Bicycle: A Vital Transportation Means in Tianjin, China

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Nonmotorized transport (NMT), especially bicycle transport, plays an essential role in the traffic systems of Tianjin City, the third-largest city in China. The growth of the bicycle transport mode and how bicycle transport has been working in the city's traffic are described. The problems that NMT faces and the possibility of integrating the bicycle transport mode with the public one (bike-and-ride) are discussed.

In every country in the world, serving the needs of people who do not have cars is crucial for creating a sustainable transport system. Nonmotorized transport (NMT), especially bicycle transport, is the most common form of individual transport. It is extensively used by the residents of Tianjin City, China. It offers low-cost private transportation, emits no pollution, and emphasizes the use of renewable labor energy rather than capital for mobility. It is well suited for short trips for most people in Tianjin City regardless of income. It offers an alternative to motorized transportation for many short trips. The city's structure and transport systems have changed under the influence of the bicycle transport mode.

Tianjin City is one of three special cities directly under the jurisdiction of the central government of China and is one of the most important economic and industrial bases in China. As the city's economy has developed, traffic problems have become more serious. Economic growth has been hampered by inefficient transport systems. NMT, especially bicycles, has been emerging to meet transport demands. Commuting by bicycle is common in Tianjin.

Bicycles have become the predominant type of private vehicle in Tianjin City. A large number of bicycles are used daily for essential travel. According to the city authority's survey in March 1990, bicycle ownership in Tianjin was more than 3 million and was increasing rapidly. Almost everyone at the cycle age is using a bicycle for daily trips, mainly for commuting to work.

TIANJIN CITY'S TRAFFIC SYSTEMS

Conflicts with Old Streets

In 1860, Tianjin City was invaded by British and French armies, and in the latter part of the 19th century Tianjin was conquered by the combined armies of nine countries. The city was divided into many small blocks and areas. Many streets were built noninterchangeably for the purpose of the colonies' concessions' self-defense. Yingkou Avenue, the old boundary between the English and French concessions in the first half of the 20th century, was a typical example (see Figure 1) (*1*). Streets crossing Yingkou Avenue were staggered, curved, and T-typed. It was difficult to enter the old British concession from the French side because of the artificially imposed obstacles.

Another example is the Horse Field Road (see Figure 2) (*1*). The road was made by Britain's colonists for their horse racing and games. It extended into the central areas among the English, American, and German concessions. The road was planned so that travel would not be easy. It was crooked in several places, with few right intersections. To change its course or reconstruct it was impossible because of the many buildings and important facilities along the road. The road is still there in Tianjin City as it was half a century ago. It often slows traffic to a standstill.

There were several similar cases in the old colonized Tianjin City. It was not easy to reconstruct the unreasonable streets and structures built in colonial times, because the structures on the avenues and the streets were beautifully and solidly built. In addition, finances were not readily available for reformation. These old street networks have made the city's automobile traffic awkward and caused the city center to be congested and inefficient. In these streets, NMT is often faster than automobile traffic.

Population and Land Use

The population of urban Tianjin was about 1.8 million in 1949 when the People's Republic of China was established. It increased to about 3.5 million in 1988 (see Table 1) (*2*,p.15) distributed over Tianjin's six regions—Hebei, Hexi, Heping, Hedong, Nankai, and Hongqiao. The area was 154 km^2, for a density of 22,695 residents per square kilometer.

Most of the industrial areas were in the suburban towns. But the residential regions and newly developed housing areas were not attractive enough to accommodate people who were working in the suburban industrial areas while still living in the central urban part of the city. It was clear that this pattern implies a large increase in the number of commuters and the average length of commuting travel. It helped to bring about the city's high proportion of work trips, which are mainly composed of bicycle trips.

