 percent) than in U.S. cities (20 to 25 percent) (*12*). The limited available road infrastructure quickly became congested in Japan, encouraging commuters to seek alternative, faster modes.

This pattern of investment in favor of rail, which had a major impact on the nature of urbanization in Japan, has long historical roots. When Japan entered the modern era after the Meiji Restoration, its road system was extremely underdeveloped. During the Tokugawa Shogunate wheeled vehicles were prohibited, the use of roads was tightly controlled, and the bridge infrastructure was left undeveloped, all as security measures to prevent sudden attacks by road on Edo (modern Tokyo). In Japanese cities wheeled traffic was also banned. Thus, when the Japanese economy began to modernize, its road infrastructure was very primitive, inducing modernizers to focus on the rapid development of rail, while the road system was used as a feeder system to the rail network.

Not long before the Meiji Restoration the ban on wheeled vehicles was lifted. The rickshaw, introduced in 1870, quickly came to dominate the urban transport scene, replacing the hand-carried palanquin or sedan chair. The first railroad was also introduced in 1872 between Yokohama and Tokyo. In the 1880s horse-drawn carriages and later omnibuses came to compete with the rickshaws. It was ultimately the bicycle and then the electric tram around the turn of the century that undermined the rickshaw. By World War II, the rickshaw had all but disappeared, resurfacing briefly after the war until about 1956 (*25*). The bicycle was thus a relatively modern vehicle that developed at roughly the same time as the first imported motor vehicles. Therefore, the notion that the motor car is more "modern" than the bicycle is a fallacy.

Economic nationalism was an important factor in the continued dominance of rail and bicycle relative to the motor vehicle in Japan. Rickshaws were almost certainly invented in Japan and first mass produced there, and from almost the beginning bicycles were manufactured domestically (*26*). By 1880 Japan had regained national control of shipping, and by 1920 Japan was manufacturing all of its own railroad equipment as well. The rail system also ran on coal and electricity, both of which were widely available domestically. By contrast, the Japanese automobile industry was destroyed by competition from General Motors and Ford, which had set up U.S.-owned subsidiaries in Japan by 1926. Japan's road-based modes were thus dependent on foreign-owned producers, foreign spare parts, and approximately 99 percent dependent on

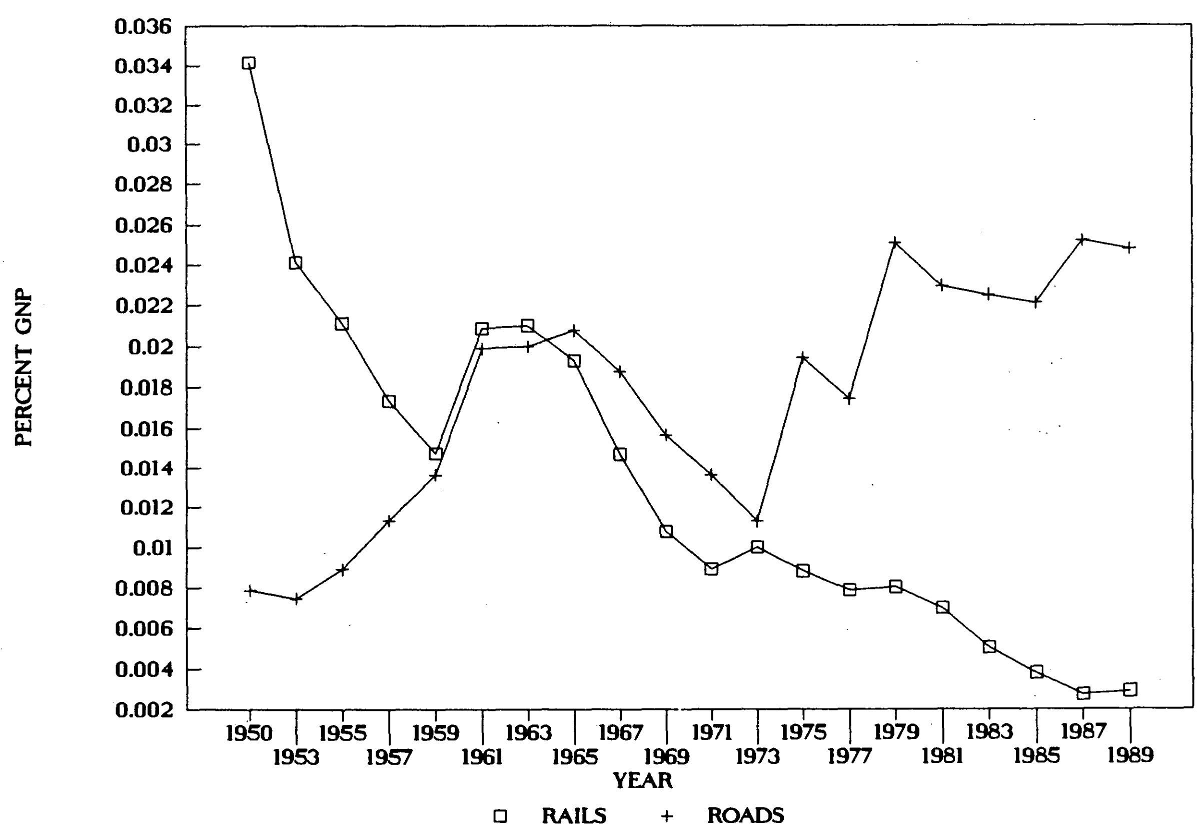

FIGURE 1 Japanese aggregate investment, roads and rail, 1950–1989 (*22–24, Japanese Ministry of Transport*).

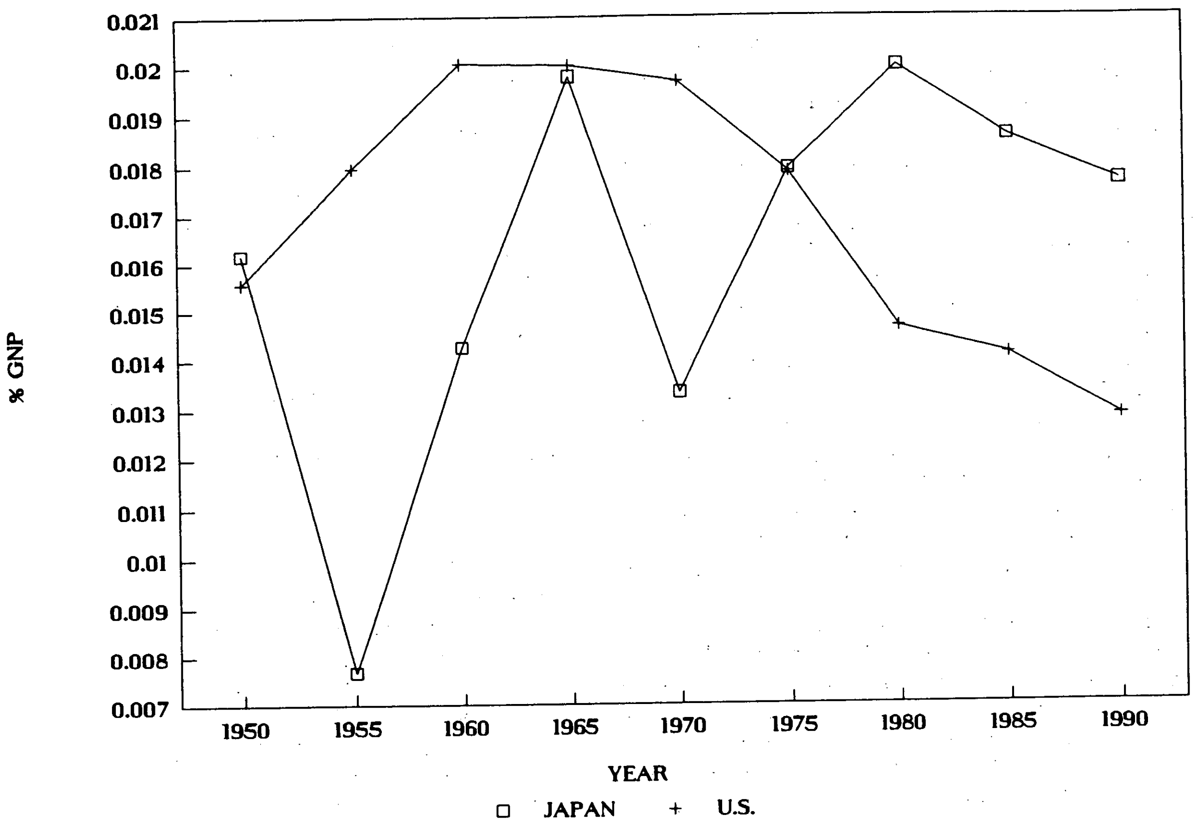

FIGURE 2 Total public spending on roads, Japan and United States (*3,24*).

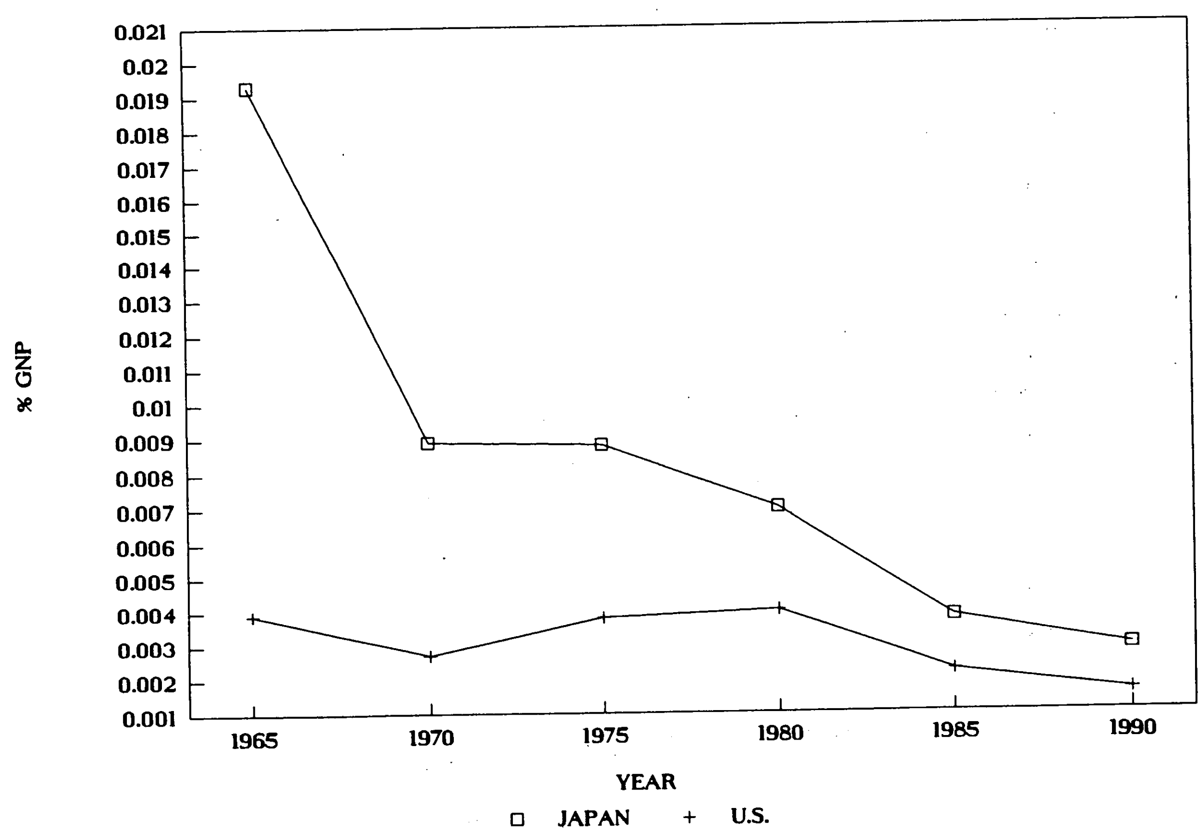

FIGURE 3 Total investment in rail, Japan and United States (*3*, Japanese Ministry of Transport).

imported oil. As a result, public spending on road infrastructure was never made a priority (*23*).

With the Japanese government pursuing an increasingly expansionist foreign policy in the 1930s the vulnerability of road-based modes to the blockade of oil and spare parts became a critical national security concern (*23*). The military government essentially created Nissan and Toyota Motors by a combination of favorable government contracts and subsidies and, after 1936, drove out the foreign motor vehicle corporations by increasingly tighter restrictions on foreign motor vehicle business operations (*27*). But during the war, with scarce oil reserves needed for the war effort and with shipping and oil supplies increasingly subject to aerial bombardment, more and more freight and passenger transport was shifted to rail.

After the war, both transportation infrastructure and production facilities were badly damaged by Allied bombarding. The occupation authorities restricted Japanese access to oil and motor vehicles for security reasons. Wanting to get the economy back on its feet, the occupation authorities decided to revitalize rail first, which was easier to monitor. As late as 1956 the main road between Tokyo and Osaka was still unpaved and almost not passable in significant sections. Thus, although investments into road infrastructure took off in Japan in the early 1960s, particularly before the 1964 Olympics, the road system was starting from a very low baseline, ensuring the continued importance of rail and continued high-density, rail-focused urbanization.

Other public policies also discourage automobile use and encourage walking, bicycling, and mass transit use. First, car owners must prove that they own a parking space before they can register their car in Tokyo, and parking is enormously expensive. It can cost over $100 to park for a day in some areas in downtown Tokyo, in part because of taxes. Parking violations can result in fines of up to $1,500. Fuel taxes and import duties also are very high, driving fuel costs in Japan to 3.1 times the U.S. level. The total tax levy on a car in Japan is roughly $1,285/year, compared with $232/year in the United States. Meanwhile, a driver can pay the equivalent of $98 in tolls to drive from Osaka to Tokyo, about the same distance as that from New York to Washington where the tolls cost a U.S. driver from nothing to $14.00, depending on the route. Another crippling cost of driving in Japan is called the "shacken." Every 2 years drivers have to have their cars inspected. The cost of inspection is roughly $900.00, and if the car does not have the inspection sticker by the end of the year the cost is doubled. Above and beyond this one must pay mandatory replacement costs on all sorts of vehicle parts (*7,8,28*).

Furthermore, most Japanese employers pay for the entirety of their employees' commuting expenses if they commute by public transportation. As a result, families tend to have only one car and treat it as a luxury, using it for weekend outings, rather than as a means of commuting.

Surprisingly, despite some of the highest gasoline taxation, tolls, and other user charges among OECD countries, these revenues still have been significantly less than the amount of money the Japanese government has spent on road infrastructure since the 1960s [Figure 4 (*3,29*)]. The level of direct subsidy to the private automobile in Japan actually has been higher than in the

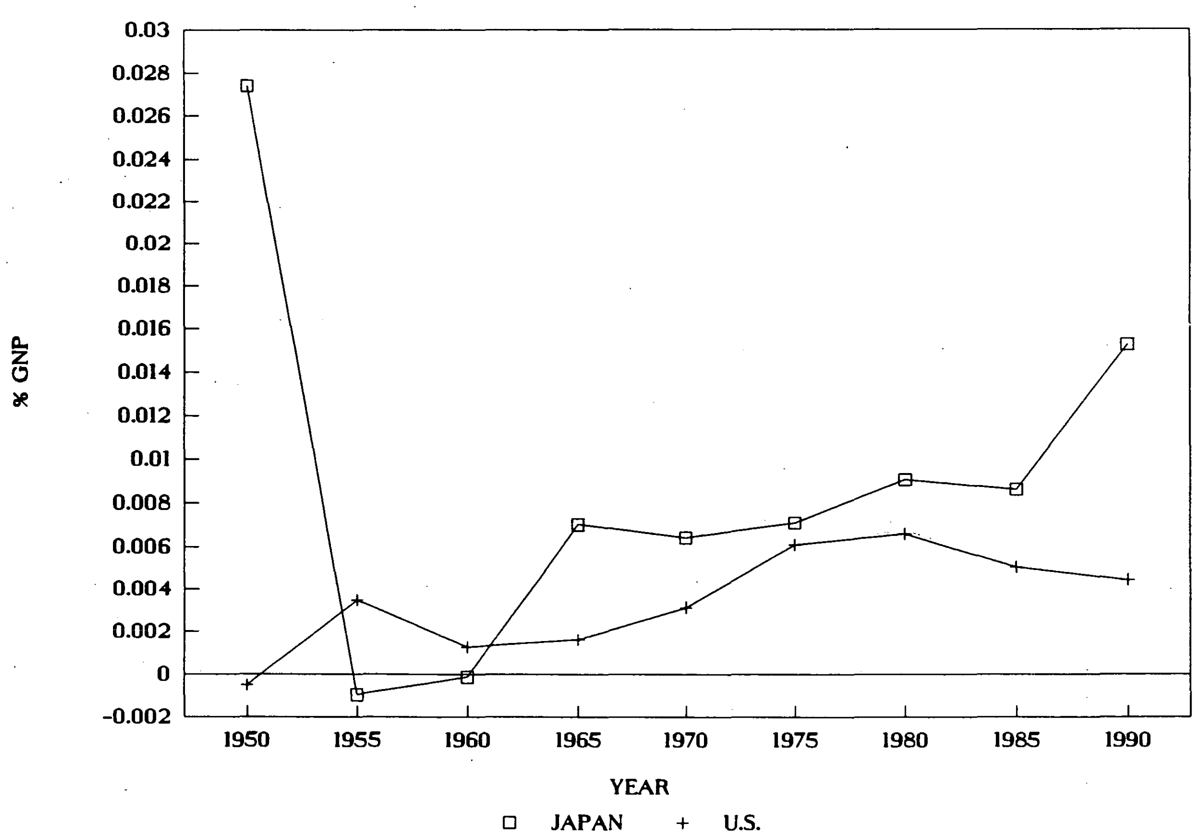

FIGURE 4 Road subsidies, Japan and United States (*3,30*).

United States for several decades. Rail and mass transit subsidies were higher in Japan than in the United States until 1970 but have been higher in the United States since then. In both countries, however, the level of public subsidy to these modes increased dramatically from 1970 until 1980 and have fallen sharply since then.

Despite enormous public expenditures into roads since the early 1960s, Japan has built far less physical road infrastructure largely because of the high cost of land acquisition. Land consistently accounts for between 70 and 80 percent of total costs for road projects in Japan, compared with some 25 percent in the United States (*30,31*). Construction costs also are higher because to minimize land acquisition costs most Japanese highways in urban areas are elevated, freeing the land below for alternative uses.

Land prices in Japan, while in part a reflection of the lack of arable land relative to the density of population, cannot be explained by purely geographical factors. According to Ricardian theory, one would generally expect that the value of land would reflect the economic activity on that land. The total value of land in the United States relative to that of Japan should be in the same ratio as the ratio between the two GNPs. This would still give Japan a much higher land value per square meter than the United State. However, since the 1970s, the total value of land in Japan has been between two and four times the total value of land in the entire continental United States (*32*).

Several factors have contributed to high land prices in Japan. First, large Keiretsu firms tend to have extensive land holdings, particularly in urban areas, giving them oligopolistic control over the land market and a vested interest in maintaining high land prices. Similarly, small landholders at the urban periphery, many of whom received their land in the post-war land reform, also have a stake in high land prices as most of their savings are tied up in land. These two groups have formed the political alliance critical to maintaining public policies that maintain high land prices.

