

Factors Influencing Ownership and Use of Nonmotorized Vehicles in Asian Cities

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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,

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 (I)

| 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 (I)

| 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 freight 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 still 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 *pardah* (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 inter-related. 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.

ACKNOWLEDGMENTS

Findings in this paper were based on the authors' work on the World Bank-executed "Study of Nonmotorized Vehicles in Asian Cities." Consequently, the authors acknowledge the World Bank and particularly the following staff for their valuable assistance and involvement with the study: John Flora, Slobodan Mitric, Paul Guitink, Richard Scurfield, Peter Ludwig, Hubert Nove-Josserand, Peter Midgley, and Shunso Tsukada. The authors would also like to extend their gratitude to the many others who contributed at various stages of this study.

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