BICYCLE TRANSPORTATION AND WORK MODAL SPLIT

To produce correct predictions and an applicable master plan, Tianjin City authorities implemented a large-scale traffic modal

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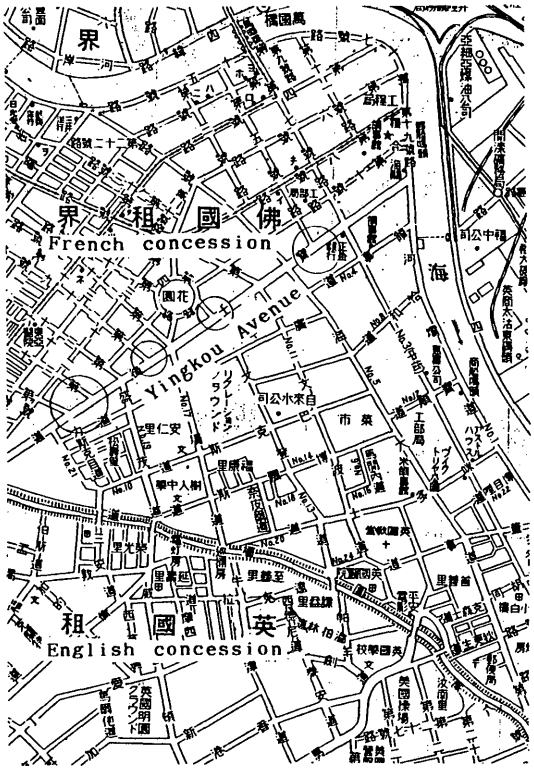

FIGURE 1 Yingkou Avenue.

split survey in March 1990. A total of 35,743 residents from 10,227 families in different regions and streets responded to survey questionnaires. This was approximately 1 percent of the urban Tianjin population and was supposedly representative of urban Tianjin residents. The results of the survey indicated that the bicycle transport mode played a major role

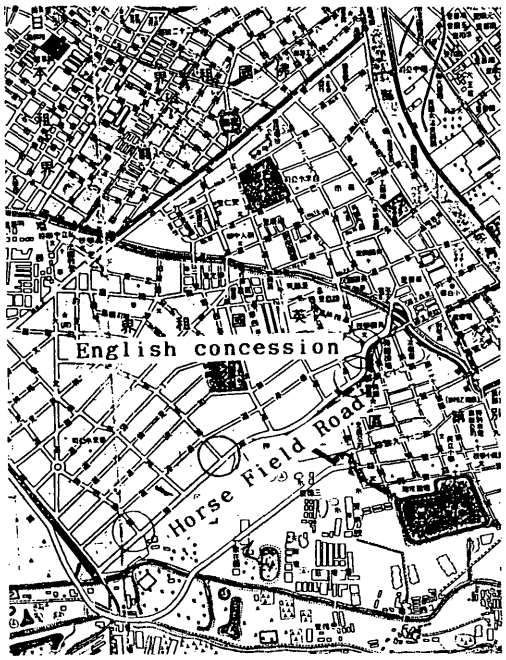

FIGURE 2 Horse Field Road.

TABLE 1 Urban Population Change in Tianjin

Year	Population(,000)	Background
1840	200	Opium War
1860	300	Invasion of Britain and France
1903	750	Invasion of Multi-National Army
1920	850	After World War I
1937	1,080	Invasion of Japanese Army
1949	1,790	P.R. of China Established
1959	2,820	National Census
1966	2,950	"Cultural Revolution" Began
1988	3,495	

in residents' transportation, especially in commuting to and from work.

About 68 percent of total daily trips in 1981 were work trips, and 56 percent of them were made by bicycle. In 1990 the proportion of bicycle work trips had increased to 74.6 percent (see Figure 3) (*3*,p.6). Bicycle work trips increased by 18.4 percent compared with 1981.

First, why did work trips have such a large increase? According to the investigation in 1981, work trips took 68 percent of total daily trips (which were estimated to be about 7.5 million per day). Major traffic problems occurred mostly during peak times for work trips, so we have to understand why work trips took such a high percentage of total daily trips in the city.