Both price supports on rice and tax laws have slowed the conversion of agricultural land to residential and commercial uses. Property taxes on land that ostensibly is being used for agricultural purposes are minimal. Thus, speculators intentionally do not develop their land to avoid paying higher property taxes. Within major Japanese cities including Tokyo extensive land holdings are being used to grow vegetables. These and other elements of the tax laws have constricted the supply of land available for development and have worked to keep land costs high (*32,33*). It is largely these policies that have driven up land costs, which in turn have discouraged the use of the land-intensive automobile. These same policies have also driven up the cost of housing, which lies at the heart of Japan's attempt to constrain consumption and drive up the savings rate (*34*).

Acquiring the land to construct the right-of-way for roads and highways is not only expensive, it is also problematic. Since the 1960s a number of powerful urban citizens' movements in Japan have been fighting the construction of new highways. Because the state's powers of eminent domain were abused during the period of military governments leading up to and during World War II, current public officials are extremely reluctant to seize land for public purposes. By organizing property owners in the planned rights-of-way and convincing them not to sell their land, citizens' movements have successfully delayed road projects all over Japanese cities. The completion of both the inner and outer ring roads in Tokyo has been delayed for decades by environmentally oriented citizens' movements allied with local property owners (*35*).

Furthermore, Japan has very powerful tenants' rights laws. Most tenants hold leases lasting a minimum of 30 years, and even when the lease has expired the tenants cannot be removed without just case. The landlord is not able to sell the land without the tenant's approval. Highway authorities wishing to purchase land for right-of-way must enter into complex negotiations with tenants as well as landowners. As a result, even in central Tokyo there are many areas where most buildings are only one or two stories, even though the zoning permits much higher buildings.

Citizens' movements reacting against environmental degradation and concerned primarily about quality-of-life issues also were instrumental in electing progressive governors in many of Japan's major urban areas in the 1960s and 1970s, including Tokyo. In Minobe's "Blue Skies over Tokyo" campaign he promised not to build a single bridge if there was a single dissenting voice. Tokyo Governor Minobe began the "Pedestrian Paradise" program of closing city streets to motor traffic particularly on weekends and evenings. This program proved to be extremely popular and now has spread to many commercial areas of the city, and to other cities. These pedestrian areas, generally open to truck delivery in the mornings and late evenings, have played an important role in expanding the amount of public open space that is sorely lacking in most Japanese cities. This program also has helped to increase the popularity of nonmotorized modes such as bicycling and walking.

Land use controls and land use regulation may have played some role in encouraging a higher-density urban fabric, but zoning laws and development controls are notoriously weak in Japan. Both the National Capital Regional Development Law of 1956 and the Urban Planning Law of 1968, which tried to concentrate growth into subcenters and preserve "green zones," basically failed as a result of resistance by suburban property owners (*36,37*).

Thus, several public policies have reduced the supply of land available for development leading to extremely high land prices. With automobile transportation only able to move some 150 to 400 persons per meter per hour, compared with subways, which can move 9,000 persons per meter per hour, and bikeways, which can move 1,400 persons per meter per hour (*38*), the land cost of providing sufficient road infrastructure to accommodate the automobile has become prohibitive. Despite extensive subsidies to road infrastructure in Japan since the early 1960s, the cost of land has driven the Japanese transportation system to more land-efficient and cost-efficient modes.

CONCLUSION

A history of extensive investment into rail-based transportation, policies discouraging the use of the automobile, and policies encouraging high land costs have led to a high urban density in Japan. With densities high, a transportation system increasingly reliant on nonmotorized transportation linked with rail-based mass transit proved to be economically more viable. This cost-efficient and land-efficient transportation system has been critical to Japan's economic success. Society as a whole, spending far less of its economic resources on transportation than in the United States, has been able to use these extra resources on new investment. With the costs of commuting low, Japanese workers were able to save more of their money, thereby increasing the savings rate, decreasing the cost of capital, and encouraging investment. As an input into Japanese products, the low transportation costs have helped lower the total cost of producing Japanese goods, making them more competitive in international markets.

Although before the mid-1970s the relative weakness of the domestic automobile industry discouraged high levels of expenditure into road infrastructure, since then road investments have increased to levels well above those of the United States as a share of GNP. However, continuing high land costs and the resistance of environmentally oriented citizens' groups have meant that these expenditures did not translate into as many kilometers of new and expanded roadway as might have been expected. With severe limitations on the ability to further expand road infrastructure in Japan, traffic congestion continues to worsen and travel speeds decline. These factors have forced Japanese automobile manufacturers to look to Southeast Asia as their primary growth market. As a result, Japanese Overseas Development Assistance is increasingly focusing on road building in East and Southeast Asia.

Although nonmotorized modes have been important to travel in Japan since the 1870s, particularly for short distances in urban areas, recently this role has been expanding. With growing congestion on the road network, and in the absence of any attempt to use congestion pricing, many Japanese motorists and bus users are switching to bicycles, particularly for reaching commuter rail stations. Growing distances between new housing developments and rail stations have also induced new residents to reach rail stations by bicycle rather than by walking.

Thus, the view that the widespread use of nonmotorized vehicles is associated with economic backwardness is a fallacy. Not only are nonmotorized vehicles a long-established and increasingly important part of Japan's urban transportation system, they have played a critical role in Japan's low-cost transportation system and high-density land use pattern. This transportation-land use system has in turn played an important role in Japan's economic success. It is, in a sense, the spatial manifestation of Japan's export-oriented growth model. Thus, developing countries wishing to promote a transportation system that will best facilitate rapid economic development would do well to follow Japan's historical example.

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Factors Influencing Ownership and Use of Nonmotorized Vehicles in Asian Cities

CHIAKI KURANAMI AND BRUCE P. WINSTON

Nonmotorized vehicles (NMVs) such as bicycles and cycle-rickshaws offer low-cost personal mobility, are nonpolluting, use renewable energy, are labor-intensive, and are well-suited for short trips in most cities in Asia regardless of culture, income, location, or size. The extent to which they are owned and used in a region, however, varies considerably among cities. NMVs account for a significant or even majority share of all traffic in certain cities, whereas in others only a marginal portion of total traffic is nonmotorized. On the basis of a World Bank–funded inventory of NMV needs and opportunities in 10 Asian cities, the existing situation and trends are summarized and the factors influencing NMV ownership and use are assessed. The cities covered in the study were Phnom Penh (Cambodia), Hanoi (Vietnam), Dhaka (Bangladesh), Kanpur (India), Shanghai (China), Surabaya (Indonesia), Manila (Philippines), Chiang Mai (Thailand), George Town (Malaysia), and Tokyo (Japan).

Nonmotorized vehicles (NMVs) such as bicycles and cycle-rickshaws offer low-cost personal mobility, and they are widely owned and used in Asia. The extent to which NMVs are owned and used, however, varies considerably among cities in the region. In certain cities NMVs account for a significant or even majority share of all traffic, whereas in others only a marginal portion of total traffic is nonmotorized. The findings presented in this paper are based on a World Bank–funded inventory of NMV needs and opportunities in 10 Asian cities (*1*). The first section presents brief "pen sketches" of each of the case study cities included in the inventory. Topics covered in this section include general background information on the cities, the extent of NMV ownership and use, relevant factors influencing NMV ownership and use, and major NMV issues in the cities. A cross-city analysis of the existing situation and trends of NMV ownership and use is then presented in the section that follows. Finally, an analysis of factors influencing the ownership and use of nonmotorized vehicles is presented.

OVERVIEW OF NMVs IN CASE STUDY CITIES

Phnom Penh

Phnom Penh is the capital city of Cambodia, one of the poorest countries in the world with an estimated per capita income of approximately U.S. $200. The 1992 population of Phnom Penh was 700,000, implying a population density of 16,200 persons per square kilometer (41,958 persons per square mile). Except for Phnom Penh's four main boulevards, most of the city's roads are unpaved and in very poor condition, which creates an advantage for NMVs, which can be maneuvered more easily than cars, trucks, and buses on damaged streets. Excluding motorcycles, Phnom Penh has only 16 motor vehicles per 1,000 persons, the lowest level of motorization in all of the study cities.

Approximately half of the vehicles in Phnom Penh are NMVs, with bicycles accounting for 47.1 percent of the city's total vehicle stock and cycle-rickshaws (cyclos) for 4.2 percent. The popularity of NMVs in Phnom Penh results primarily from the high demand for low-cost transportation and the city's low level of motorization. Bicycle prices are reasonably low (U.S. $48 for a standard model) and cyclo fares are low ($U.S. $0.04/km, U.S. $0.06/mi) because of low labor costs. The city has only 23 buses, but motorcycles and cars are becoming more numerous. The national government would like to phase out the use of cyclos in Phnom Penh to improve safety and reduce congestion. Early action is required to protect the interests of NMV users and ensure improvement of the overall urban transport system.

Hanoi

Hanoi, Vietnam's capital, had a 1992 urban population of 1.1 million and a population density of 25,580 persons per square kilometer (66,252 persons per square mile). Vietnam has a low gross domestic product (GDP) per capita, estimated at U.S. $200, roughly comparable to that of neighboring Cambodia. The urban area of Hanoi has 187 km (116 mi) of paved streets, 75 percent of which are 7 to 11 m wide (7.7 to 12.0 yd; 2 to 3 lanes). Given the narrow width of Hanoi's roads and the extensive use of two-wheeled vehicles, bus operations are very difficult.

Hanoi is a heavily NMV-dependent city. The city's estimated 1 million bicycles and 5,100 cycle-rickshaws (cyclos) account for approximately 85 percent of the vehicles in the city. NMVs account for approximately two-thirds of the city's vehicular traffic. Factors contributing to the popularity of NMVs in Hanoi include the presence of a local bicycle industry, which produces bicycles of a reasonably good quality at low prices; household incomes insufficient to purchase motorcycles; government control of ownership of private cars; and a shortage of buses, resulting in a low level of bus service. City government officials, including the traffic police, complain about the dominance of NMVs on Hanoi's streets and the difficulty of enforcing traffic regulations controlling NMV movements. Although financial constraints as well as an energy shortage make it difficult to upgrade the city's bus service, government officials would like to reduce bicycle and cyclo traffic to increase bus speeds. NMV management and bus planning are urgently required to improve Hanoi's urban transport system.

Dhaka

Dhaka, the capital and largest city of Bangladesh, has experienced dramatic population growth over the last three decades. In 1961,

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the population of Dhaka was just over a half million; as of 1992, the population of the central city had increased to 3.4 million, with a population density of 27,400 persons per square kilometer (70,966 persons per square mile). An estimated 1 million live in slums and squatter areas. Rapid population growth has created immense pressure on the city's already overloaded infrastructure, especially on its transport system.

Dhaka is another NMV-dependent city, with the city's 200,000 cycle-rickshaws (simply called rickshaws locally) accounting for 53.8 percent of the city's total vehicle stock and bicycles accounting for 10.7 percent. NMVs also account for 51.8 percent of the vehicles on typical NMV-use roads. The popularity of cycle-rickshaws in Dhaka may be attributed to the high demand for low-cost transportation, a low level of motorization, a low level of bus service, and an abundance of low-cost labor. Cycle-rickshaws, which are used for relatively short-distance trips [2.5 km (1.6 mi), on average], benefit from the high-density development of the urban area, 27,400 persons per square kilometer (70,966 persons per square mile). The popularity of rickshaw use is also supported by the prevailing cultural environment because women in predominantly Muslim Bangladesh prefer not to use crowded buses for reasons of modesty.

Several types of specially designed freight rickshaws are available for deliveries and for traveling salesmen; their maneuverability on narrow streets leads to their use instead of motorized vehicles. Bicycles are less widely used in Dhaka because of the relatively high price of bicycles in relation to income, the (perceived) high risk of theft, and the low social status associated with bicycle users.

The local government plans to eliminate rickshaws from the streets, but the issue is highly political. A compromise will have to be reached regarding the roles of NMVs and motor vehicles (MVs), and appropriate facilities and management measures will have to be introduced.

Kanpur

Kanpur, originally developed as a British army camp on the Ganges River, had a metropolitan population and population density in 1992 of 2.3 million and 7,560 persons per square kilometer (19,580 persons per square mile). Located in the Indian state of Uttar Pradesh, Kanpur is the eighth largest metropolis in India and the second largest in northern India, after Delhi. Its population has approximately doubled in the last 20 years, and local government planning studies forecast the metropolitan population to reach 4 million by 2010. Yet the length of roadway that can be used by automobile traffic in Kanpur is only 225 km (140 mi), with the remaining streets having a width of less than 3.5 m. Moreover, the use of street-side space by vendors, squatters, and others reduces the effective width of the right of way, which exacerbates the city's traffic congestion problem.

NMVs account for 51.5 percent of all vehicles owned in Kanpur, with the city's approximately 500,000 bicycles alone accounting for 47.1 percent. The share of NMVs in Kanpur's traffic is 55.7 percent, including bicycles (39.7 percent of the total traffic), cycle-rickshaws (13.3 percent), and carts (2.7 percent). Factors contributing to the popularity of NMVs in Kanpur include the low level of service provided by bus and other motorized public transport modes (e.g., three-wheeled motorized taxis); low labor costs, which result in lower costs for NMV acquisition, maintenance, and operation, which in turn results in relatively low fares; the provision of bicycle parking facilities at major bicyclist destinations; and the laissez-faire attitude toward NMVs adopted by the city government.

Although NMVs have thrived to date in Kanpur's laissez-faire environment, the growth of MVs may eventually lead to the banning of NMVs, such as animal carts, from the city's main streets, as has happened in other Indian cities. Although Kanpur's main streets are wide enough to allow for the coexistence of a mix of modes, it may be necessary to upgrade the city's overall street system if both motorized and nonmotorized modes are to be accommodated in most parts of the city.

Shanghai

Shanghai, one of the three centrally administered cities in China, had a 1992 population of 8.4 million, implying a population density of 23,470 persons per square kilometer (60,787 persons per square mile). Including 10 adjacent counties, the Shanghai metropolitan area has a population of 12.8 million, the largest in China. Shanghai is a center of business, culture, education, and industry, and it has the busiest shopping district in the country, attracting millions daily.

Like most Chinese cities, Shanghai is now largely dependent on bicycles as a consequence of an explicit national policy to prevent the widespread use of motorcycles and private cars and to implement urban land use strategies that ensure that residences are within reasonable bicycling distance of workplaces. Nearly 96 percent of the vehicles in Shanghai are bicycles, and the 7.1 million bicycles owned by Shanghai residents are equivalent to nearly two bicycles per household. More than 87 percent of all vehicles in traffic in Shanghai are bicycles. One reason that bicycles are popular in Shanghai is that buses are often slow and crowded, whereas bicycles are faster and more reliable. Commuting expenses are subsidized by employers, and these subsidies can be used to purchase a bicycle. In addition, residential and employment location patterns allow for relatively short commuting distances that are well suited for bicycle travel. Other factors promoting bicycle use in Shanghai include a well-developed bicycle industry, low bicycle prices, and the use of high prices to control the ownership of motorcycles and private cars.

Separate networks for MVs and NMVs are planned, and some progress toward implementation already has been achieved. However, with increasing traffic congestion and changing land use patterns, buses will play a significant role in the near future, and the role of the bicycle as a feeder mode to buses will become more important.

Surabaya

Surabaya, Indonesia's second largest city and the capital city of East Java, had a 1992 population and population density of 2.7 million and 9,310 persons per square kilometer (24,113 persons per square mile). The physical area of the city has expanded rapidly in the last 15 years, as the city sprawls to the south and west. Roads are the principal form of transport infrastructure in Surabaya, but many of the city's roads serve a variety of traffic and modes, causing conflicts and congestion. Also, there is a lack of traffic signals and controls, which results in a hazardous environment that hinders nonmotorized transport.

Approximately 45 percent of the vehicles in Surabaya are NMVs, 40.1 percent bicycles, and 4.6 percent cycle-rickshaws. However, NMVs account for only 15.6 percent of the city's vehicular traffic. The role of bicycles in commuter transport has decreased, primarily because of the increased affordability of motorcycles. The role of cycle-rickshaws, known locally as becaks, has decreased because of restrictive regulations (e.g., the banning of becaks from operating on developed commercial streets). Nevertheless, becaks are preferred over motorized public transport for relatively short-distance trips in which passengers are carrying goods. Although the fares are higher, users prefer becaks because they provide door-to-door service even within areas with narrow streets.

Unlike in Jakarta, where becaks have been banned and confiscated, the local government in Surabaya has a policy of accommodating becaks and other NMVs. Nearly 20 years ago, a policy of day and night becaks was implemented to reduce their numbers and to stabilize operators' incomes. A major urban transport study in 1991 recommended that the becak continue to provide feeder services for public transport, direct services in selected inner-city areas, services in outlying areas and special-interest destinations, and services to promote tourism (*2*). In addition, a 1992 study formulated a strategy for increasing bicycle use by improving traffic conditions for bicycles in residential areas (*3*).

Manila

Metropolitan Manila consists of 4 cities and 13 municipalities, with a total 1992 population of approximately 8.4 million, implying a population density of 13,160 persons per square kilometer (34,084 persons per square mile). The road length in metropolitan Manila totals 2980 km (1,852 mi), 85 percent of which is paved. Although the main thoroughfares are in relatively good condition, many of the side streets have broken pavement and insufficient drainage. Cycle-rickshaws, known locally as pedicabs, are favored by many for trips along these side streets because of a lack of pedestrian facilities, especially after heavy rainfall.

NMVs account for about 13 percent of metropolitan Manila's vehicle stock, with 12.6 percent bicycles and 0.7 percent pedicabs. According to a 1984 person trip survey, NMVs account for fewer than 1 percent of all nonwalk trips. However, recent traffic counts at 12 typical NMV-use locations in the city found NMVs accounting for 34 percent of vehicular traffic, with pedicabs alone accounting for 19.9 percent of the total.

Although Manila is confronted with increasing unemployment, an energy shortage, and increasing fuel prices, government officials do not wish to encourage NMVs. Consequently, pedicabs are prohibited from operating on major thoroughfares and places already served by motorized transit. Nevertheless, pedicabs are expected to continue operating in selected areas, especially in locations near public markets, shopping malls, offices, and schools.

Chiang Mai

Chiang Mai, located about 800 km (497 mi) northwest of Bangkok, had a 1992 population of 243,000 and a population density of 2,290 persons per square kilometer (5,931 persons per square mile), the lowest of all the cities included in the inventory. Although Chiang Mai's population is only about 4 percent that of Bangkok, it is the country's second largest city.

Like many other cities in Thailand, Chiang Mai has become dependent on motor vehicles. NMVs account for only 4.8 percent of the city's vehicle stock and 2.2 percent of its vehicular traffic. Bicycle use is not very common because motorcycles are widely available (430 per 1,000 population). Samlors (i.e., cycle-rickshaws) have remained in operation despite the increasing number of tuk-tuks (i.e., three-wheeled motorized taxis), which compete directly with samlors. Samlor passengers use samlors for shopping or commuting over relatively short distances. The city government plans to preserve samlors by designating existing roads within the old city as NMV routes to promote objectives related to pollution, traffic, tourism, and historic preservation.

George Town

The city of George Town is located in the northeast corner of Penang Island, which is connected to peninsular Malaysia's mainland by the 13.5-km (8.4-mi) Penang Bridge. Penang Island had a 1992 population of 588,000 and population density of 2,060 persons per square kilometer (5,335 persons per square mile). Approximately 45 percent of the island's residents live in George Town, which had a 1992 population and population density of 260,000 persons and 10,250 persons per square kilometer (26,548 persons per square miles), respectively.

