

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

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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.

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 minibuses) 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.

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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 km²) 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

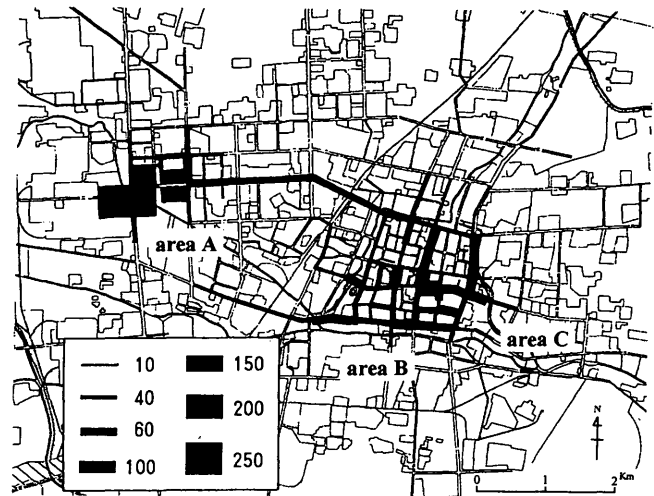


FIGURE 1 Bicycle routes used in commuting trips.

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

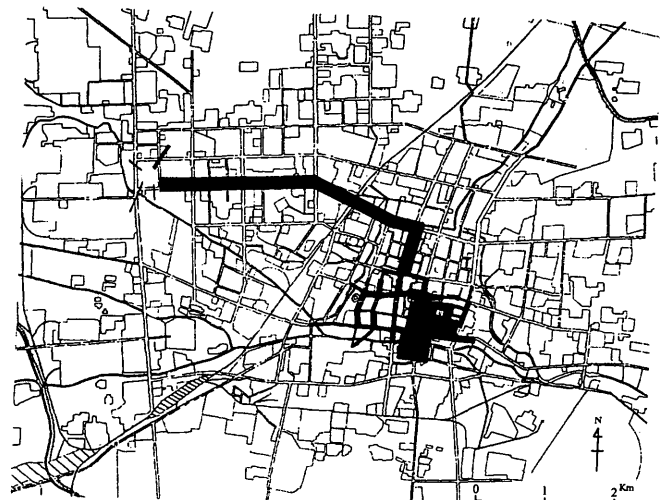


FIGURE 2 Bicycle routes used in shopping trips.

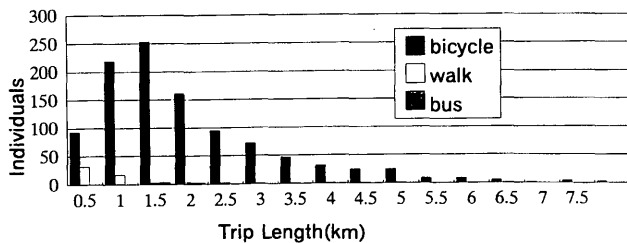


FIGURE 3 Trip length distribution by mode, commuting trips.

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

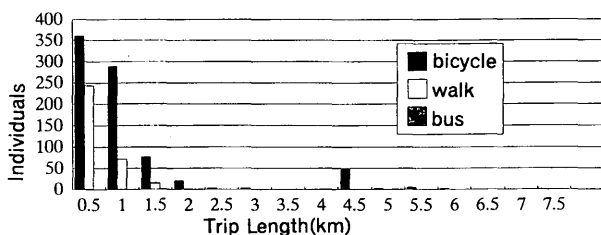


FIGURE 4 Trip length distribution by mode, shopping trips.

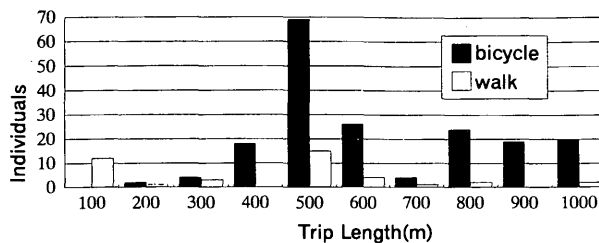


FIGURE 5 Short-distance trip length by mode, commuting trips.

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-

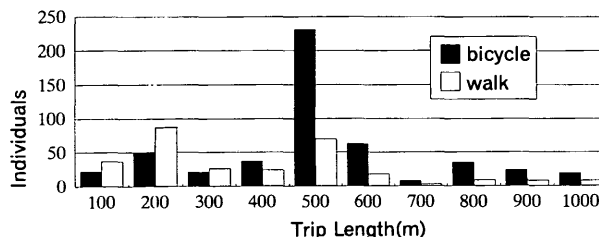


FIGURE 6 Short-distance trip length by mode, shopping trips.

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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