1. It is customary for husband and wife to have their own occupations, which doubled the work trips.
2. In the daytime, not many housewives go out for a day trip. They go shopping on their way back home after work.
3. There are fewer social activities.
4. In the evening the couple must do housework because they both work in the daytime and have a limited number of holidays to do housework.

These reasons indicate that the majority of resident trips were for work. Second, they indicate the important role that the large number of bicycles plays in work trips. The survey results showed that approximately 74.6 percent of work trips were made by cycling in 1990. This was the main transportation mode that ordinary Tianjin residents used and was a main component of city traffic.

Production of Bicycles

The largest bicycle producer in China, Tianjin Bicycle Manufacturing Group, produced 6,123,000 units in 1989. Bicycles were readily available, and the bicycle market has become a buyer's market.

The average price of an ordinary bicycle is about RMBY 300 or about $45. The price of a higher-quality bicycle would be twice that of an ordinary one. Compared with bicycle prices in developed countries, $45 seems inexpensive. However, for an ordinary Chinese person, this represents an average monthly

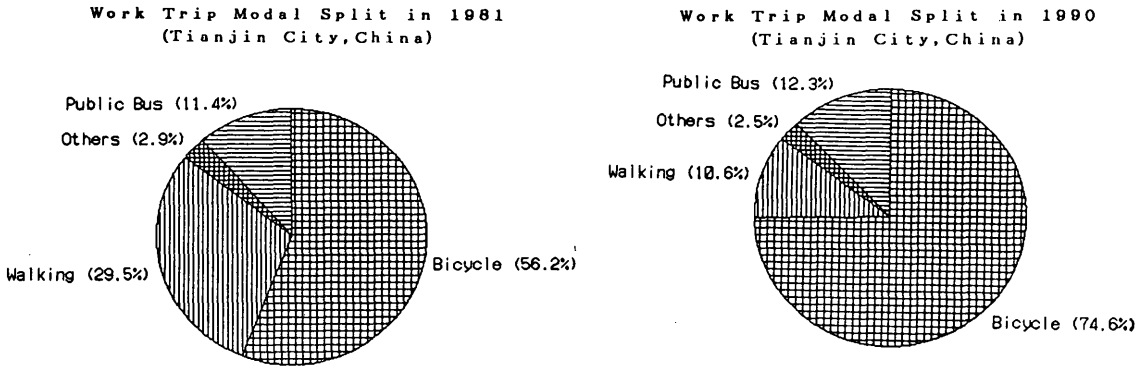

FIGURE 3 Work trip modal splits.

salary. Nevertheless, they are buying new bicycles without hesitation, because bicycles have become the only vehicle they can afford. Bicycles are a convenient, money-saving, and gas-saving mode of transportation, and people like them. In addition, because their social system is different, people do not have to worry about problems concerning land, housing, and food. A bicycle may be their only possession, which could contribute to its popularity.

Status of Bicycle Utilization

Bicycle ownership in the urban area was 3.05 million at the end of 1988. The population of the area at the same time was 3.5 million, which means that 87 percent of the residents possessed bicycles (see Table 2) (*4*,p.14).

When investment in public transportation could not keep up with population growth (there were about 2,400 residents per bus in 1985), bicycles were useful in meeting transportation needs, although they were seen as a symbol of backwardness and were considered an obstruction of high-speed traffic by some government planners and some residents. Bicycles became extremely useful not only for daily travel but also for transporting a family or goods. A bicycle would be used for transporting materials, towing a trailer or baby buggy, or carrying a friend or relative to a destination. This is observed especially in the suburban areas.