Similar to Chiang Mai, George Town is a motor vehicle–dependent city, with NMVs accounting for only 6.5 percent of the vehicles in traffic. Although approximately half of the vehicles in George Town are NMVs, bicycles are used predominantly for recreational purposes and cycle-rickshaws (locally called trishaws) have been reduced in importance since the Municipal Council in 1969 decided to prohibit the issuance of new trishaw licenses. The city government now plans to ban trishaws from busy roads. Although certain sectors of society in George Town depend on cycle-rickshaws for shorter, goods-accompanied trips, the long-term role of the trishaw in George Town may be only for tourism purposes, particularly considering that younger persons are not interested in becoming cycle-rickshaw drivers because many other employment opportunities are now available in Penang's vibrant economy.

Tokyo

Tokyo, the capital of Japan, is the most populous city in the country with 11.9 million persons and a population of 31.8 million in the metropolitan region. The estimated income per household in Tokyo was approximately U.S. $60,000 in 1992, by far the greatest of all the study cities. Tokyo has an extensive urban rail system with a total length of 614 km (382 mi) of passenger railways within Tokyo prefecture. The length of roads is 23 419 km (14,553 mi), but roads occupy only 7.1 percent of the total land area of the prefecture and 22.4 percent of central Tokyo. Road coverage in Manhattan by comparison is 37.6 percent. The urban toll road network in Tokyo prefecture totals 220 km (137 mi) and is severely congested 16 to 18 hr/day. Urban streets generally are narrow.

Approximately 60 percent of all vehicles in Tokyo are bicycles, and bicycles account for 36.1 percent of all person trips in the

TABLE 1 Number of Vehicles Per 1,000 Population (*1*)

City	Bicycles	Cycle-Rickshaws	Animal Carts	Buses	Motorcycles	Other Motor Vehicles
Phnom Penh	156.25	13.92	0.63	0.03	144.72	16.23
Hanoi	909.09	4.64	0.00	0.15	116.36	44.06
Dhaka	11.76	58.82	0.00	1.41	17.70	20.74
Kanpur	227.27	14.70	2.43	0.38	77.43	93.18
Shanghai	865.37	12.68	0.00	2.44	4.88	17.07
Surabaya	129.63	14.74	0.00	1.04	124.98	52.80
Metro Manila	11.90	0.65	0.03	0.62	7.93	72.97
Chiang Mai	100.00	14.50	0.00	0.17	429.95	135.90
George Town	528.17	6.17	0.02	0.39	308.29	220.76
Tokyo	534.54	0.00	0.00	1.33	123.02	233.61

city. Bicycle use has increased in recent years since bus service levels have deteriorated because of increased traffic congestion. The national Bicycle Law, enacted in 1980, has encouraged local governments to provide bicycle lanes, paths, and parking facilities near rail stations to promote the use of bicycles as a feeder mode for rail service. Other factors contributing to the use of bicycles in Tokyo include the high level of development of the Japanese bicycle industry, low bicycle prices in relation to income, and the use of sidewalks by bicyclists. Many housewives use bicycles for shopping, and high school students use them extensively to commute to school. The respective roles of NMVs and MVs in urban transport are well delineated in Tokyo, where bicycles will remain an important feeder mode to suburban rail.

CROSS-CITY ANALYSIS OF NMV OWNERSHIP AND USE

Data on NMV ownership and use patterns in the 10 Asian cities inventoried for the World Bank–funded inventory are presented in three tables:

- Ownership of nonmotorized (and motorized) vehicles per 1,000 population (Table 1);
- Annual growth rates of NMVs in recent years for the cities for which reliable data are available (Table 2); and
- Comparison of NMV and MV traffic shares (Table 3).

Salient points with respect to specific NMV modes are set in the text that follows.

Bicycles

Bicycles are the most widely owned NMV in the cities studied, except in Dhaka, where the number of cycle-rickshaws exceeds the number of bicycles. The cities in which bicycle ownership is the highest are Hanoi and Shanghai, with ownership levels of 909 and 865 per 1,000, respectively. Both Tokyo and George Town have more than 500 bicycles per 1,000 population, whereas the remaining cities have bicycle ownership levels below 200 per

TABLE 2 Growth Rates of NMVs in Selected Study Cities in Recent Years (*1*)

City	Type of NMV	Period	Average Annual Growth Rate
Kanpur	Bicycle	1983–92	5.3%
Kanpur	Cycle–Rickshaw	1983–92	2.0%
Kanpur	Pushcart	1983–92	1.5%
Kanpur	Animal Cart	1983–92	–0.7%
Shanghai	Bicycle	1980–90	14.9%
Shanghai	Other NMVs	1980–90	5.3%
Surabaya	Cycle–Rickshaw	1985–92	–0.7%
Chiang Mai	Cycle–Rickshaw	1978–92	8.8%
George Town	Cycle–Rickshaw	1978–92	–1.2%

TABLE 3 Shares of NMV Versus Motor Vehicle Traffic on Typical NMV-Use Roads (1)

City	Non-Motorized Vehicles (excl. peds) (%)	Motor Vehicles (%)
Phnom Penh	52.1	47.9
Hanoi	64.3	35.7
Dhaka	51.8	48.2
Kanpur	55.7	44.3
Shanghai	87.2	12.8
Surabaya	15.6	84.4
Metro Manila	33.8	66.2
Chiang Mai	2.2	97.8
George Town	6.5	93.5
Tokyo	36.1	63.9

1,000. The lowest rates of bicycle ownership were observed in Dhaka and Manila, both about 12 per 1,000. Bicycle growth rates appear to be high in the region, with reliable historical data including annual average growth rates in bicycle ownership of 5.3 percent in Kanpur (1983 to 1992) and 14.9 percent in Shanghai (1980 to 1990).

The growth of bicycle ownership in the study cities is noteworthy, particularly considering the development of exogenous factors that tend to suppress NMV ownership. One such factor is that average trip lengths are increasing in the region as cities decentralize. For example, the average trip length in Kanpur increased from 1.4 km (0.9 mi) in the late 1970s to 3.6 km (2.2 mi) by 1987. Longer commuting distances are also becoming more common in Shanghai because of the expansion of the city and relocation of industries and housing.

The modal share of bicycle in traffic counts tends to be highly correlated with the proportion of total vehicles that are bicycles. Hanoi, Kanpur, Shanghai, and Tokyo all have a relatively high rate of bicycle ownership and a high proportion of bicycle traffic. However, bicycle ownership in George Town is also comparatively high, with bicycles accounting for nearly half of all vehicles but only about 5 percent of all vehicular traffic.

The difference in bicycle trip purposes should be noted. In most NMV-dependent, low-income cities, bicycles tend to be used for the entire trip (e.g., for commuting, shopping). However, the major purpose of bicycle use in middle-income cities such as Chiang Mai and George Town is recreational. In high-income Tokyo, bicycles are increasingly used as a feeder mode to rail stations as well as for shopping and other purposes. The rail feeder modal split of bicycle (and motorcycle) in metropolitan Tokyo increased from 2 percent in 1968 to 10 percent in 1988.

In many of the lower-income cities bicycles are used extensively to carry goods. Although Shanghai restricts fright haulage by bicycle, in Phnom Penh, Hanoi, Kanpur, and Surabaya bicycles are used by policemen, in mail delivery service, by persons carrying goods to and from markets, by hawkers, and for goods delivery. Bicycles are also used as taxis in Phnom Penh, although motorcycle taxis are becoming increasingly common. In Tokyo, not a low-income city, bicycles are commonly used by the police and by bank and postal workers.

Cycle-Rickshaws

Dhaka is by far the most dependent on cycle-rickshaws of all the study cities. The "cycle-rickshaw capital of the world" has about 59 cycle-rickshaws per 1,000 persons, whereas the ratio in all the other study cities is less than 15. Phnom Penh, Surabaya, and Chiang Mai—all with 14 to 15 cycle-rickshaws per 100,000—followed Dhaka in terms of the rate of cycle-rickshaw ownership. Hanoi and George Town also have cycle-rickshaws, with 6 per 100,000, whereas there are few left in Manila (0.65) and none in Tokyo (0). Cycle-rickshaw growth rates vary from negative in Surabaya (−0.7 percent, 1985 to 1992) and George Town (−1.2 percent, 1978 to 1992), two cities in which the total number of licenses issued is fixed, to 8.8 percent in Chiang Mai, where the local government has adopted a more accommodating attitude toward the mode.

Cycle-rickshaws are used primarily as passenger taxis or for small-scale freight haulage (i.e., up to 200 to 300 kg, or 440 to 660 lb). Taxi use is more common than freight transport use in most of the study cities, except in Shanghai where cycle-rickshaws are used mainly as freight carriers. Cycle-rickshaws in most of the study cities are used for a variety of trip purposes, including work, shopping, and social trips. They are frequently used for relatively short-distance trips and trips in which passengers are accompanied by freight. In some cities (e.g., Kanpur, Dhaka) cycle-rickshaws are used to transport school children, with the vehicles carrying up to eight students in one vehicle. In addition, there are a variety of other types of cycle-rickshaws designated for specific uses such as food and beverage delivery.

Other Types of NMVs

Kanpur, with 2.4 animal carts per 100,000 population, has the highest rate of ownership of animal-drawn carts of all the study cities, although the number of animal carts in Kanpur has been decreasing at an annual rate of 0.7 percent since 1983. Animal carts in Kanpur are used for both passenger and goods transport. A small number of bullock carts are found in Phnom Penh and George Town. Horse-drawn carriages are found in small numbers in Manila and Surabaya.

Many hawker's carts are observed in low- and middle-income cities such as Dhaka, Kanpur, Surabaya, Manila, and George Town. In Dhaka, two-wheeled pushcarts operated by several persons are sill used for large-scale freight haulage. Handcarts are widely used for waste removal and numerous other purposes, especially in the low-income cities.

FACTORS INFLUENCING NMV OWNERSHIP AND USE

Overview of Factors

A wide variety of factors may be identified as having an effect on NMV ownership and use in Asian cities, including the following:

- Affordability of NMVs,
- Attractiveness of NMVs compared with that of other modes,
- City size and urban form,
- Safety of NMV use,
- Risk of NMV theft,
- Social attitudes toward NMVs and other cultural factors,
- Topography,
- Climate,
- Environmental concerns,
- Tourism and recreation, and
- Governmental policies.

Each of these factors is discussed; because of the difficulty of drawing statistically significant conclusions from what is after all a relatively small sample size (10 cities), the discussion is necessarily qualitative and occasionally cites examples from other cities.

Affordability of NMVs

One important factor affecting the ownership and use of NMVs is their affordability (*4*), which can be defined in terms of costs relative to income. Factors that in turn affect affordability, because they relate to either costs or income, include the following:

- Distribution of income, which affects the number of individuals or households that can afford an NMV;
- Availability of economy and used models, which may widen the range of households that can afford an NMV (as in Hanoi but not in Dhaka);
- Degree of development of the local NMV industry, which may result in comparatively low average prices for NMVs (as in Hanoi, Kanpur, and Shanghai) and may secondarily create employment for persons who themselves may then be able to buy an NMV;
- Low labor costs (as in many of the study cities), which result in lower costs of NMV (particularly cycle-rickshaw) operation, which in turn results in relatively low fares;
- Availability of low-interest loans and subsidies for the purchase of NMVs (as in Kanpur and Shanghai), which effectively reduces the price of an NMV to the potential buyer; and
- Prevalence of high tariffs and other taxes on NMVs (as in Bangladesh), which adversely affects NMV ownership and use by increasing the price of NMVs to users or degrading the quality of NMVs offered for sale on the local market, or both.

Attractiveness of NMVs Compared with Other Modes

The attractiveness of NMVs relative to competing modes is another important factor affecting the ownership and use of NMVs. The NMV share of the vehicle stock and the modal split of NMVs may be expected to increase

- When bus service is poor, as in Phnom Penh (a city with only 23 buses), Hanoi (with only one bus for every 6,875 residents), Kanpur [with only 80 buses used for intracity service, each averaging only 71 km (or 44 mi) per day], and Shanghai (where travel by bicycle is faster than travel by bus);
- Where the ownership of motorcycles and automobiles is low, as a consequence of low incomes or high tariffs, or both, and other taxes on MVs (as in Phnom Penh, Hanoi, and Shanghai, but not in Chiang Mai);
- Where good NMV facilities are available, as in Shanghai (which has made substantial progress in the implementation of separate networks for NMVs and MVs), Kanpur (with the provision of bicycle parking facilities at major bicyclist destinations), and Tokyo (with its advanced bicycle parking facilities); and
- When there is a high degree of integration between NMVs and public transport (as in Japan, where the national Bicycle Law has encouraged local governments to provide bicycle lanes, paths, and parking facilities near rail stations to promote the use of bicycles as a feeder mode for rail service).

City Size and Urban Form

Controlling for other factors, the ownership and use of NMVs is inversely related to a city's size and the extent of urban decentralization (*4,5*). Trip distances increase as cities grow and spread out, and human- or livestock-powered vehicles are necessarily less competitive for longer trips. Thus, for example, relatively compact Hanoi has been termed a "paradise" for bicycles (*4*), whereas NMVs have largely disappeared from the streets of the large, sprawling city of Bangkok. In addition, cycle-rickshaws tend to thrive in old city centers, such as Old Dhaka and the historic center of Chiang Mai. Of course, NMVs can continue to play a role in large, decentralized cities; in the Tokyo megalopolis, for example, approximately 10 percent of all rail feeder trips are made by bicycle.

Safety of NMV Use

NMVs may be termed "vulnerable road users" (*5*) because they are often the victim of aggressive driving by motorists, especially in bicycle-hostile street environments where slow and fast modes are inadequately separated (*4*). The extent of NMV ownership and use appears directly related to the quality of the bicycling environment and inversely related to accident risk. In Shanghai, a city that offers a relatively safe, user-friendly bicycling environment, 95.9 percent of all vehicles owned and 87.2 percent of all vehicles in traffic are bicycles. In contrast, bicycles in Surabaya and Chiang Mai were found to account for less than 6 and less than 1 percent of all vehicles in traffic, respectively, a consequence of unsafe conditions for bicyclists in the two cities.

One may hypothesize a "vicious circle" by which decreasing bicycle use and increasing motorization result in degradations in the quality of the bicycling environment and increases in accident risk, leading to further decreases in bicycle use. Bicycles "rule the road" in bicycle-dependent cities such as Hanoi and Shanghai, and consequently bicyclists in these cities are confronted with comparatively minor conflicts with motorized modes. With continued motorization and consequent degradation of the safety of the bicycling environment, substantial decreases in bicycle use in these cities may be expected unless effectively counteracted by policies to improve the bicycling environment.

Risk of NMV Theft

Although there is a dearth of formal data on NMV thefts, the possibility of NMV theft was found to represent a barrier to NMV ownership in some of the study cities (e.g., Dhaka, Surabaya). Even in low-income cities where the statistical probability of theft is relatively low, the perception of the risk of losing a major investment in an instant likely deters many from owning NMVs. A survey of bicyclists and nonbicyclists in ten low-income neighborhoods in Delhi in 1985 found that whereas only 1 percent of the bicyclists reported having had a bicycle stolen, theft was seen as a significant deterrent to bicycle ownership by the nonbicyclists (*4,6*). However, in Japan bicycle theft is rather common but does not significantly suppress the ownership and use of bicycles because bicycle prices are rather low in relation to incomes.

Social Attitudes Toward NMVs and Other Cultural Factors

Local social attitudes can have a significant impact on the ownership and use of NMVs (*4,5,7*). For example, the prevalence of NMVs can be influenced by the status of their use. In Bangladesh, most bicycle owners are middle-income persons because more affluent individuals prefer to travel by other means, even by foot, than to lower their status by using a bicycle. Although poorer and less well educated bicyclists in Bangladesh have been found to use their bicycles every day, wealthier and better-educated bicyclists are more likely to use their bicycles only occasionally.

The extent of NMV ownership and use also can be influenced by attitudes related to gender. Female bicycle riders are much more common in China and Vietnam than on the Indian subcontinent or in Indonesia, where traditional clothing styles and cultural norms make it difficult for women to use bicycles. On the other hand, women commonly use cycle-rickshaws in the predominantly Muslim city of Dhaka, where *purdah* (the social seclusion of women) makes it difficult for women to share crowded buses with the predominantly male passengers.

Topography

Not surprisingly, NMVs tend to be more prevalent in flat cities than in hilly ones. It is difficult to illustrate this common-sense point from the study cities because all were selected because of their predominantly level terrain. However, to illustrate the point, consider Myanmar, with hilly and MV-dependent Yangon, and flat and NMV-dependent Mandalay, the latter of which has been dubbed "a city of bicycles." Of course, bicycles can thrive in mountainous countries and even in hilly cities, if there are sufficiently large expanses with relatively level topography (*5*).

Climate

There are no clear relationships between NMV use and ownership and climate. In some of the study cities (e.g., Manila), hot and rainy climates were found to deter bicycle ownership and use but increase the use of cycle-rickshaws. However, bicycles were found to predominate in other study cities with similar climates (e.g., Hanoi). And bicycles have become increasingly popular in the rainy North American cities of Seattle and Vancouver (*8,9*), which average 160 days/year of measurable precipitation.

Environmental Concerns

Evidence from outside Asia indicates that, at least at certain levels of development, bicycle ownership and use may be related to the environmental consciousness of a community or country. The Netherlands, one of the world's leading countries in environmental policy, has 14 million bicycles compared with 15 million people and only 5.5 million motor vehicles; 29 percent of all trips in Holland are made by bicycle, and the modal split for commuting trips in certain towns is approximately 70 percent (*10*). Evidence also indicates that North American cities in which bicycle use is prevalent (e.g., Toronto, Vancouver, Seattle, Santa Monica) are among the most environmentally conscious (*8,9,11,12*).

Tourism Promotion and Recreation

Tourism promotion and recreation are two additional factors contributing to NMV ownership and use. In George Town, bicycles account for nearly half of all vehicles but only about 5 percent of all vehicular traffic because they are used primarily for recreational purposes. Cycle-rickshaws (trishaws) have been preserved in George Town largely because of their nature as a tourism asset on an island that derives 15 percent of its GDP from tourism. Although local government officials in the historic city of Chiang Mai have indicated their desire to see cycle-rickshaws (samlors) promoted for tourism purposes, tourists currently account for only about 2 percent of all cycle-rickshaw passengers in Chiang Mai.

Governmental Policies

NMV ownership and use are also highly dependent on policies at various levels of government. These policies include

- Unbalanced urban transport planning favoring MVs over NMVs (as in Jakarta and Bangkok, but not in Shanghai);
- Low-interest loans and subsidies for the acquisition of NMVs (Kanpur and Shanghai);
- Policies promoting (China and Vietnam) or hurting (e.g., high tariffs on bicycle parts in Bangladesh) NMV industries;
- The relative taxes charged MVs and NMVs (e.g., favoring MVs in Bangladesh, but favoring NMVs in China);
- The construction of NMV (network and parking) facilities by the government or by the private sector under public-private cost sharing schemes (Kanpur, Shanghai, and Tokyo);
- Investment in competing modes (e.g., investment in mass transit in Shanghai and Tokyo);
- Registration and licensing regulations, which may either burden NMVs (as in Surabaya and Jakarta) or promote NMVs (as with Shanghai's theft-preventing bicycle registration system);
- Traffic regulations, which may aid NMVs by promoting a safer environment (as in Shanghai) or may hinder NMVs (as in Dhaka, where NMVs are banned from certain "VIP roads");
- Level of traffic enforcement and education of users (e.g., high in Japan, low in Cambodia); and
- Land use policies, which may promote NMVs by concentrating residences and workplaces (e.g., Shanghai's traditional approach) or which may discourage NMV use by decentralizing cities (e.g., Shanghai's current approach of developing satellite towns).