TABLE 2 Urban Tianjin Bicycle Growth

Year	Population (thousand)	Bicycle (thousand)	Possession Rate
1981	3,026	1,629	53.8%
1982	3,072	1,952	63.5%
1983	3,172	1,969	63.0%
1984	3,186	2,078	65.2%
1985	3,247	2,310	71.1%
1986	3,339	2,530	75.7%
1987	3,396	2,750	81.0%
1988	3,500	3,052	87.2%

Bicycle transport mode has been extensively accepted by urban Tianjin residents. It has directly or indirectly provided greater mobility and has benefited the city's difficult traffic circumstances as well as providing advantages to commuters. It is irrefutable that bicycles have become the most significant part of Tianjin's transportation system and are indispensable.

There are several reasons why bicycle utilization expanded so rapidly in Tianjin City:

1. The scope for bicycle riding is reasonable. The urban city area is about 173.3 km^2. The average radius of the urban city area is $R = (S/3.14)^{1/2} = 7.43$ km. The average distance from the residential areas in the six administration regions to the central area is about 4.8 km. The average distance from industrial areas to the central area is 6.5 km. The area with all of the city's political, economic, and cultural activities is inside the Middle Ring Road—the center of the city, about 71 km^2. The average velocity of bicycles in other large cities of China is 11 km/hr. In Tianjin, where many new bicycle lanes are made to prevent bicycles from being mixed with automobile traffic, bicyclists can travel more easily than in other cities. The average velocity is higher than that of other cities and is estimated to be 13 km/hr. According to the travel time estimate by Gibson for daily trips such as trips to work, shop, and play (see Table 3) (*5*,p.172), if the acceptable bicycle trip time is 25 min, a reasonable radius for bicycle travel will be as follows: 13 km/hr * (25/60) hr = 5.4 km.

2. The central city has been undergoing a great change from a residential-commercial-industrial to a business-commercial-residential area. People have been moving away from the noisy narrow streets of the central city. From 1980 to 1988, about 170,000 residents moved from inside the Inner Ring Road. About 207,000 moved out of the area between the Inner Ring and the Middle Ring. These people, who used to commute on foot, have shifted to bicycles. The completion of the Ring roads, especially the Middle Ring Road, also encouraged people to use bicycles because the Ring roads have broad paths exclusively for bicycle transport mode.

3. Public transportation service is poor. Many people who are supposed to take the bus or train for work trips use bicycles. Shortages of financing have kept public transportation to low availability. The quality of service of the public transportation system falls far short of meeting the normal demand.

TABLE 3 Estimated Travel Times (min)

Travel Time	Minimum (Ideal)	Average (Don't Care)	Maximum (Barely Tolerable)
To work	10	25	45
To shop	10	20	35
To play	10	30	85

Usually there is no timetable at a bus stop in Tianjin. Buses come irregularly. Sometimes two or three buses come together and sometimes they will not appear again for a long time. Because of this, people prefer bicycle riding. The ratio of buses to residents is only 1:2,400. Buses are operating under oversaturated conditions. Looking at the bicycles traveling faster than the bus, passengers who are squeezed inside the bus decide not to ride the bus and then make a different and inevitable choice. This has accelerated bicycle usage in Tianjin.

The inaccessibility of convenient connections of public transportation is another reason for choosing to bicycle. People do not want to use two travel modes in one trip. They believe that it is better, even for a long time or a great distance not easily endured, to ride a bicycle. This way they can go all the way to their destination rather than going by bicycle to a bus station and then getting off the bus to take another bicycle on to their destination.

There are almost no work trips made by private cars in Tianjin, so for most residents, to give up bus transportation means using a bicycle. That is the only transportation choice they have.

4. As living standards rise, the ordinary resident's purchasing power has had a great boost. Considering the bicycle as the only private transportation means for their daily trips, they take it for granted that everyone has a bicycle. People who go to work by bicycle have been subsidized by the government and their companies. They will get money (about 6 RMBY per month) for bicycle maintenance if they declare that they use a bicycle to commute. This amounts to about 2 percent of their salary. People who commute by public bus have to pay a part of the traffic fare themselves. This policy also has become a major factor in encouraging people to use bicycles as much as possible.

Organization of Bicycle Traffic

Traffic conditions in the city have become serious because of the increasing numbers of bicycles. The most severe problems occurred at some intersections where more than 20,000 bicycles passed per hour. At some intersections more than 30,000 bicycles passed per hour. Since bicycles are regarded as a type of vehicle, they must take turns with automobiles and follow the same traffic signals at intersections. Left-turning bicycles and automobiles were the foremost cause of traffic problems. Though roads and streets were improved greatly in the 1980s by separating fast from slow traffic modes with fences or green belts, the two would join at intersections. Reasonable bicycle traffic organization is needed to create new routes and to guide bicycle traffic flow on the newly developed routes.

The cyclists often do not like to change their established routes once they have chosen them. Yet, cyclists may not necessarily prefer the direct route if it follows heavy motorized traffic. There might be many controlled intersections and frequent stops, or it may pass through an area considered undesirable from the personal safety standpoint.

Figure 4 shows an example of how to divert the flow of bicycles from Route A to Route B (*4*,p.30). Wujiayao Road is the city's trunk road, with many intersections and signals. It connects several residential areas with business areas. One large intersection is at Qixiangtai Street. In the 1989 survey, the intersection had about 18,500 bicycles passing through between 7:00 and 8:00 a.m. Most of the bicycle commuters going to Quanyechang business area live in the residential areas along Wujiayao Road. Route A was thought to be the

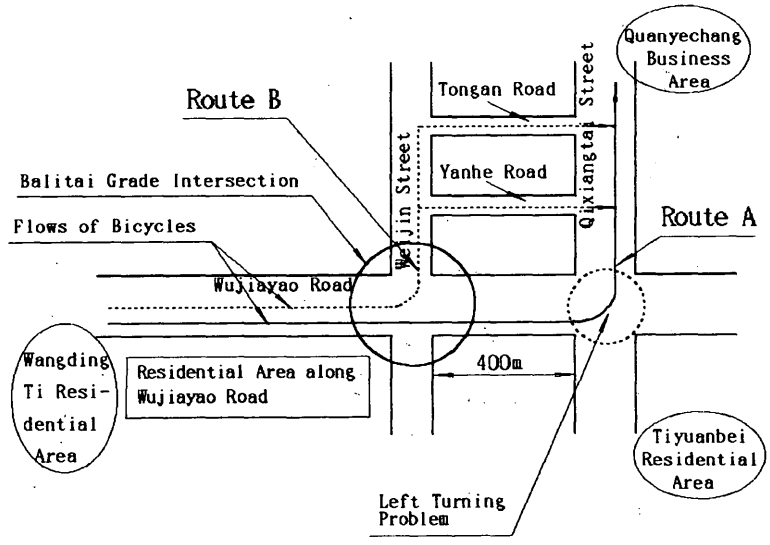

FIGURE 4 Bicycle route arrangement.

simplest route for the cyclists to travel. However, on the Route A turning point of the intersection, bicycles turning together with automobiles caused massive traffic congestion.

To solve this problem, experts suggested, a bypass route had to be developed to move a portion of the bicycle flow in a separate direction. Route B was proposed for cyclists, who could turn left at Balitai Grade Intersection, turn right to Yanhe Road or Tongan Road, and proceed to Qixiangtai Street.

There are dozens of similar examples in Tianjin City. Changes and adjustments of the routes, especially at intersections, should be made to improve traffic flow.

BICYCLE SAFETY

According to the report of the Tianjin police station, there were 4,316 traffic accidents in 1990 in Tianjin City, with 3,098 injuries and 422 fatalities. About 40 percent of the accidents were related to bicycles.

The most severe problems occurred at intersections where more than 20,000 bicycles passed per hour. Regarded as a kind of vehicle, bicycles take turns with automobiles observing the signals at the intersections. Motorcycles and other motorized two-wheelers offer greater speed, mobility, and status than bicycles. Left-turning bicycles and automobiles were the foremost causes of accidents.