CONCLUSION

Many of the factors affecting NMV use and ownership are interrelated. A few examples will suffice to illustrate this point:

- The affordability of NMVs is related to the availability of governmental policies providing low-interest loans and subsidies for the acquisition of NMVs.
- The attractiveness of NMVs is related to the extent to which governments provide good NMV facilities.
- The attractiveness of NMVs also depends on motorization rates, which in turn are related to tax levels among other factors.
- The safety of NMV use is related to the modal split of NMVs, which in turn is related to most other factors considered earlier.

Although there are many variables, no one factor is controlling. Instead, cities with relatively high NMV ownership and use are likely to exhibit a combination of favorable factors. Thus, for example, NMV-dependent Shanghai is a city with relatively low bicycle prices in relation to income, employer subsidies for the purchase of NMVs, relatively poor bus service and a low degree of motorization, a concentrated urban form (at least historically), a bicycle-friendly environment, relatively low risk of NMV theft, favorable social attitudes toward NMV use, and relatively flat terrain.

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The views presented in this paper and any errors remain the responsibility of the authors.

PART 4

Issues and Experience

Urban Transport Strategy for Cairo: Advice and Dissent

SLOBODAN MITRIC

Greater Cairo, Egypt, in the early 1980s suffered from severe traffic congestion, polluted air, and high accident rates. Its population was growing at the high annual rate of 4 percent, and car ownership was growing at 17 percent, but the great majority of daily trips (63 percent) were by public transport. The road system was only 60 percent paved and consisted mainly of ordinary streets with poor traffic control. Public transport vehicles, operated by Cairo Transport Authority, were the main victims of traffic congestion, in addition to other, internal sources of inefficiency. In response, an unusual urban transport program was initiated at that time, partially financed by the World Bank. It consisted of low-cost measures, for example, improved traffic management, selected road improvements, and greater productivity and cost recovery in public transport. A review of Cairo's experience since the mid-1980s reveals that the actions actually implemented in Cairo went in the opposite direction from the low-cost approach. For example, traffic management measures were minimal; cost recovery and efficiency in public transport, after initial improvements, actually decreased; and parking capacity was increased, but parking management was not. What has been done is a variety of large-scale investments, of which Cairo Metro is the most prominent, but considerable road building has also taken place. Four issues whose resolution would reduce the gap between action and technical advice are identified: the acceptance or otherwise of the inevitability of street traffic congestion in Cairo, the need to diversify travel markets, possible sources of finance for transport improvements, and institutional arrangements and capacity to undertake lower-cost methods.

The principal theme of this paper is the contrast between the strategy recommended in various transport studies for greater Cairo, Egypt, and the actions undertaken by the authorities.

The paper is organized as follows. The next (second) section of the paper summarizes urban transport problems in greater Cairo as diagnosed in the late 1970s and early 1980s through various studies carried out or commissioned by the Egyptian government (EG). The third section reviews the composition of and the experience with various projects undertaken in the 1980s by the EG or the three governorates comprising greater Cairo, or all of these. These include among others, the Cairo Metro, and urban transport elements of the Greater Cairo Urban Development Project (GCUDP) financed in part by the World Bank. The fourth section reviews current urban transport problems, plans, and proposals in this megacity, as reported in recent documents written by local officials and experts. The fifth and final section identifies the differences between the advice given and actions taken and develops a menu of key issues that would need to be discussed and ultimately resolved before significant improvements in urban transport in greater Cairo can be made.

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GREATER CAIRO URBAN TRANSPORT PROBLEMS AND PROPOSALS 10 YEARS AGO

In 1981 greater Cairo already had about 8.5 million people—possibly more—and was growing at an alarming rate of 4 percent a year (*1*). Much of the growth was the result of migration from rural areas where the population increase exceeded the capacity of the local economy to create jobs. The average gross population density was high at 40,000 people per square kilometer reaching 100,000 in some older Cairo districts. Egypt's gross national product was about $750 per capita, placing Egypt among the better-off of the low-income countries. An economic factor that affected urban transport in a major way was that the distribution of income and wealth left about 30 percent of all urban families under the poverty threshold (defined as $715/household/year in 1980 terms) (*1*).

Public transport, including taxis, was by far the major transport mode, carrying 63 percent of all trips and as much as 90 percent in thy peak hour (data probably coming out of a 1978 survey). Cars and motorcycles accounted for only 14 percent of all trips, and walking was surprisingly low at 23 percent. Data on car ownership are ambiguous, possibly because it is customary to quote the ratio of cars per 1,000 population, and various sources differ in their use of the denominator. The most consistent source gives 105,000 cars (including taxis) in 1973 (17 vehicles per 1,000 population) and about 400,000 cars in 1983 (43 vehicles per 1,000 population) (M. Daoud, unpublished data). Private car ownership was said to be increasing at 17 percent a year in the early 1980s (*1*). Travel by car was being stimulated through a fuel price subsidy, local prices at that time being 60 percent of the world price for gasoline, 12 percent for diesel.

Transport problems of Cairo residents included severe congestion (mapped into long delays and low moving speeds); high accident rates; extreme crowding in buses; bumpy rides and obstructed sidewalks; explosive mixture of people, parked cars, and moving vehicles in the same traffic lanes; and poor accessibility to any motorized mode of travel for some Cairo residents. The congestion and safety were critical in central Cairo, and accessibility to jobs and services was particularly low for residents of several lower-income districts.

Behind these problems lay an array of deficiencies on the supply side of urban transport. On the infrastructure side, these included the poor state of paved roads, particularly bus routes, with a high proportion (60 percent) of the road network without any surfacing and street lighting whatsoever. This last meant that neither public transport vehicles nor the household waste collectors could get into some of these areas; flooding also was a problem. On the traffic side, signal installations were few, of diverse makes, in poor mechanical and operational state, and widely disobeyed by drivers and pedestrians alike. Parking places were scarce, and parking habits chaotic, seriously reducing the capacity of the street system for the moving traffic.

Taking yet another step back along this cause-effect chain, the diagnoses mentioned a glaring absence of trained staff, facilities, and institutional arrangements for diverse engineering and other activities related to road traffic. On the local government side, the three governorates coresponsible for greater Cairo were understaffed; their pay scales were so low that they could not hire or retain technicians necessary to regulate and manage various urban service systems. The transfer of responsibility for urban projects and services from the EG (i.e., sectoral ministries) to the governorates had only recently started.

On the public transport side, Cairo Transport Authority (CTA) and its subsidiary, Greater Cairo Bus Company, had too small a service capacity for an urban area of this size and car ownership level. CTA's fleet had 2,300 buses in total, of which only about 70 percent on the average could be placed in service on an average day. Its operating environment—mixed traffic on city streets—was as difficult as that of anywhere in the world. CTA's operation was inefficient, overstaffed, and ill supplied with both maintenance equipment and facilities. Much of this state could be blamed on CTA's low ratio of fare revenue to total costs: under 40 percent (*1*). The loss was not sufficiently compensated by the EG: in 1979, operating subsidy was about 25 million Egyptian pounds (LE) ($35 million at the official rate), against the loss of LE 38 million. In the same year, a capital subsidy of about LE 27 million was also paid. A separately run streetcar line, Heliopolis Metro, provided a useful but limited-scope service from this well-to-do suburb to the downtown. Its operating speed was reasonable along the suburban part of the route, where it operated on a protected right-of-way, but it joined buses as a victim of congestion as soon as it approached the central area. Two Egyptian Railway lines entered the city, from the northeast and from the south but were not connected because of a 5-km missing link; the existing infrastructure and the rolling stock were in poor shape as well. One bright spot in this picture was provided by some 800 privately owned, shared taxis (really 12-seat minibuses), operating on pre-established routes.

Much of the diagnostic work was associated with various World Bank studies. To this view of the problem corresponded a recovery program also proposed by the World Bank, developed in the context of preparing GCUDP and the associated $59 million loan (*1,2*). This is not to say that there were no other propositions, but the bank strategy was the only one attempting to be comprehensive and spelled out in some detail. Its backbone was the proposition to adopt "a revised urban transport strategy that explicitly focuses on low-cost engineering and management measures, improve the efficiency of public transport, and to strengthen Government institutions thereby developing their management and planning capabilities and enhancing their capacity to undertake further urban development" (*1*,p. 10). The characteristics of the approach practiced until then by local authorities, which the bank team wished to revise, were not cited.

In accordance with the proposes strategy, GCUDP had the following urban transport components:

1. Traffic engineering and road maintenance component, a 4-year time slice of low-cost investments in road repair and resurfacing, traffic signals, and other intersection improvements, street lighting, two off-street parking garages, and road maintenance equipment; these accounted for about 50 percent of what the three governorates were expected to spend on road improvements. Geometric and signal improvements on radial corridors and in the central area were to be the key elements of this component. Full cost recovery for garages was to be adopted.
2. Traffic enforcement component, involving the rehabilitation of a traffic police training center, and the related equipment, including such things as motorcycles, radios, and tow trucks to improve the enforcement of traffic and parking regulations.
3. CTA component, including the construction or refurbishing of a bus overhaul workshop, or both, and a training center for drivers and mechanics. This was to be a part of a program under which CTA would replace its costs and increase its revenues from fares on the road to financial viability.
4. Institutional component, basically training, technical assistance, and studies for CTA and the governorates, including the traffic police.

It is of interest that, outside this project, the construction of Cairo Metro (Line 1) had already started in December 1981. This project involved the provision of the missing link between the Helwan and El Marg railway lines by constructing a tunnel through the downtown section, and the upgrading of the existing railway lines to metro standard. The entire line would on completion provide 42 km of continuous rapid transit service. Thus the World Bank–supported project could be seen as a counterpoint to the metro in that it was meant to demonstrate the effectiveness of low-cost means.

ACTIONS TAKEN IN PAST DECADE

Although an exhaustive list of what has been achieved in the past decade is not available, and it is not quite clear which of the implemented subprojects belonged to the original list adopted for GCUDP, the major achievements in the Fifth Plan period (1982 to 1987) were as follows (M. Daoud, unpublished data):

1. Some 34 large-scale structures were constructed, consisting mostly of elevated roads, viaducts (flyovers), and underpasses at major intersections.
2. About 760 km of roads and streets (8.4 million m^2) was paved, including the elevated roads, flyovers, and underpasses cited under the preceding item, in addition to another 2 million m^2 of paved roads within urban development projects.
3. Multistory garages were constructed at Ataba and Opera Squares, plus another six surface parking lots, increasing the parking capacity of the central area by more than 100 percent (to 67,000 vehicles per day).
4. About half of an estimated 72-km ring road around Cairo was constructed.
5. The CTA training center was refurbished and equipped, and the bus overhaul workshop was started (the construction should be finished as of this writing).
6. CTA received 820 new buses and the Greater Cairo Bus Company received 440 new buses. In addition, the CTA received about 500 minibuses to operate its own shared-taxi services. The available sources do not state what happened to private minibus operations.
7. Some 28 km of the Cairo Metro, Line 1, was completed and placed into service in 1987.

The remaining 14.5 km of the metro, Line 1, was completed and placed into service in 1989. The cost was about 5,368 million French francs, all inclusive (M. H. Salam, unpublished data). It is not clear whether these are current or constant francs; at roughly 6 francs per U.S. dollar, this amount is equivalent to about $895 million. In 1991, Cairo Metro carried about 703,000 passengers on an average day, with a peak day traffic at 845,000. In that same year, the metro had a revenue of LE 35.5 million.

The GCUDP experience has yet to be evaluated in detail. A perusal of documents from the last stages of the project indicated that the CTA component was implemented largely as envisaged, although with considerable delays; the financial viability remained an elusive goal, CTA's 1989 to 1990 deficit reaching LE 126 million of which only LE 61 million was compensated; the multistory garages were constructed, but it is not stated whether they are recovering their costs; some road paving and construction subprojects were implemented, but most were canceled; the central area traffic improvements program and a similar subproject on radial corridors were dropped at the tendering stage, when all plans and detailed designs were ready; traffic police training was carried out and enforcement equipment was purchased, but the practice of enforcement does not seem to have improved; and an attempt was made to introduce traffic management capability in the Cairo governorate, but the specialist staff left after the initial 2-year contract expired and no new effort was launched to rekindle this activity.

CURRENT PROBLEMS AND PROSPECTS

In urban transport professional circles in Cairo, it is commonly said that the investments mentioned earlier have improved the overall travel conditions in the urban area and that sizable costs savings and passenger benefits are associated with the operation of the Cairo Metro. There is, however, a dearth of quantitative indicators to back up this conclusion. For example, no data have been offered to show that CTA has improved its operating efficiency, or that travel times on the street network have been reduced, or that the safety record has become better. It is not clear whether any before-and-after studies actually have been conducted, not to mention more sophisticated with-project and without-project analyses. The few numbers available are not encouraging. For example, it appears that the average commercial speed of CTA buses is only 12 km/hr, not an improvement relative to the past. Nor does its cost recovery show a better trend. Still the considerable investments made over the last decade must have had visible results. It is likely that the average traffic and transport conditions in greater Cairo have not improved by much, except for those travelers living in corridors where the major road investments were located and those using the new metro. This whole matter needs to be examined closely. The space vacated on the existing system by users of new facilities may have been filled, or more than filled, by the hitherto repressed demand. The street congestion could actually be worse now than it was before the new projects. This of course does not preclude the existence of net benefits, since the transport system now carries a much higher volume of travel.

The data indicate that car ownership has continued to increase, reaching about 703,000 in 1987, or 66 vehicles per 1,000 population. This figure implies a population of about 11 million in 1987 and possibly as much as 13 million today. CTA now has about 3,200 buses in daily circulation (in two shifts), compared with about 1,700 in 1983. It is understood that the transport system now carries about 7.6 million trips on an average day; of this, about 5.2 million is carried by CTA and its subsidiaries (including the Heliopolis Metro), some 80 percent by standard buses (M. Daoud, unpublished data). This is about 25 percent more than was reported in 1982 (*1*). Cairo Metro reports an average daily usage in 1991 of 703,000 passengers, all of them either previous bus or train users or new passengers. This is implied by the absence of any automobile-related benefits in the available evaluation of metro impacts (M. H. Salam, unpublished data). The remaining 1.6 million presumably move by cars and taxis. It is not clear what happened to special company buses and the remaining private minibuses.

It is also of interest in this context to examine what is being proposed for urban transport in greater Cairo in terms of future projects and programs. Judging only from unpublished documents prepared for a recent, informal workshop in Cairo, the investment plans for public transport in coming years include the following:

1. Incremental investments to increase the capacity, improve the level of service, and increase safety on the existing (Line 1) of the metro;
2. The construction of Line 2 of the metro; its Phase 1 will be 11 km long (from the north to the city center) and is expected to cost about LE 2 billion in 1991 prices, of which 50 percent is in foreign currency;
3. About 300 standard buses per year for CTA and an additional 1,300 minibuses to create a fleet of 2,000; and
4. New garages for standard buses and minibuses.

To these should be added the completion of the remaining half of the Cairo ring road and additional road interchanges, underpasses, and multistory garages. Other ideas apparently not yet in the design stage include the reorientation of the bus network to serve metro stations and the rehabilitation of the existing tramway system and its extension in the new suburban developments on a protected right of way.

On the noninvestment front, proposals for consideration include the fragmentation of CTA into separate companies, with coordination provided by a head authority for Greater Cairo Transit; new fare policies for CTA to improve the cost recovery, and the encouragement of the private sector to enter the sector as a relief to the public sector.

ISSUES

The approach agreed to for GCUDP was essentially an application of a model urban transport strategy recommended by the World Bank for populous urban areas in developing countries. This strategy was first formulated in a publication entitled *Urban Transport*, published by the World Bank in 1976, and then restated and expanded in a new policy study under the same title, published in 1986 (*3*). The substance of that policy, marginally expanded and reinterpreted by this writer, amounts to the following principles:

1. Urban transport should be operated and expanded over time as a single system, the value of which is to be optimized from the point of view of city residents, but ensuring the reconciliation with demands for other urban services, under common resource constraints. This requires a unified institutional arrangement,

ideally an urban area government or agency, whose jurisdiction would include all aspects and functions of urban transport. The national government should not own or manage urban transport entities in any individual city.

2. The short-run policies and current investments (affecting the supply side) should ensure the maximum utilization and proper maintenance of presently available infrastructure and rolling stock, before the proposals for expanding the system are made and implemented. Allocation of street space to favor the more efficient transport modes (typically public transport) is the basic tool in this respect.

3. The demand for urban transport services should be managed, in contrast to catering to unconstrained traffic growth ("satisfying needs"); the key method of demand management is pricing driven by cost recovery objectives, although other types of restraints may be used. In urban public transport, this affects the fares policy; in the road sector, it calls for introducing user fees for moving and parked vehicles.

4. The full cost-recovery objective in urban public transport may be modified by other social concerns (affordability, socially preferred modal shifts), but fare subsidies and cross-subsidies should be applied selectively and efficiently.

5. The capital-intensive investments in roads and public transport systems should be the means of last resort, employed only after the measures to achieve the optimal use of the existing system have been taken. Such investments must pass stringent tests of economic and financial viability (cost-benefit and cost-effectiveness analyses). In Egypt, this principle would be difficult to apply. Habitual methods of project appraisal are based on the principle of "need satisfaction," where need is based on observed demand contaminated with distorted prices. This is also true of costs (e.g., subsidized fuel prices), and on the benefit side (e.g., the value of time).

6. The existence of public objectives and demands in urban transport should not be confused with either owning or operating urban transport services and infrastructures. Both public and private sectors have their strong and weak sides as providers of services. Generally, good results are achieved by introducing competition and other aspects of markets into urban transport, in terms of improved efficiency of transport operations, reduced costs of supporting functions, improved and better diversified transport services, or mobilization of the private investment capital.

7. Scarcity of resources is a permanent feature of life, not just a temporary setback caused by the current economic difficulties faced by a country. This requires a careful selection of projects and testing against other potential uses of public funds. It also requires that the planning decisions have taken the budget constraint in consideration and that project financial planning is a part of the investment decision process.

The account given in preceding sections of the Cairo experience is admittedly cursory, incomplete, and with big holes in the available data. Still, it suggests a clear pattern concerning the approach the authorities in greater Cairo have used in dealing with urban transport problems. If this perception is accurate, then there is a considerable divergence between what the governorates and the EG actually have done in the recent past in this sector (and evidently plan to continue doing) and the strategy implied in the objectives of GCUDP, recommended to the governorates by the World Bank.

It appears that the approach actually implemented in Cairo reaches first for the most intensive capital investment projects (the metro, elevated roads, viaducts), with only marginal improvements to the traffic and public transport that remain on ordinary city streets. Going through the items, one by one, it is possible to see the following in the Cairo experience: traffic management measures have been minimal; demand management through user charges does not exist; cost recovery in CTA, after initial improvements, actually decreased; parking capacity has been increased, but parking management has not; and there has been little opening toward the private sector. CTA adopted the concept of minibus services, which the private sector had first introduced in Cairo, but then seems to have pushed the private operators out.

The reasons for the divergence of the strategy adopted by the authorities and the advice received are complex. Some of them involve different perceptions of what the underlying urban transport problems actually are; others may involve different local and foreign assumptions on what the objectives are and who should be the beneficiary of public expenditures; yet others have to do with institutional capacity for continuous actions to improve system performance. A sociopolitical and institutional analysis of the extent of and the reasons for this divergence has not been done and would require considerable fieldwork, skills, resources, and local interest. The balance of this paper, therefore, takes a pragmatic approach, focusing on four issues whose resolution is of critical importance for the further development of urban transport in greater Cairo and would reduce the gap between action and advice. These critical issues include the perception that congestion is inevitable; travel market diversification; financial resources for transport improvements; and institutional aspects.

Inevitability of Congestion and Large-Scale Projects

It is often said by local transport planners that in greater Cairo "surface solution to the public transport demand was not possible, as the surface roads had become overloaded," a conclusion used to justify the construction of the underground railway and (possibly) elevated highways. The trouble with this statement is that it implies that the overcrowding of the street system is inevitable, when this in fact is not the case. Roads in Cairo account for about 25 percent of the total area, which is quite good. Unfortunately, many streets are not paved or are not maintained. Even those that are in a reasonable shape have a great part of their capacity wasted on such factors as chaotic parking, incursion of pedestrians, unruly traffic behavior, and poor signals. Moreover, there is probably more driving than is necessary because fuels are not economically priced and road use is free. Finally, road use is equally available to private cars, which carry few people, and buses and tramways, which carry many more.

The consequences of accepting the inevitability of congestion have been grave and will continue to plague greater Cairo. To start with, the unmanaged congestion tends to send a wrong signal to the decision makers, who then place higher priority than is necessary on system expansion (even if it is just a question of timing of new projects). This does not mean that Cairo did not need to expand its off-street infrastructure, including the Cairo Metro, but that something else should have been done first to improve the operation of the street system that was already there. It is highly likely that both the scope and timing of the large civil works could have been somewhat reduced or postponed, or both, with considerable savings for the state/governorate budgets. Instead, there seems to be an official acceptance of permanent on-street congestion. However much one would expand the system through new construction, however, there is a high chance that the existing street system would stay as congested, or even more so. Trip rates in Cairo indicate substantial suppressed demand for travel, thus any diversion of travelers from the ordinary streets to new primary roads is quickly followed by new trips hitherto suppressed. It is doubtful whether the city or state budget would have the capacity to invest enough to stay ahead of the new traffic generation. Even if it did, this would probably mean that some other needs will have gone unmet because Egypt is not a rich country.

The permanent congestion of city streets has three major negative consequences. The first one is that on-street public transport vehicles cannot achieve an efficient level of operations (that is, low unit costs per seat offered) and that their services are kept at a low level. Needless to say, this affects some 85 percent of all public transport users, the metro notwithstanding (at the current modal split). The second negative impact is that the permanent congestion means permanent environmental degradation in terms of noise, emissions, and safety. The third aspect is that permanent congestion affects poor people more than others because they tend either to use street buses or aspire to use them when their financial capacity improves; they also tend to be heavily represented among pedestrians, thus their suffering from congestion is disproportional.

In conclusion, heavy investment cannot be a substitute for managing traffic on regular (rather than limited-access) urban roads and streets. Among the many efficient ways of doing this are of course the allocation of street space for exclusive use of public transport vehicles, the priority of passage at intersections for buses and tramways, delay-minimizing traffic control systems, and parking charges and enforcement.

Travel Market Diversification

The travel market in greater Cairo consists of at least three distinct groups: higher-income people, usually car owners; the lower-income group, who tend to be pedestrians or bus users; and the middle group, who use buses or the metro, or both. The car drivers benefit from investments in new roads and bridges. The lower-income people are served by inexpensive but low-quality bus services (possibly also metro services). It is not clear whether the middle group is well served. The middle group benefits by paying fares meant to be affordable to the poor, but they get a lower quality of service than many of them would want and could pay for. From the public budget point of view, they get an unwanted subsidy. This group would profit from having higher-priced, but better-quality, services; for example, seat-only buses operating on a reserved-space street itinerary. Experience in other countries indicates that this type of service is best provided by the private sector, working under concession or other arrangement with the local government, typically without subsidy. The most successful of such cases of recent vintage are private bus companies in Casablanca and Rabat, Morocco, where a seat-only, private bus fleet within 2 years became comparable in size to the regular, public operation (*4*). Cairo's experience with private minibuses went in this direction, and some of its advantages may have been preserved even in the CTA minibus operation.

Financial Resources

Until now the financing of urban transport in Cairo has been based on a limited contribution by public transport users, with fares being kept low (or free) to make the system affordable to poorer city residents or some special categories of travelers, or both. The cost recovery from fares has slipped to about 20 percent. The corresponding subsidy from the budget has never been fully paid, which of course hampered the maintenance and expansion of the public transport infrastructure and vehicles. It is the capacity of the state budget, rather than the passengers' capacity and willingness to pay that affects the performance and expansion of the public transport system. Road users also are being subsidized. Although Cairo roads appear to have received more attention than public transport, for roads also the limits to expansion have been determined by constraints on the state budget, not user choice. It could be hypothesized that roads in Cairo might have expanded faster if a system of user charges were linked directly to operating and investment budget of a transport agency.

It is not at all clear how long the current approach to transport financing can continue. There are signs that the process of government decentralization will speed up and, with it, some kind of self-financing of urban services may be inevitable. There are many persuasive reasons why goods and services whose impact is local should be paid for from local sources, among them the simplest principle that costs should fall where the benefits accrue (*5*). It is prudent to start thinking of the financial issues related to decentralization beforehand. In the context of GCUDP, the financial focus was to reduce operating costs and increase fare revenues. Neither of these efforts has borne fruit and will have to be revisited and retried by some other means. There is concern that the question of efficiency in supplying services does not seem to be a priority for transport operators in greater Cairo. It is rare to find any technical paper on the subject of the metro and CTA that addresses operating costs or standard efficiency indicators of the two operators. What is being mentioned is the level of subsidy necessary and (sometimes) the revenues. As for fares, there is a possibility that they have been unnecessarily chained to too low levels. For one thing, the linkage between poverty and transport has never been studied in Cairo. For another, there are ways to provide direct assistance to the poor without adversely affecting the financial state of public transport operators.

If cost recovery in public transport has been problematic in Cairo, road user charges have not been considered at all. This topic is under increasing attention in many cities of the world, in rich and less rich countries alike, often because urban authorities have come to realize that charging for roads has a double role (as already cited): to discipline the demand (thus moderating negative effects of congestion) and to provide funds for maintenance, traffic control, and capacity expansion. The simplest charging systems are usually countrywide, that is, ownership-based fees or use-related fees (gas taxes), or both; these are typically collected by the national government and either fused with general taxes or earmarked and redistributed throughout the country on the basis of some allocation formula. Fuel taxes can affect the general level of automobile use but cannot be used for demand management in individual cities. Of more interest in this matter are local charges related to the time and place of use for moving or parked cars, sometimes called congestion charges. Fuel taxes are widely used, whereas congestion charges are only now getting increasing attention. Several cities in Northern Europe currently are testing such charges, having given up hope that road and transit investments and low transit fares will do the trick (e.g., Oslo, Trondheim, and Bergen, Norway; and Stockholm, Sweden). These follow the early successful example of downtown entry fees in Singapore in the 1970s and the planned, but never implemented, Hong Kong experiment with electronic road use charges. Several variations on both concept and method of collection and control are available. Recent comparative studies indicate that area licensing schemes with human controllers are the most suitable as a congestion-reducing method, especially in countries where labor costs are low. Although the economic theory frowns at earmarking of thus generated funds for investing back into the road system, it is felt that in the case of urban road traffic a compromise can be made because earmarking makes the onerous aspects of yet another use tax more palatable to the population (*6*).

It is opportune to mention again the private sector participation when discussing financial issues in urban transport. In industrialized countries that recently went through major deregulation of bus services (e.g., the United Kingdom), the objective has been to profit from greater efficiency of supply that private enterprises bring (mainly lower unit costs per bus-kilometer or per passenger, or both). Reportedly this has helped reduce by half the level of public subsidies in some cities. In a developing country such as Egypt, greater efficiency and a reduction of subsidies would also be important objectives, but there are others. Foremost among these concerns is the private investment capital that private operators would bring into the bus and tramway operation. This capital could provide great relief to the capital budget of the governorates, especially in view of the backlog of investments in CTA. The already-cited case of Casablanca and Rabat provides a host of useful lessons and should be studied in detail by Cairo planners (*4*). If foreign participation were also involved, there could be additional benefits (on both the cost and effectiveness side of the ledger) from technology transfer, that is, from the introduction of up-to-date expertise in traffic operations, maintenance, fare systems and collection, cost accounting and control, inventory management, and information systems. It would be regrettable if the governorates allowed the CTA to squeeze out the private minibus operations, a self-installed and subsidy-free alternative provider of services.

Institutional Issues

Three different themes are covered under the heading of institutional issues. The first one touches on the capacity of an urban government, such as the Cairo governorate, to start doing traffic management. GCUDP failed in its objective to develop this capacity because the governorates appear to have preferred to go for the large investments instead. It is interesting to look into reasons for this failure. This type of failure is not unique; it has been very difficult to achieve success in many, if not most, developing countries. The city of Tunis is one of the rare exceptions, with a competent and active traffic unit in the municipality of Tunis since the late 1970s. On the other hand, such units are commonplace in the industrialized countries. The paradox is that low-cost methods are easy to apply in rich countries, whereas poor countries are reduced to large-scale investments to achieve similar results. One of the reasons is that traffic management methods are very staff intensive. In some cases, particularly in many African countries, there are simply no trained technicians to do the job. In Cairo there are technicians galore, but they tend to avoid public service, because of its low pay scales. The problem could be resolved in the same way as for any other large undertaking by contracting out.

Another hypothesis is that local governments do not place value on low-cost methods, since neither prestige, nor power, nor financial remuneration can be associated with them. In other words, the Cairo governorate agreed to set up a traffic management unit in the context of GCUDP but did not have a real commitment to this activity and let it fall by the wayside. Recent literature points to a need to do a new kind of institutional analysis that would look at the structure of the administrative authority and the motivation and incentives of the civil servants involved in implementing a given program. The results of this analysis would be used to correct the program's design accordingly (*7*).

The second institutional issue is the need to unify the responsibility for all elements of an urban transport system in the hands of one authority. The situation in greater Cairo is particularly complicated because of the presence of three governorates, the national government, strong ministries, and some strong public enterprises. The continuing fragmentation of responsibilities for urban transport among different tiers of government is problematic from the point of view of establishing priorities and coordinating policies and investments. The community of interest, the distribution of political power, the fiscal environment, and the scope of decision making for a city government are quite different from that of a ministry, or a large, single-purpose public enterprise (such as the CTA, for example). These differences can lead directly to misallocation of investments within a given sector, as it may have happened in urban transport in greater Cairo. Moreover, in the system of split jurisdictions, it is very difficult, if not impossible, to make intersectoral trade-offs for a given city, for example, between investments in water resources and investments in transport. This has been recognized by some officials in the sector and it will be worthwhile to look into alternative administrative arrangements for a unified jurisdiction, a real Cairo Transport Authority this time—not just a name.

The last institutional issue mentioned here concerns the role of the state. In Egypt, the state is very strong in every aspect of urban transport and presents a barrier to the creation of a unified urban transport authority in the urban area. With the progressive decentralization and increased resource mobilization on the local level, this influence will weaken although it will not disappear. It is of interest to consider a possible future role of the state in the area of urban transport finance, once it stops paying massive subsidies. In is essential not to confuse partial financing of urban transport projects, which the state may want to do under certain conditions, with project ownership, which should be left to the city (governorate) level. A view consistent with the public finance theory is that local investments, whose impacts will be local only, should come primarily from local equity funds. This is based not only on the principle that costs should fall where the benefits accrue; the decision to commit local funds is a good measure of the "true" value of a project to the city in question. Numerous projects get implemented only because it means getting state investment funds, that is, a free project. It could be envisaged, particularly in a transition period away from the state ownership of local projects, that the city would own an urban transport project and provide equity funds for it, while the state would participate in its partial financing through a national program of matching grants, loans, or loan guarantees. The financial aid program of the state should be designed with explicit policy objectives, eligibility rules, and procedural guidelines. In Egypt, such a program could be used to stimulate greater Cairo or Alexandria to follow urban transport policies deemed beneficial to society, or to follow model planning practices. For example, no Egyptian city would become eligible for financial aid from the state unless it implemented a program of environmental protection, traffic law enforcement, or measures that would give priority to public transport vehicles in street traffic (e.g., exclusive bus lanes or priority passage at signalized intersections). Valuable examples of this approach are the agreements (''development contracts'') that the authorities of individual French cities sign with their national government (*8*) and a capital grants program for urban public transport investments run by the U.S. Department of Transportation (*9*).

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Bicycling and Transportation Demand Management

TODD LITMAN

The means by which bicycle promotion can be incorporated into transportation demand management (TDM) programs are examined. Bicycle transportation benefits are reviewed with respect to various transportation improvement goals, including reducing traffic congestion, alleviating air pollution, reducing parking demand, decreasing user costs, conserving energy, creating mobility for nondrivers, promoting health, and sustaining urban development. The potential of bicycling as a transportation mode is considered. Potential problems associated with increased bicycling and bicycle encouragement programs are examined. Specific bicycle transportation encouragement strategies are discussed and guidelines are provided for incorporating bicycling into TDM programs. Most conclusions also apply to walking as a means of transportation.

There are two general approaches to reducing traffic congestion and related transport problems. Road capacity can be increased, or existing capacity can be used more efficiently by reducing travel demand. This second strategy is often cheaper, especially when total benefits and costs are considered, and is used increasingly under the name transportation demand management or TDM. Bicycling compares well when measured by TDM goals, but bicycle transportation is often undersupported in TDM programs because the decision-making process does not effectively optimize investments on the basis of multiple criteria and because many planners are unfamiliar with cost-effective bicycle encouragement strategies.

This paper examines two questions. First, the optimal level of investment in bicycle encouragement is explored on the basis of estimates of total savings. Second, strategies for encouraging bicycle transportation are considered, focusing on those that are most cost-effective. Most conclusions in this paper also apply to walking as a means of transportation.

BICYCLE TRANSPORTATION BENEFITS

Traffic congestion, air pollution, and parking capacity are the primary justifications for TDM programs, although other goals may be recognized or implicit, including user cost savings, energy conservation, increased mobility for disadvantaged populations, reduced municipal costs, and encouragement of more efficient land use patterns. Ideally, transportation improvements are evaluated by taking into account all potential benefits and costs. Recent studies provide estimates of total motor vehicle costs, including external and nonmarket costs. These estimates are used here to calculate potential savings for a shift from driving to bicycling for a typical 4-km (2.5 mi) trip under three road conditions: urban peak, urban off-peak, and rural trip.

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Congestion

The social cost of traffic congestion is the additional travel time required by road users, plus increased vehicle operating costs, stress, and air pollution caused by stop-and-go driving. The potential congestion reduction and travel time savings resulting from a shift from single-occupant vehicle (SOV) travel to bicycling depends on the specific circumstances. For analysis of bicycle congestion impacts, traffic conditions are divided into the following four classes:

1. *Uncongested roads or separated paths.* Bicycling on an uncongested road or path contributes little or nothing to traffic congestion and delays.
2. *Congested roads with space for bicyclists.* Bicycling on the road shoulder (common on highways), the curb lane (common in suburban areas and newer urban streets), or a designated bike lane contributes little to traffic congestion except at intersections and driveways where other vehicles' turning and lane shifting maneuvers may be delayed.
3. *Narrow, congested roads with low-speed traffic.* Bicycling on a narrow, congested road when the rider can safely keep up with traffic (common in urban traffic averaging 25 km/hr or less) probably contributes slightly less to congestion than an average car because of a bicycle's smaller size.
4. *Narrow, congested roads with moderate- to high-speed traffic.* Bicycling on a narrow, congested road when the rider is unable to keep up with traffic can contribute to traffic congestion, depending on how easily faster vehicles can pass.

Congestion is reduced when automobile drivers shift to bicycling under the first three condition classes. Only under the last condition class would a shift from driving to bicycling fail to reduce congestion. This probably represents a minor portion of bicycle transport mileage because most bicyclists avoid riding under such conditions.

Congestion costs are highest for urban peak period trips, whereas little or no congestion costs are associated with off-peak and rural driving. Typical cost estimates for urban peak-period driving range from \$0.03 to 0.15/vehicle-km (*1–4*). For this analysis a \$0.09/km midpoint cost is used and bicycles are assumed to contribute one-ninth the congestion of a typical automobile, for an average savings of \$0.08/km. A shift from driving to bicycling is estimated here to provide a congestion cost savings of \$0.32/4-km urban peak period trip, and \$0.03/urban off-peak trip. No congestion benefit is assumed for rural travel.

Pollution

Bicycling produces virtually no air or noise pollution. Air pollution savings are even greater than would be expected on a mileage basis because bicycling usually replaces short automobile trips, for which internal combustion engines have their highest emission rates because of cold starts. Thus, each 1 percent of automobile travel replaced by bicycling decreases motor vehicle air pollution emissions by 2 to 4 percent (*5*).

Several estimates have been made of automobile air pollution costs, with average values ranging from slightly under $0.01 to $0.28/vehicle-km in southern California (*1,2,4,6*). A conservative estimate is $0.05/km for urban peak driving, $0.03 for urban off-peak driving, and $0.01 for rural driving. Because motor vehicle emissions are higher for short trips as a result of cold starts, potential air pollution cost savings are doubled, yielding $0.40/urban peak trip, $0.24/urban off-peak trip, and $0.08 per rural trip.

Estimates of noise costs range from $0.001 to $0.025/vehicle-km and vary depending on location and type of vehicle (*2,4,6,7*). Marginal noise costs are greatest on residential streets, where an increase of a few hundred vehicles per day can significantly reduce property values (*8*). Because bicycling tends to replace driving on these noise-sensitive streets, a reasonable value is $0.02/urban trip and $0.01/rural trip.

Parking

Parking is a major cost of automobile use and a major subsidy to driving. A total of 80 percent of commuters and an even greater portion of shoppers use free parking (*9*). Typical urban parking facility cost estimates range from $50 to $100/month (*4,9,10*), or about $2.00 to $4.00/day. Bicycle parking costs less. Up to 20 bicycles can be stored in the space required for one automobile, and bicycles are often parked in otherwise unused areas. Bicycle lockers cost about $500 each, but free bicycle lockers are uncommon.

Parking cost savings for drivers shifting to bicycling are estimated here at $1.50/urban peak trip ($3.00/day for commuter parking), $0.25/urban off-peak trip (short-term parking for shopping and errands), and $0.05/rural trip.

User Costs

User cost savings are an assumed benefit of most transportation improvements, although not always a stated goal of TDM programs. Bicycles are inexpensive to operate, typically costing much less than driving. Since most bicycles and automobile costs are fixed, actual savings depend on specific circumstances. People who already own both an automobile and a suitably equipped bicycle save the difference in variable costs. If increased bicycling allows a household to own fewer or less-expensive cars, greater savings can be enjoyed.

Travel time is another significant user cost. Although door-to-door travel times are similar for bicycles and motor vehicles for some trips, bicycling is generally assumed to be slower than driving, which implies increased user costs. However, many people enjoy bicycling and appreciate its aerobic exercise. Until research quantifies these additional costs and benefits any additional travel time as a result of bicycling is not considered a cost.

Variable automobile operating costs average about $0.06/km (*11*), with 50 percent higher costs for peak period urban driving caused by stop-and-go conditions. Costs per kilometer are double for the short trips replaced by bicycling because of high fuel and maintenance costs from cold starts. Variable bicycling costs are estimated at $0.01/km. Savings are estimated at $0.60/urban peak trip, and $0.40/urban off-peak or rural trip. Greater savings are possible when bicycling allows a household to own fewer or cheaper cars.

Road Maintenance

Vehicle road wear costs are a function of vehicle weight and, in some regions, studded tire use. Automobile accidents damage signs, lighting, and other roadway facilities. Bicycles impose virtually no road damage.

Estimates of road damage costs from automobiles range from $0.001 to $0.028/km, with higher costs in urban areas (where maintenance costs are high) and for vehicles with studded tires, and much greater costs for heavy vehicles (*2,4,6*). A reasonable estimate is $0.02/trip for urban driving and $0.01/trip for rural driving.

Energy Conservation

Bicycles require virtually no petroleum products to operate. Their energy source is food calories, which most North Americans have in abundance. As with air pollution, potential energy savings are even greater than might be expected because bicycling replaces short trips for which automobile engines are least efficient because of cold starts (*1*).

A variety of studies attempt to quantify the external benefits of energy conservation (*4,12,13*), resulting in estimated average costs of $0.006 to $0.03/vehicle-km, with actual costs varying on the basis of vehicle type and driving conditions. Because cold starts, affect a vehicle's efficiency, benefits are double for the short trips typical of bicycling, yielding savings of $0.12/urban peak trip, $0.10/urban off-peak trip, and $0.08/rural trip.

Additional Environmental and Social Benefits

Automobile use and ''automobile dependency'' cause or contribute to several additional problems: suburban sprawl (*14*), degradation of urban neighborhood social networks (*15*), reduced residential property values (*8*), and decreased mobility for nondrivers (*16,17*). Each of these imposes its own set of costs. For example, sprawl increases service costs for utilities, emergency services, and school transportation; imposes environmental impacts; and increases long-term transportation costs (*14,18*).

It is difficult to quantify bicycling benefits with respect to these additional costs, but a rough minimum estimate can be made for some of these impacts using transit subsidies as a benchmark. In 1991 U.S. public transit service received an average subsidy of $1.14/trip (*19*). The American Public Transit Association lists 10 justifications for these subsidies, including three that were already considered (reduced traffic congestion, air pollution, and energy consumption) and four that do not necessarily apply to bicycling (greater retail sales, creation of jobs, safety, and increased productivity from existing transit investments). Three other benefits apply to bicycling: rational urban development, mobility for nondrivers, and mobility during crises. Although more research is needed to develop better estimates of the various costs and benefits of different transportation modes, it seems reasonable to recognize the potential of increased bicycling to discourage urban sprawl, and to provide mobility to nondrivers, as representing at least 20 percent ($0.23/trip) of the subsidy currently provided transit service.

Total Potential Benefits

Table 1 summarizes the potential benefits of a shift from driving to bicycling for a 4-km (2.5-mi) trip under urban peak, urban off-peak, and rural conditions.

Calculating Optimum Bicycle Encouragement Investments

Using these estimates, the following formula can be used to determine the maximum investment justified for TDM programs that achieve a shift from SOV travel to bicycling:

Optimal investment/year = (savings/trip × modal shift)/year

Table 2 presents the maximum bicycle program funding for each 1 percent shift from driving to bicycling in a hypothetical urban or suburban community with 10,000 commuter and 35,000 noncommuter trips each day, on the basis of estimated savings in Table 1. In this case up to $160,500 could be spent for each percent of commute trips, and up to $165,000 for each percent of noncommute trips shifted from driving to bicycling.

BICYCLE TRANSPORTATION POTENTIAL

Current and Potential Use

A 1993 report for the National Bicycling and Walking Study published by the U.S. Department of Transportation estimates that bicyclists ride 9.6 to 35.5 billion km (5.8 to 21.3 billion mi) annually in the United States, representing 0.28 to 1 percent of total passenger vehicle mileage (*5*). About half of this bicycling displaces a motor vehicle trip; the other half is recreational. Approximately 0.4 percent of U.S. commute trips are made by bicycle (*20*), and a 1990 Harris survey indicates that about 2.6 percent of adults sometimes commute by bicycle (*21*). Levels of bicycle use vary significantly between communities; more than 5 percent of trips are made by bicycle in several North American cities, including Palo Alto, California; Madison, Wisconsin; Boulder, Colorado; and Eugene, Oregon (*22*). The high levels of bicycling in such geographically diverse communities and lower levels in geographically similar areas indicate that community attitudes and transport policies are more important than geography or climate in determining bicycle use.

Various estimates have been made of potential bicycle use in North America. Two-thirds of U.S. urban trips are shorter than 8 km (5 mi), distances suitable for bicycling (*23*). According to the 1990 Harris survey, 17 percent of adults would sometimes bicycle commute if secure storage and changing facilities were available, 18 percent would bicycle commute if employers offered financial incentives, and 20 percent would bicycle commute if they could ride on safe bike lanes (*21*). The National Bicycling and Walking study estimates that U.S. bicycle use could increase 3 to 5 times by the year 2000 (*5*). According to one estimate, 22 percent of SOV commute trips (13.7 percent of commutes) in the Chicago urban area could shift to bicycling, and the city of Chicago has set an official goal to shift 10 percent of commutes under 5 mi to bicycling by the year 2000 (*24*). Even higher levels of bicycling are possible in some communities. Cities in several developed countries, including the Netherlands, Denmark, Germany, and Japan, actively encourage bicycle transportation, and bicycles are used for more than 20 percent of all trips. Thus, increases of 2 to 10 times appear feasible in typical communities using moderate incentives and investments.

TABLE 1 Estimated Total Per-Trip Savings of Shift from Driving to Bicycling

	Urban Peak (commuting)	Urban Off-Peak	Rural
Congestion	$0.32	$0.03	$0.0
Air Pollution	0.40	0.24	0.08
Noise	0.02	0.02	0.01
Parking	1.50	0.25	0.05
User Costs	0.60	0.40	0.40
Road Maintenance	0.02	0.02	0.01
External Energy Costs	0.12	0.10	0.08
Environmental & Social	0.23	0.23	0.23
Total	**$3.21**	**$1.29**	**$0.86**

TABLE 2 Maximum Funding per 1 Percent Modal Shift for Hypothetical Bicycle Encouragement Program

	Commute Trips	Non-Commute Trips
Trips per day	20,000	35,000
Days per year	250	365
Savings per trip	$3.21	$1.29
Calculation	20,000 x 250 x 3.21 x .01	35,000 x 365 x 1.29 x .01
Totals	**$160,500**	**$165,000**

Barriers to Increased Bicycle Transportation

It is sometimes argued that North Americans love cars too much to embrace other modes such as transit and bicycling, but the evidence contradicts this. North Americans respond to incentives, such as fuel and parking prices, as readily as other people. Shoup and Willson have found that "cashing out" free parking (i.e., giving commuters the option of receiving cash in place of free parking) motivates about 20 percent of SOV commuters to use other modes (*9*). Similarly, each 1 percent long-run increase in real fuel prices reduces driving by approximately 0.5 percent (*25*). High levels of automobile use in the United States can be explained by low fuel prices, free parking, and decades of transport and land use patterns oriented toward automobile use, rather than by a cultural precondition. The success of some TDM programs demonstrates that travel patterns can change with appropriate incentives. The following are considered barriers to increased bicycling safety, roadway bottlenecks, and cultural and institutional biases.

Safety

The risk of accident is often cited as a deterrent to increased bicycle transportation, although the actual risk for responsible adult bicyclists is uncertain. Reliable bicycle travel data are not available so accident risk can only be estimated. After comparing 1990 U.S.-reported bicycle fatalities with various bicycle mileage estimates, a study by the Human Powered Transport Subcommittee of ASCE concluded that the best guess per-mile bicyclist fatality rate was 4 to 4.5 times the rate for non-Interstate motorists, with a range of estimates from 2.3 and 11.6 times (M. Elliott, ASCE Human Powered Transportation Subcommittee Chair). The total health risk from bicycling is less than these estimates indicate for several reasons (*5*):

- Bicycles pose a minimal risk to other road users;
- Bicyclists tend to travel shorter distances than motor vehicles, so the per trip risk is low;
- Bicycle transport encourages land use and lifestyle patterns that reduce travel distances compared with automobile dependency (*5,14*); and
- Bicycling offers significant health benefits. Hillman estimates that the aerobic exercise of bicycling compensates accident risk by 20 to 1 in average life expectancy (*26*).

Changes in bicyclist behavior could reduce current bicycle accident risk. Bicyclists committed one or more traffic errors in 66 percent of fatal bicycle accidents (*27*). Nearly 20 percent of bicyclists killed had blood alcohol contents of 0.01 g/dl or greater, and 16 percent were considered intoxicated. The ASCE study concluded that a combination of increased helmet use, bicyclist education, improved night lighting, and education of motorists regarding bicycling could have reduced the 1990 bicyclist fatality rate per mile by two-thirds (see Table 3), to between 0.8 and 3.9 times that of non-Interstate motorists, with a best guess of 1.3 to 1.5. Roadway improvements for bicycle safety could further reduce risk. U.S. bicyclist fatalities decreased 16 percent in 1991 and 1992, despite reported increases in adult bicycling, indicating a trend toward reduced bicycle accident risk. Increased helmet use is considered a significant contributor toward this reduction in bicyclist fatalities and indicates a comparable reduction in brain injuries.

A responsible adult bicyclist who follows traffic rules and wears a helmet is estimated to have an accident fatality rate per mile between one and two times that of non-Interstate automobile occupants, a fatality rate per trip approximately equal to that of non-Interstate automobile occupants and poses a minimal accident risk to other road users, resulting in a reduction in overall fatalities compared with motor vehicle driving. Considering these factors, there is no evidence that shifting travel from driving to bicycling by responsible adults causes significant increases in total road fatalities; bicycling need not be considered a public health risk, especially if safety education and facility improvements are provided.

TABLE 3 Strategies for Reducing Bicycle Fatalities

	Potential Fatality Reduction
Teaching riders to avoid common mistakes.	50% or more
Helmet use.	40% to 50%.
Eliminating intoxicated bicyclists (28).	16%
Eliminate intoxicated automobile drivers (26).	16%
Enforcing nighttime lighting requirements.	10% or more
Teaching motorists to share the road with bicyclists.	5% or more
Infrastructure improvements.	Unknown

Risk factors overlap and are therefore not cumulative.

Roadway Bottlenecks

Various conditions can create problems for bicyclists riding on the roadway system. These include narrow roads with high-speed traffic, and surface irregularities such as cracks, potholes, and rough railroad crossings. Even if no bicycle accidents are reported (and many bicycle accidents are not reported to authorities), there may be an unmet demand for bicycling. Bottlenecks are especially discouraging to bicycling on corridors where there are no alternatives to heavy traffic arterials or highways. Several strategies can reduce such problems, including bicycle maps to provide information on alternative routes, spot improvements to eliminate specific hazards, improved road shoulders, bicycle education to help bicyclists learn to deal with road hazards, bicycle lanes, and separated bicycle paths. Solutions are necessarily situation specific, and most communities require a combination of techniques to improve their bicycling environment.

Lack of separated paths is not necessarily a deterrent to bicycle transportation. The importance and benefits of separated bicycle facilities is controversial among bicycle planners (*22,29,30*). The majority of bicycle mileage takes place on public roads, even in areas with bicycle path systems. This is especially true of transportation bicycling, which is destination specific, as opposed to recreation cycling for which riders can choose a route that is enjoyable, easy, and safe for bicycling.

Cultural and Institutional Biases

Bicycles traditionally have been considered a child's toy and a transportation mode of last resort in North America. In recent years this stigma has been balanced by an increase in adult bicycling. Much of this is recreational riding, but a growing number of adults are bicycling for transportation, at least occasionally (*21*). Several factors contribute to this trend: desire for aerobic exercise, environmental concern, and increased choices in adult bicycle designs. Although some people in North America still consider bicycling an inferior travel mode, one can no longer assume that most adults have this opinion.

Bicycling has been undersupported by transportation agencies and professionals for several decades. In many cases bicycling is not counted or is underreported in travel surveys (*31*). Bicycle planning is given little or no attention in North American traffic engineering curricula (*32*). Bicycle projects are ineligible for many transportation funds. Many decision makers argue that bicycle use must increase before more resources can be invested in bicycle programs, creating a chicken-and-egg quandary. These institutional barriers must be overcome before bicycle transport can achieve its full potential.

Bicycling in Current TDM Programs

Some TDM programs focus on just a few options, such as transit, ride sharing, and flex time and fail to include bicycling, but this is less common as TDM programs become more sophisticated. Even if it is not specifically mentioned, bicycling can be encouraged by general TDM activities such as increased automobile parking fees and enforcement, financial incentives ("transportation allowances" that replace parking subsidies, thus providing a cash benefit to commuters who do not use a parking space), guaranteed ride home (a free or subsidized taxi ride for employees who use alternative commute modes, an emergency service that in practice is seldom used), flextime, contests, and public recognition for commuters who do not drive alone.

Many TDM programs do include specific bicycle encouragement features. A total of 45 percent of employers participating in Southern California's commute trip reduction program provide bike racks for employee use, and 26 percent provide shower and locker facilities (*33*). Only 30 percent of these employers offer financial incentives for bicycle commuting, lower than the 68 percent for transit riders, and 41 percent for carpooling, or the 32 percent for walkers. A 1991 survey of transportation management associations indicated that 17 out of 52 provided racks, lockers, or showers for bicyclists (*34*). A study in Pima County, Arizona, indicated that employers who provide showers for bicyclists are more likely to meet their commute trip reduction goals than employers who do not (*35*). The Washington State Commute Trip Reduction program gives nonmotorized modes (bicycling, walking, telecommuting, and modified work week) 20 percent extra credit over motorized mode because of their minimal environmental and social costs (*36*). Initial experience indicates that TDM programs can encourage bicycling, but success varies widely and more work is needed to identify effective incentives (*33,35,37*). In some cases, bicycle encouragement under TDM programs may be simply token efforts that are selected for their low cost and provide little real benefit to bicyclists or society.

BICYCLE TRANSPORTATION ENCOURAGEMENT STRATEGIES

During the past decade many transportation agencies have developed bicycle plans that usually cover a broad range of recreational and transportation bicycling goals. TDM bicycle programs are more focused, emphasizing cost-effective techniques that encourage a shift from driving to bicycling for transportation purposes. The following techniques are considered effective (*37*).

General Commute Trip Reduction Incentives

Commute trip reduction (CTR) programs usually include various incentives and disincentives to discourage SOV commuting and may include specific trip reduction goals. Effective CTR techniques include increased parking fees and enforcement, financial incentives, alternative mode information, flextime, guaranteed ride home, contests and prizes, recognition in company newsletters, and other benefits to employees who do not drive alone to work (*33,35*).

Encouragement Programs

Encouragement programs consist of endorsements, company policies, information, and activities that support bicycle commuting. Some employers and communities have bicycle advisory committees to promote and help accommodate bicycling. Contests in which bicyclists compete for prizes and awards by riding the most often or the most mileage in their class are a popular way to promote bicycle transportation. These may be sponsored or endorsed by bicycle clubs, private organizations, local governments, and employers.

Bicycle Safety Education and Enforcement

A safety program that offers basic bicycle skill training, encourages helmet use, targets bicyclists' nighttime lighting and driving while intoxicated law enforcement, and educates motorists on how to safely share the road with bicyclists can reduce accident risk. Employers, bicycle clubs, and other private organizations can distribute bicycle safety information and sponsor bicycle safety activities. Bicycle safety programs are most effective at the community level, especially if they involve law enforcement officials. A variety of bicycle safety resources are available from organizations given in Table 4.

Bicycle Maps

A map that highlights preferred bicycle routes can encourage bicycle transportation, especially beginning riders. Bicycle maps often include reference and safety information.

Multimodal Connections

Bicycling and transit are complementary modes. Bicycling is ideal for making short trips in low traffic areas, whereas transit is most efficient on longer trips on congested corridors (*38*). Bicycles are widely used to access transit stations in many parts of the world. Such intermodal bicycle trips can be encouraged by providing secure bicycle storage at transit stations and park-and-ride lots, by allowing bicycles to be carried on buses and trains, and by promoting bicycling along with other efficient modes.

Bicycle Parking and Showers

High-quality bicycle parking is important for bicycle transportation. Long-term parking must keep valuable bicycles and accessories safe from theft and protected from weather. Convenient short-term parking is important near commercial areas. Many bicyclists refuse to use poorly designed racks that place pressure on bicycle wheels rather than the frame. Many bicycle commuters need showers and clothes lockers, especially those who must wear professional clothes, or who ride long distances in hot, humid, or rainy climates. Minimum bicycle parking requirements have been added to zoning requirements in several communities.

Roadway Improvements

Some bicycle improvements are relatively small and inexpensive. These include pothole filling, paving short stretches of road shoulder, installing curb cuts, paving short paths, and smoothing rail-

TABLE 4 Sources of Bicycle Encouragement and Planning Resources

Name	Address	Types of Resources
American Association of State Highway and Transportation Officials (AASHTO)	444 N. Capitol St. NW, #225 Washington DC 20001 (202) 624-5800	Publishes Guide to the Development of Bicycle Facilities ($11).
Association for Commuter Transportation	1518 K St. NW, #503 Washington, DC 20005 (202) 393-3497	Produces publications, information and conferences to support TDM programs.
Bicycle Federation of America	1818 R St. NW Washington D.C. 20009 (202) 463-6622	Publications and resources for bicycle planning professionals.
Bicycle Forum	P.O. Box 8308 Missoula, MT 59807 (406) 721-1776	Produces and distributes a variety of bicycle planning and safety literature.
Institute for Transportation and Development Policy (ITDP)	611 Broadway, #616 New York, NY 10012 (212) 260-8144	Provides international bicycle transportation resources and encouragement.
Campaign for New Transportation Priorities	900 2nd Street NE, #308 Washington, DC 20002 (202) 408-8362	Provides legislative and program support for efficient transportation.
League of American Wheelmen (LAW)	190 Ostend St., #120 Baltimore, MD 21230 (301) 539-3399	Provides support for bicycle advocacy and planning and event promotion.
U.S. Federal Highway Administration, Bicycle-Pedestrian Program Office	HEP-50, 400 7th St. SW Washington DC 20590 (202) 366-5007	Federal information, National Bicycling and Walking Study

road crossings. Bicycle spot improvement programs encourage bicyclists to identify potential improvements and provide funding mechanisms for quick implementation (*39*).

Bicycle Lanes and Paths

Well-designed paths (Class 1 facilities) such as those converted from railroad rights-of-way have proven popular and can encourage bicycle commuting if appropriately located. The Burke-Gilman trail system in Seattle averages over 2,000 bicycle commuters each day, and has more than repaid its construction costs by reducing demand on public automobile parking. Communities such as Davis, California, and Eugene, Oregon, have achieved high levels of bicycle transportation by developing an extensive network of paths and on-street bicycle lanes. However, a poorly designed or maintained bicycle facility is often more dangerous than none at all (*31*).

Bicycle lanes (Class 2 facilities) or wide and smooth road shoulders or curb lanes are usually the most cost-effective strategy for encouraging bicycle transportation because these facilities can be added to existing roads with relatively low cost (*29*). In rural and suburban areas bike-wide shoulders can be specified whenever roads are improved in addition to special bicycle projects. In urban areas, bicycle lanes often can be developed without any construction costs by removing parallel parking.

SOURCES OF INFORMATION

Bicycle information and resources have developed rapidly over the last decade. Useful information is now available on bicycle planning, program development, safety education, facility design, incentives, and equipment availability. Transportation professionals should be skeptical of material that is more than 4 or 5 years old and that is not endorsed by an established engineering or bicycle planning organization. Table 4 presents organizations that provide current bicycle program information and resources.

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Bicycle Ownership and Use in Amsterdam

M. J. H. BECK AND L. H. IMMERS

A study was undertaken to provide a better understanding of the constraints that hinder bicycle ownership and use and to propose measures and incentives that may help to promote the use of bicycles. In 1991, 3,000 inhabitants of the Amsterdam conurbation were interviewed about their ownership and use of a bicycle. Some of the main results of the survey are as follows. A total of 77 percent of the people interviewed own a bicycle. The main reasons for not owning one are hazardous traffic conditions, bicycle theft, and the availability of other means of transport. A total of 44 percent of all inhabitants use a bicycle on a regular basis; 33 percent own a bicycle but rarely or never use it. The main reasons for not using a bicycle are high risk of bicycle theft, long distances, absence of luggage-carrying facilities, and a lack of comfort.

Since the 1950s there has been a tremendous increase in people's mobility. This is mainly because of a greater mobility by car. High mileage gives rise to many negative effects. Harmful exhaust emissions create environmental problems, and parked and moving cars cause congested streets. In various government reports (*1–3*) and the *Draft Traffic and Transport Plan* (*4*), the question of a "sustainable society" is discussed as a criterion for the policy to be implemented. Environmental problems caused by traffic and transport must be tackled. The bicycle can play a more significant role in this policy.

Since 1960 the number of trips by bicycle in Amsterdam has halved every 15 years [from 300,000 to 70,000 in the evening rush hour (*4*)]. The reasons for this decrease include the enormous rise in the number of people who own a car and the constant increase in the distance between home and workplace. This development does not mean that the role of the bicycle in the future should be dismissed. In a city environment such as Amsterdam, a bicycle can offer a good alternative means of transport, especially to a car, mainly because of its speed and excellent ability to penetrate traffic.

In a report by the Physical Planning Department, or DRO (*5*), the possible increase in bicycle use in Amsterdam was estimated on the basis of objective constraints. With the constraints used (bicycle ownership, distance, and age), it was not possible to indicate the true scale of the possible increase in bicycle use. This led to DRO being commissioned to carry out this follow-up study.

AIM

The aim of the follow-up study is to provide a better understanding of the constraints that hinder the use of bicycles within the Amsterdam conurbation and the measures that may promote their use. This makes a positive contribution to the traffic and transport policy as specified previously (*1–4,6*).

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ORGANIZATION OF STUDY

The starting point for determining the constraints that hinder bicycle use is the individual. The constraints include the motive for traveling by bicycle (very much determined by the activity routine of the individual), the place of residence, and the possession or otherwise of a bicycle, a car, or a public transport season ticket. Once the constraints have been established, judgments can be made about the package of measures that can be implemented to promote bicycle ownership and use.

To gain a better understanding of the constraints identified, a telephone survey was conducted of 3,000 inhabitants aged 12 and over of the Amsterdam conurbation (the conurbation includes Amsterdam, Amstelveen, Badhoevedorp, Diemen, Duivendrecht, and Ouderkerk on the Amstel). The survey was divided into the following:

- Questions about bicycle ownership;
- Questions about bicycle use broken down per motive for traveling;
- Questions about proposed measures to promote bicycle use;
- Questions about the attitude of the person interviewed toward bicycles; and
- General background questions (age, income, composition of the household, main activities, and postal code of the place of residence).

The survey was conducted between October and December 1991 by the Amsterdam Bureau of Research and Statistics. The results of the survey were scaled up for the whole conurbation.

The order of this paper is based on the order of the questions in the survey. The next section describes bicycle ownership within the conurbation, whereas the following section looks at bicycle use. Then the reasons for using a bicycle or not are described and broken down per motive. A variety of motives for traveling are identified elsewhere (*7*). This paper will concentrate on the home-to-work motive; the most notable results of the other motives will be briefly presented. Besides the home-work motive, the following motives for traveling have been identified: home-school or study, home-shopping, and home-leisure.

A more detailed account can be found in the main report (*7*).

BICYCLE OWNERSHIP

The conurbation has been divided into four areas to provide a good description of the differences in bicycle ownership in the various parts of the conurbation (Figure 1). Each of these areas comprises a number of districts that are based on the existing living conditions and the period in which the areas were built. The areas are the city center (District A), the prewar area (Districts C through M), the outskirts (Districts N through T), and the neigh-

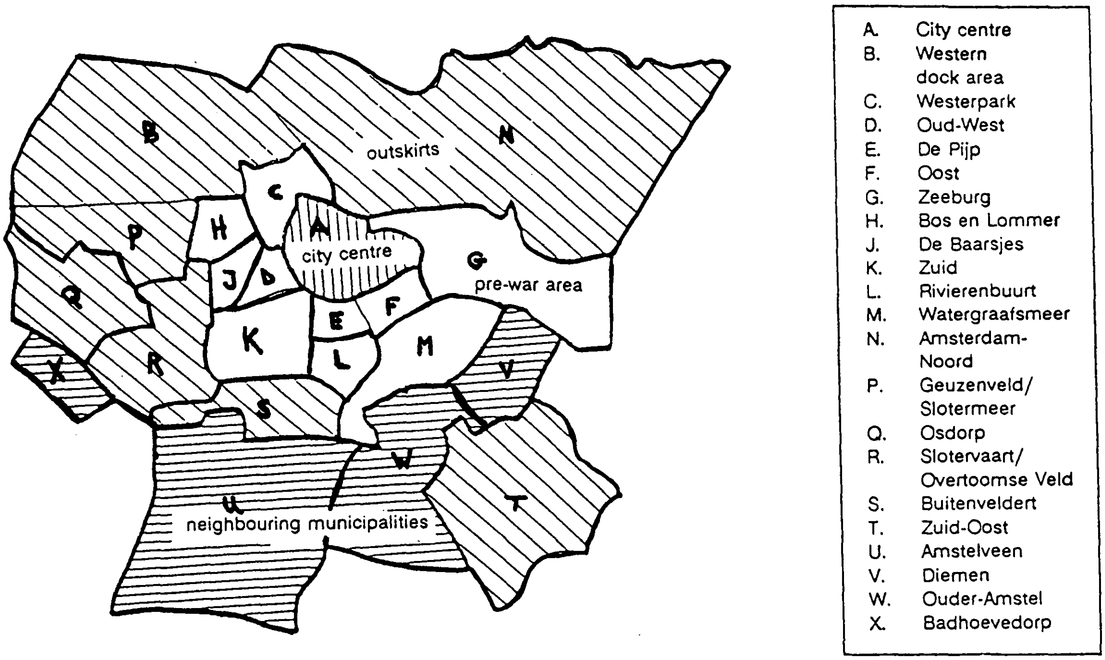

FIGURE 1 Division of conurbation into areas

boring municipalities (Amstelveen, Diemen, Ouder Amstel, and Badhoevedorp).

Description

About three-quarters of the inhabitants of the conurbation own a bicycle. However, the percentage of ownership varies somewhat if the different areas are considered individually. A look at the four areas (Table 1) identified will show the following about bicycle ownership: that bicycle ownership in the districts Zeeburg, Bos en Lommer, and Rivierenbuurt is low compared with the average in the prewar districts. The survey indicates that bicycle ownership increases in line with the standard of education, income, car ownership, and possession of a driving license. The older the respondent, the less likely he or she is to own a bicycle.

Reasons for Not Owning a Bicycle

A significant proportion (23 percent) of the inhabitants of the conurbation does not own a bicycle. To be able to indicate whether

TABLE 1 Bicycle Ownership per Area

	Bicycle ownership
city centre	82%
pre-war districts	73%
outskirts	77%
neighbouring municipalities	86%
conurbation	77%

this proportion can be reduced, the reasons for not owning a bicycle were explored. As part of the survey these people were presented with a number of possible reasons for not owning a bicycle. At the same time they were asked to indicate the two main reasons (of all the reasons presented) for not owning a bicycle. The following reasons were presented to the respondents:

A. I cannot ride a bicycle.
B. I do not like cycling.
C. I think the risk of theft is too high where I live.
D. I think the risk of theft is too high in general.
E. I do not need a bicycle.
F. I think is is hazardous to cycle in traffic.
G. A bicycle is too expensive.
H. I am not allowed to cycle for health reasons.
I. Other reason (including do not know/no opinion).

The main reasons for not owning a bicycle are represented in Figure 2. The percentages indicate how often a particular reason was given as one of the main reasons. The total percentage is 100 percent. If 5 percent is indicated for one particular reason (e.g., health), this means that health was given by 10 percent of people as being one of the two main reasons.

The main reason for not owning a bicycle appears to be that it is hazardous to cycle in traffic (Reason F). Theft (Reasons C and D), not needing a bicycle (Reason E), and reasons other than the ones given (Reason I) also appear to play a major role. The study reveals that bicycle theft has reached alarming proportions. Every year 40 percent of all bicycles in the Amsterdam conurbation are stolen, that is, about 256,000 bicycles annually.

There are, however, fairly large differences in the reasons given for not owning a bicycle where the place of residence of the respondents is taken into consideration. To illustrate this point, by far the main reason given by people living in Amsterdam city

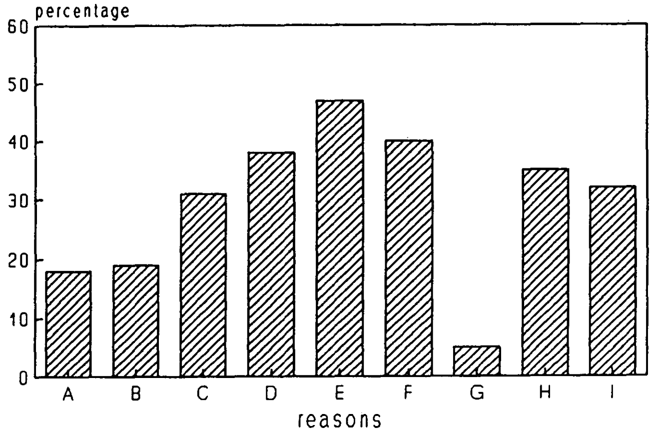

FIGURE 2 Reasons for not owning a bicycle.

center and in the neighboring municipalities is that they do not need a bicycle. In the city center and in the prewar districts, theft from the home environment is much more common than in the neighboring municipalities and on the outskirts. Theft in general (Reason D) is considered much more significant in the two outer areas then theft from the home environment (Reason C), whereas in the inner areas the converse is true.

BICYCLE USE

The most important part of the survey is the questions about whether people use their bicycles. In this part of the survey, people were asked which means of transport they used. In addition, bicycle owners were asked their reasons for not choosing to use their bicycle.

The inhabitants of the conurbation are divided into two groups: a group of cyclists and a group of noncyclists. The cyclists all own a bicycle and use it for at least one motive. The noncyclists never cycle no matter what the motive. The fact that people are classified as noncyclists does not mean that they do not own a bicycle; many of them do but never use it. Just over half (56 percent) of the inhabitants of the conurbation are classified as noncyclists and hence never cycle. The others (44 percent) do cycle. The previous section explored bicycle ownership and discussed the distribution of bicycle ownership over the different areas. The distribution of bicycle use over the different areas will now be examined. Table 2 indicates the proportions of the inhabitants of the Amsterdam conurbation who actually use a bicycle. To encourage more people to cycle, those people who do not cycle

TABLE 2 Cyclists and Noncyclists per Area

	cyclists	non-cyclists	
		with bicycle	without bicycle
city centre	63%	19%	18%
pre-war districts	48%	25%	27%
outskirts	34%	43%	23%
neighbouring municipalities	43%	43%	14%
conurbation	44%	33%	23%

TABLE 3 Absolute Numbers of Noncyclists per Area

		non-cyclists	
	all	with bicycle	without bicycle
city centre	26,500	13,500	13,000
pre-war districts	155,000	74,000	81,000
outskirts	164,500	106,000	58,500
neighbouring municipalities	56,500	42,500	14,000
conurbation	402,500	236,000	166,500

must be considered, and these are shown in the table as well. A distinction is made between cyclists and noncyclists. Table 2 also shows that although the proportion of bicycle use is highest in the city center, 19 percent of the inhabitants there own a bicycle but never use it. On the outskirts and in the neighboring municipalities, 43 percent of the population own a bicycle but do not use it. Bicycle use in the neighboring municipalities is, nevertheless, markedly higher than it is in the outskirts. The proportion of people who do not own a bicycle is highest in the prewar districts, as Table 1 has already indicated. The proportion of noncyclists is highest in the Bos en Lommer district where 72 percent of the population do not cycle. In absolute terms, the numbers of noncyclists are distributed over the areas as shown in Table 3. This table indicates that many people do not cycle in the prewar districts and on the outskirts. Implementation of the right measures might show that the highest absolute growth in bicycle use can be achieved there. It seems easier to encourage people who already own a bicycle to use it than to make people go out and buy a bicycle. The outskirts would then have a tremendous growth potential. Two-thirds of noncyclists there already own a bicycle.

Reasons for Using a Bicycle

If the respondents indicated that they made a particular trip by bicycle, they were asked to give a reason for this. This was done in the same way as with the reasons for not owning a bicycle. A number of reasons were given, and the respondent was asked to indicate whether the reason played no role, played a role at all, or even played a major role in using a bicycle. The following reasons were given:

a. It is faster by bicycle.
b. With a bicycle you do not have to queue in traffic.
c. With a bicycle you do not have any parking problems.
d. It is better for your health to use a bicycle.
e. It is good for the environment.
f. It is cheaper.
g. With a bicycle you do not have to depend on public transport.
h. I only own a bicycle.
i. Other reason.

With regard to the "leisure" motive, another reason was given:

j. If I use my bicycle I can drink alcohol.

As was the case when indicating the reasons for not owning a bicycle, the respondents were asked to name the two main reasons for using a bicycle (Figure 3). In most cases the main reason is that a bicycle is faster (Reason a) or that you do not have to depend on public transport if you use a bicycle (Reason g).

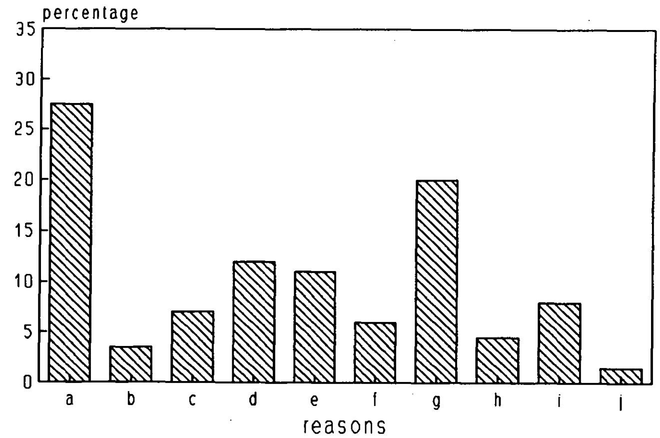

FIGURE 3 Main reasons for using a bicycle.

In the city center the speed factor (Reason a) and not having to depend on public transport (Reason g) emerge as the two main reasons, with the first reason playing a much more important role than the second. Of the four areas, the lack of parking problems (Reason c) is mentioned most often in the city center. This might also explain why a bicycle is faster than a car in the city center since the traveling time by car includes the time needed to find a parking place. On the outskirts and in the neighboring municipalities the speed factor (Reason a) and not having to depend on public transport (Reason g) are also mentioned but much less often than in the other areas. The reason given that cycling is good for your health (Reason d) also plays an important role in the two outer areas.

Reasons for Not Using a Bicycle

One-third of inhabitants own a bicycle but never use it. If a particular trip was not made by bicycle, the respondents were asked why the bicycle was not used. A number of reasons were given for each motive for traveling and the respondents had to indicate whether the reason played no role, a significant role, or a major role.

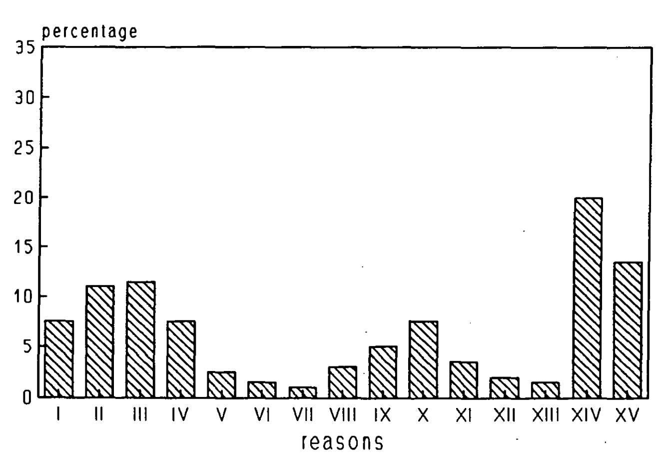

FIGURE 4 Main reasons for not using a bicycle.

TABLE 4 Choice of Means of Transport per Motive for Traveling (Bicycle Owners)

	home-work	home-study	shopping	leisure
bicycle	38%	58%	25%	25%
car	36%	4%	30%	41%
public transport	18%	33%	21%	19%
on foot	5%	4%	22%	11%

The following reasons were given:

I. It is slower by bicycle.
II. A bicycle is uncomfortable.
III. I cannot carry any bags on a bicycle.
IV. There is a risk that the bicycle will be stolen from the destination.
V. It is dangerous or unsafe on a bicycle.
VI. The surface of the cycling route is poor.
VII. The cycling route is bad; I would have to make a detour.
VIII. The cycling route is socially unsafe (e.g., for women cycling alone).
IX. With the car/public transport I can combine various rides.
X. With the car/public transport I can travel with other people.
XI. I have a car/public transport season ticket.
XII. I can travel with someone by car.
XIII. I think it is nicer.
XIV. It is too far to cycle.
XV. Other reason.

Reasons XII and XIII were put only to people who traveled by car and not to those people who used public transport. Figure 4 indicates the main reasons for not using a bicycle. The main reason mentioned is that the distance is too far (Reason XIV). However, no major differences are noted if a distinction is made in the place where people live. Furthermore, the absence of luggage-carrying facilities on a bicycle (Reason III), the lack of comfort (Reason II), and the risk of bicycle theft (Reason IV) are major factors in the decision not to use a bicycle. Hazardous traffic conditions (Reason V) and the quality of the route (in terms of the surface and the need to make a detour) (Reasons VI and VII) are of minor importance. One notable aspect is that the possession of a public transport season ticket is a more likely reason for not cycling than is having access to a car.

BICYCLE USE PER MOTIVE FOR TRAVELING

The survey asked a number of questions per motive. Four motives were examined; home-work, home-school, shopping, and leisure. In the case of the home-work and home-study motives, respondents were asked how they normally traveled. With regard to the shopping and leisure motives, they were asked about the last time they made a trip of this kind. Respondents were asked about the reasons for cycling, or otherwise, for each motive. In addition, a few questions specific to particular motives were asked.

Table 4 shows that there are substantial differences per motive with regard to the bicycle percentages in the modal split. Possible reasons for this are discussed. In general it can be stated that, independent of the motive, the distance to be traveled is given as the main reason for not cycling.

TABLE 5 Reimbursement of Traveling Expenses and Choice of Means of Transport by Employed People

	km allowance	only public transport costs reimbursed if used	public transport season ticket	none
car	57%	24%	25%	30%
public transport	19%	44%	37%	10%
bicycle	18%	27%	31%	48%
on foot	1%	2%	1%	7%
% employed people reimbursed	37%	26%	15%	22%

Home-Work Motive

Some 350,000 inhabitants of the conurbation, aged 12 and over, state in the survey that they are in paid employment or do voluntary work. This is about 50 percent of all of the inhabitants of the conurbation aged 12 and over. With regard to the home-work motive, besides the distance involved, comfort (or more accurately the lack of it), speed, and the lack of luggage-carrying facilities are given as reasons for not cycling to work.

The survey asked a few questions specific to this motive concerning such things as reimbursement of traveling expenses, parking facilities, and storage facilities for bicycles. These questions were put only to bicycle owners. The effect of these factors on bicycle use will be examined. Whether or not traveling expenses are reimbursed has a major effect on bicycle use. If a traveling allowance is provided, bicycle use drops sharply.

It can be seen in Table 5 that a kilometer allowance encourages people to travel by car. If public transport costs are reimbursed or a season ticket is provided, car use appears to decrease. If traveling expenses are not reimbursed, car and bicycle use is higher. To make a large number of people travel by bicycle, therefore, no traveling expenses should be reimbursed.

As expected, car parking facilities affect the means of transport chosen (Table 6). It appears that the poorer the parking facilities are, the fewer the number of people who drive to work. The parking facilities for employed people are as follows: 50 percent can park their car at no charge on the company's premises; 22 percent also have adequate free parking facilities, albeit on the public highway; 28 percent have inadequate free parking facilities at their workplace. This last group can be divided into two: 6 percent do have inadequate free parking facilities but can pay to park their car; for 22 percent parking facilities are totally inadequate, paid or otherwise.

If parking facilities are poor, the use of bicycles and public transport increases and the use of cars decreases. With distances shorter than 5.5 km, bicycle use in particular increases, whereas with distances longer than 5.5 km, the use of public transport increases. However, even where long distances are involved, almost 25 percent of people travel by bicycle if parking facilities are totally inadequate.

The different storage facilities for bicycles do not have the expected effect on the modal split. The survey reveals that in places where good storage facilities are available, bicycle use is low, and vice versa. However, it is often companies in areas on the outskirts of the conurbation that provide good storage facilities. The distance to be cycled is therefore too far in many cases to make the bicycle a viable alternative. Moreover, these areas can be reached easily by car. With regard to the converse effect, the city center and the prewar districts in particular have poor storage facilities for bicycles. The distance to be cycled is reasonable in these areas, but the risk of theft hinders bicycle use.

Other Motives for Traveling

Ownership and use of a bicycle by students and school pupils (11 percent of the people interviewed were school pupils or students) are higher than average. Bicycles are owned by 91 percent, and the bicycle accounts for 58 percent in the modal split (see Table 4). The main reasons for not cycling therefore apply to a limited group.

Pupils and students indicate that the possession of a public transport season ticket is a reason not to cycle to school or place of study. Thanks to the Student Grants Act, 70 percent of people who travel for this motive have a student's season ticket. This group of travelers accounts for a high proportion of public transport use, which is at the expense of bicycle use in particular (because car use already is particularly low among this group).

Shopping can be roughly split into two categories: daily shopping and occasional shopping (e.g., to buy clothes, gifts, books, and recordings). In the survey, people were asked about shopping trips for occasional purchases.

TABLE 6 Parking Facilities at Workplace and Choice of Means of Transport by Employed People

	adequate		inadequate	
	own premises	public highway	adequate paid facilities	totally inadequate facilities
car	49%	42%	22%	15%
public transport	18%	12%	20%	23%
bicycle	27%	35%	48%	50%
on foot	3%	6%	4%	7%

Shoppers choose not to cycle because of the problems associated with carrying bags on a bicycle. In addition, lack of comfort, the wish to travel with several people, and the risk of shopping area theft all contribute to a choice of transport other than the bicycle.

Another factor that affects the choice of means of transport is car parking facilities (as with the home-work motive). The survey revealed that on the outskirts and in the neighboring municipalities many people travel by car, even when the storage facilities for bicycles are just as good and people live less than 5.5 km from the shopping area. This is largely explained by the fact that the shopping areas here are more accessible by car as a result of them being opened up and having more-than-adequate parking facilities. The poorer the parking facilities (city center, prewar districts), the fewer the number of people who travel by car and the greater the use of bicycles or public transport. The survey asked what people last did in their leisure time. A number of options were presented: playing a sport, going out (theater, cinema, restaurant), visiting a museum, walking, cycling, or visiting friends or family. The social nature of trips for pleasure means that traveling with more than one person is an important reason for not cycling.

CONCLUSION

Three out of four inhabitants of the Amsterdam conurbation aged 12 and over have a bicycle. It follows that one out of four does not. Why not? The main reason given is hazardous traffic conditions. In addition, people feel that they do not need a bicycle or that the risk of theft is too high.

Only 57 percent of all bicycle owners actually use their bicycles. The main reasons for using a bicycle are the fact that it is faster to cycle, one is not dependent on public transport, it is good for one's health, and there are fewer (car) parking problems.

One-third of inhabitants own a bicycle but never use it. Furthermore, those bicycle owners who do use their bicycles do not use them for every motive mentioned. The main reason given for not using a bicycle is that the distance to be traveled is too far.

With regard to the home-work motive, besides the distance involved, comfort (or the lack of it), speed, and the absence of luggage-carrying facilities are given as reasons for not cycling to work. The survey also revealed that in the case of the home-work motive, fewer people than average choose to travel by bicycle, whereas bicycle ownership is higher than average.

Restrictions on the accessibility to a destination by car will positively affect the choice to travel by bicycle. For pupils and students, the possession of a public transport season ticket, in addition to the distance involved, is the reason for not cycling to school or university.

Like commuters, shoppers attribute their choice not to cycle to the absence of luggage-carrying facilities and the lack of comfort.

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Nonrecreational Cycling in Ottawa, Canada

DAPHNE HOPE

Ottawa, the capital of Canada, is better known for its recreational pathways than for its "other" bicycle facilities. In truth, the approximately 140 km of recreational pathways are not "bikeways" in the sense of dedicated bicycle pathways. Instead they are multiuse pathways that attract joggers, pedestrians, in-line skaters, and cyclists in large numbers. Recreational cyclists are well served by these facilities. In the past 4 years, there has been a significant shift toward examining the nature of and design for nonrecreational cyclists. Several surveys have revealed interesting data on the commuter cyclist as well as established a background of information on the demographic profile of cyclists in the area. A 1992 report by the Ottawa Cycling Advisory Group, a citizens committee advising the Department of Engineering and Works, is being used in the preparation of a plan to provide a system for utilitarian cyclists. All aspects of cycle planning will be addressed: from route design to parking provisions through zoning. An interim policy that establishes the number of bicycle parking spaces to be provided at all city buildings and facilities has been approved. In addition, several actual projects have been initiated to further encourage and support nonrecreational cycling. The Ottawa police have maintained a police bicycle squad for the past 3 years, and the city of Ottawa purchased bicycles for the use of parking control officers as a pilot project in 1993. In addition, the Regional Municipality of Ottawa-Carleton has run a program of "blue bikes" for 2 years. These bicycles are available to staff for use on corporation business. Specific development projects, such as the rebuilding of bridges, have been reviewed with the intent to incorporate bicycle facilities into the design. All of these components—research, planning, and implementation of pilot projects—have served to provide a basis for information and to support the use of bicycles for nonrecreational purposes. The completion of Ottawa's Comprehensive Cycling Plan and the implementation of the recommendations contained therein will put Ottawa back on the map, not only for recreational cycling but also for nonrecreational cycling.

Ottawa, the capital of Canada, is better known for its recreational pathways (bike paths) than for its other bicycle facilities. Recent initiatives, of both policy and design nature, are changing this reputation. These initiatives have established the important role of nonrecreational cycling in the transportation system.

The recreational pathways for which Ottawa is best known were built by the National Capital Commission (NCC) during the early 1970s as bike paths. At that time, concern over the depletion of our nonrenewable energy sources as well as a general environmental sentiment prompted much pathway development in both Canada and the United States. The pathways today provide approximately 140 km of recreational facilities for a multitude of different users. They are truly multiuse in the sense that not only recreational cyclists travel on them but many commuter cyclists as well as pedestrians, joggers, and in-line skaters use these them.

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The shift in emphasis from providing strictly recreational facilities toward providing facilities for utilitarian cycling has come partly in response to the congestion that was occurring on these pathways. As cycling has increased in popularity, so too has the number of people who are turning to the bicycle as a means of transportation. This increase has caused cycle advocates and politicians to review official policies with the intent of providing greater support for cycling. In the past 4 years, there has been a significant shift toward examining the needs of nonrecreational cyclists and designing better facilities for this sector of the transportation system.

POLICY DOCUMENTS

The importance given to the growth of nonrecreational cycling is reflected in the policy documents that have paved the way for projects. The Official Plan for the Regional Municipality of Ottawa-Carleton (RMOC), approved in 1988, contains one objective relating to energy conservation in the transportation system and two policies. The policies recognize cycling as a means of transportation not only on existing and proposed roadways, but also within transitway and utility corridors. This recognition is conditional on the feasibility of adapting such facilities to safely accommodate bicycles. In addition, a system of major bicycle corridors was identified on a schedule for use in the review of development applications.

The official plan for the city of Ottawa, approved by the council in July 1991 and currently awaiting approval by RMOC, places a strong emphasis on the protection of the quality of life in the urban environment. A number of "cycle-friendly" policies are included to encourage the use of bicycles as an alternative to the automobile. These policies appear throughout the document, reinforcing the message that planning for cycling is an integrated process.

Within this framework, Ottawa and RMOC have initiated actions to make the region as well known for nonrecreational cycling as it is for recreational cycling.

CYCLIST SURVEYS

Ottawa has long been known as the cycling capital of Canada. Claims that the city has the highest per capita cycling population have been substantiated by two recent surveys. These surveys have provided much-needed information on the number of residents who cycle (utilitarian and recreational), general characteristics of cyclists, frequency, times and distance of trip, cycling experience (number of years cycling), safety precautions, and route preferences.

The Ottawa-Carleton cyclist profile survey was carried out in September 1991 by consultants with the assistance of the Regional Cycling Advisory Group and RMOC. The consultants placed approximately 5,400 telephone calls and conducted 930 interviews. Information on the cycling frequency and destination and purpose of the trip was obtained for approximately 2,300 persons through proxy.

The objective of the survey was to develop a profile of cycling and provide insights into cycling characteristics and opinions about cycling. For the purposes of this survey, a "commuter" cyclist was considered to be any person who cycles to work or school twice or more a week. The population of Ottawa-Carleton (urban portion) was assumed to be 589,600. A summary of the findings identified the following:

- Approximately one-half of the population is composed of cyclists, with 10 percent being commuter cyclists (in actual figures 230,000 cyclists with approximately 47,000 commuter cyclists);
- Approximately 80,000 daily cycling trips are made for nonrecreational purposes;
- Approximately 2 percent of the population had combined the use of a bicycle and public transit (bus). Responses indicated that more people would be inclined to adopt this mixed-mode transportation if safe and secure bicycle parking were provided; and
- Among the measures that would encourage more frequent cycling, enhanced facilities (on-street bicycle lanes), cyclist training, and bicycle parking all were noted as high priority.

Earlier that same year, in June 1991, a survey of commuter cyclists was conducted during Bike to Work Week with the assistance of the Ottawa Cycling Advisory Group and Citizens for Safe Cycling. The survey was administered to a random sample of 2,000 commuter cyclists representing a cross section of the geographic area within RMOC. The response rate was very high; 1,786 respondents completed the questionaire. The findings are contained in a report (*1*).

Highlights from Commuter Cycling in Ottawa-Carleton—a Survey (*1*) indicate the following:

- One-third of commuter cyclists are 40 years or older;
- 60 percent of all commuter cyclists have been cycle commuting for 5 years or less;
- From May through September, more than half of all commuter cyclists ride to work 11 days or more per month; more than 40 percent ride to work 16 days or more per month;
- A total of 75 percent of all commuter cyclists spend no more than 30 min riding to work;
- 95 percent of commuter cyclists have a driver's license, and almost 75 percent have access to a motor vehicle to get to work, yet they choose to go by bike;
- One-third of commuter cyclists use major roads for more than half of their commuting trip; one-third never use recreational pathways; and
- Approximately two-thirds of commuter cyclists list health and fitness as their primary reasons for cycle commuting; other reasons include convenience, economic reasons, environmental considerations, and pleasure.

Other questions elicited responses on preferences for improvements to the existing system to encourage cycling. Among the suggestions were

- Create bicycle-only routes,
- Improve maintenance,
- Connect different bicycle routes,
- Widen curb lanes,
- Reduce motor vehicle volumes,
- Improve bicycle parking,
- Install bicycle lights,
- Educate motorists and cyclists, and
- Provide rapid transit park and ride stations.

CONSTRUCTION OF BICYCLE FACILITIES

The city of Ottawa and RMOC have taken the following initiatives that build on the recommendations coming out of these surveys. Where consultants are employed, direction is given to consult with the cycling interest groups at the beginning of the project.

- One of these initiatives is the reconstruction of the Mackenzie King Bridge, which crosses the Rideau Canal. The bridge platform currently carries two lanes of transit plus four lanes for other motorized vehicles. The proposed redesign was arrived at through extensive consultation with users and focus groups. The result is a cross section that incorporates a wide median, two dedicated bicycle lanes, two lanes for transit, and two lanes for other motor vehicles. Effectively, two lanes that previously were used by automobiles are being given over to cycles.
- The core of Ottawa's downtown—Rideau Street—has undergone several facelifts in the past decade. The first major change was the establishment of a transit mall. Dedicated transit lanes, glass canopies, and a completely enclosed sidewalk area was hailed as a model of pedestrian comfort and transit efficiency. Automobiles were not permitted to use the roadway that was reserved for transit. The road continued to be signed "Bicycle Route," but in actual fact the cycling environment was less than friendly. Now, 15 years later, the mall portion has been demolished at the request of the merchants. The transit lanes remain but automobiles have been permitted to return. The bicycle route has been enhanced: cycles are allowed to ride in the center of the lane with the automobiles, and motorists are dissuaded from passing them. The street has several traffic-calming devices in effect, with the result that the operating speed of the cars has been lowered to that of the bicycles. This is a demonstration project and will be carefully monitored to determine its applicability to other locations.
- Several other major bridge reconstruction projects have been in the design phase for the past 2 years. Cycling facilities—wider curb lanes, dedicated cycling lanes, ramped staircases—have been included in the project design. The proponents of the projects have consulted the cycling interest groups at the beginning of the project with the result that the pieces of the network are being put into place even before the plan is prepared.
- A bicycle traffic light has been installed at an intersection with a straight-through prohibition for motorists. Signage, combined with the standard traffic light, indicate that the cyclist may proceed on the green signal. The lane approaching the intersection has

been striped to show a dedicated bicycle lane going straight through.

• An on-road bicycle parking program has been initiated in the city of Ottawa with the assistance of a private sector company. The firm, Cycle-Stop Displays, has donated approximately 800 two-cycle parking units to the city free of charge. Cycle-Stop installs and maintains the racks for the period of the initial pilot project. The program is paid for through advertising revenues from plates on the parking units. Whereas at one time the city would not have considered an advertising scheme, the merits and benefits of such a joint venture are obvious and have enabled Ottawa to move one step closer to its stated goal of providing better parking facilities for cyclists.

• Bicycle-exempt signs are being used throughout the region to permit cyclists to make turns (predominantly righthand turns) that motorists are not permitted to make during specified hours. The result is a bicycle network with fewer barriers.

• Bicycle lanes have been painted in several intersections where the volume of traffic or the complexity of the maneuvers is such that cyclists would benefit from a striped (dashed) line.

• All intersections on regional roads with sensor loops for traffic light control have been fitted with yellow dots to identify the most sensitive point on the loop. This enables cyclists to trigger the light sequence even though their bicycles do not carry as much metal as automobiles.

• In response to the request for a more truly intermodal system, Ottawa-Carleton Transport has developed several bike-and-ride facilities at some of its transitway stations. These have been inaugurated this year with more to follow at all new transit stations. The transit authority actively promotes these facilities in its pamphlets.

COMMUNITY INVOLVEMENT

Most governments have found that working with the people produces decisions that receive stronger support. To this end, cycling advisory groups have been established in five of the area municipalities within the past 3 years. The Ottawa Cycling Advisory Group is the oldest and has been actively involved in working on development projects and conducting independent research as necessary to assist the city departments. One of the major successes of this groups was the incorporation of cycling policies into the new official plan.

RMOC has established the Transportation Environmental Action Plan (TEAP) with input from both citizens and a staff resource group to recommend and implement projects designed to improve the transportation system for both cyclists and pedestrians. Since its inception, TEAP has developed guidelines for a demonstration bicycle parking station in the urban core, developed an intersection improvement pilot project, worked on traffic-calming guidelines, and recommended site-specific improvements to the cycling environment.

The transportation committee of RMOC recently endorsed a statement prepared by the Transportation Association of Canada that states the following, in part:

> Cycling is part of a total urban transportation system and, like walking, is healthy and environmentally friendly. Increased opportunities for safe cycling can best be achieved through urban and community plans, and through provision of facilities. Methods include:
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> - Cycle lanes on the public right-of-way and separate cycle networks;
> - The needs of cyclists considered in the preparation of community/neighbourhood plans;
> - Storage facilities at transit stations and on transit vehicles to encourage bike and ride;
> - Storage facilities in the downtown core, suburban town centres and other key locations;
> - Provision of cycle facilities as a condition of development. (*2*)

RMOC has taken this a step further by establishing a "green hierarchy" for transportation that ranks the various modes as follows: pedestrian, cyclist, transit, automobile, and other. This hierarchy has been applied to several major reconstruction projects with the result that pedestrian and cycling facilities are now included in the design. An example of this is the Mackenzie King Bridge reconstruction project.

Moving toward a society in which cycling is a viable alternative to other forms of transportation requires an integrated approach to engineering, encouragement, and education. This shift rarely happens overnight. Rather, the social engineering must be established just as the asphalt is laid. Role models play as large a part as do the physical facilities.

ROLE MODELS

In Ottawa, the police force has been using bicycles for 4 years. The officers are highly visible and very effective. City of Ottawa and RMOC staff use bicycles for business on a limited basis. "Blue bikes" have been available to staff at RMOC for 2 years on a voluntary basis. More recently, parking enforcement officers in the city of Ottawa began using bicycles to patrol their beat. In both cases, the results have been positive—no drop in productivity or efficiency and improved morale and fitness.

PLANNING FOR BICYCLES

The city of Ottawa, following the direction in the new official plan, began a comprehensive cycling plan 2 years ago. The city was joined by RMOC who wished to complete a cycling transportation network. The underlying premise of this joint study was to focus on utilitarian cycling and to develop predominantly on-road facilities.

Staff worked with consultants to develop route selection criteria, identify issues, and develop guidelines for facility design. The route selection focused on identifying a primary network that connected destinations across the region and a secondary network within the city of Ottawa that took the network planning down to a neighborhood level.

The city's plan includes sections on roadway design, pathway design, signage and maintenance, and parking standards as well as encouragement, education, and enforcement programs. The study team was composed of staff from five departments working with the Cycling Advisory Group. Several challenging recommendations have been put forward for Council's consideration. The plan, when approved, will likely be implemented over the next 10 to 15 years.

At the time that these two studies were initiated, NCC undertook a study entitled Integration of the Multi-Use Recreational

Pathways in the National Capital Region. This study recognizes, for the first time, the role that the recreational pathways play in providing linkages in the cycle commuting network. The coordination of these two studies has ensured that a fully integrated cycling network will be established.

The work of the earlier surveys in identifying the needs and user profile of cyclists laid the groundwork for these studies. Pilot projects have tested new techniques and design, while the development of policies has given cycling a solid place in the decision-making process. All of these components—research, planning, and implementation combined—will put Ottawa back on the map, not only for recreational cycling but also for nonrecreational cycling.

REFERENCES

1. *Commuter Cycling in Ottawa-Carleton—A Survey*. Department of Engineering and Works, City of Ottawa; Ottawa Cycling Advisory Group, Ontario, Canada, 1992.
2. *A New Vision for Urban Transportation.* Transportation Association of Canada, 1992.