The lack of traffic facilities is also an important reason for Tianjin's increase in accident rates. There were only 122 signals in the city's traffic network in 1990. Only a few roads and streets had painted lines for dividing lanes. Even at intersections where traffic signals have been installed, they have to be reinforced by the physical presence of a police officer to be effective.

It is inherently dangerous for nonmotorized vehicles to operate in heavy motorized traffic flows if the motorized traffic is dominant in the street system or there has not been provision for the separation of slow and fast traffic modes.

In Tianjin City, almost no department stores, recreation areas, theaters, or hotels have enough parking places for cars. Most have none at all. Customers and clients were expected to walk or ride bicycles. Later they were expected to travel on public buses. When the social economy developed, the number of automobiles increased rapidly. People began to use automobiles for various activities, which caused more and more road parking problems. Illegal road parking has been causing problems everywhere in urban Tianjin, and its adverse effect is much more serious than in developed countries.

INTEGRATION OF BICYCLES WITH PUBLIC TRANSPORTATION

As more Tianjin residents move from the city center to the outskirts, the average trip length tends to increase. Different transportation modes can be used in one trip by the most convenient way, intermodal coordination—bike-and-ride. Bicycles would be seen as the most important feature in providing access to efficient public transport services. Because of its good accessibility and flexibility, bicycle transport mode can make existing transport systems more efficient. It offers an integration of trips and is an ideal way to travel for long-distance commuters.

To encourage bicycles to access express transit services for longer-distance trips, it is necessary to link them with motorized public transportation. Convenient bicycle parking places are important projects to be subsidized by the government.

As in other cities, as mentioned earlier, the competition for space between automobiles and bicycles has become the main problem. Coexistence between massive bicycle transport and motorized vehicle transport is very important to prevent unexpected conflicts between the two sides when bicycle transport is encouraged and at the same time the motorized public transportation is expanding.

CONCLUSION

The purpose of this paper has been to analyze utilization of NMT, especially bicycles, in Tianjin City, China. Through analysis and discussion, it is concluded that bicycle transport mode is reasonable and acceptable for the development of Tianjin City's traffic systems. The advantages of bicycle transport use in Tianjin City are summarized as follows:

1. Productivity superiority; centralized mass production: The annual output of Tianjin Bicycle Manufacturing Group in 1989 was 6,123,000 units.
2. Market superiority; individual purchasing power: People use bicycles as a kind of convenient, money-saving, and energy-efficient transport vehicle. Bicycles are their most important possession. There is a large potential market for bicycles.
3. Improved road network superiority: Every street is a potential bicycle route, and bicycles are recognized as vehicles. This concept endorses bicycles as part of the legitimate existing transport system.
4. Inferiority of city's public transportation: The service level is very low, and public transportation is more expensive than the bicycle.
5. City land use formation: The average distance of a bicycle trip is less than 6 km. This distance is too long for walking and too short for express public transport services, particularly where travel demand density or economics do not permit high-frequency public transport services. Bicycles are most important for personal transport and also accommodate light goods hauling.

However, the future of bicycle transportation in Tianjin City is threatened by growing motorization, loss of street space for safe bicycle use, and changes in urban form prompted by motorization. The following are barriers to bicycle transportation:

1. Negative attitudes to bicycle transport from society and authorities;
2. Hostile street environments for bicycles as the city develops—poor road conditions in some areas, which have too little room for the bicycle transport mode to be used;

3. Unreasonable and inappropriate regulation of bicycle transportation; and
4. The desire of the city's residents to own automobiles as a status symbol.

For long-distance bicycle trips, the bike-and-ride transport system needs to be gradually adopted to make motorized public transportation supplementary to commutes that are too difficult to bicycle. At the same time, it is important to give priority to the development of NMT such as bicycles. A large-scale motorized public transport system is needed to carry passengers into or out of the city's urban center. Individual traffic can be fed into the perimeter of the urban center area. Bicycle-bus exchange hubs and bicycle parking garages need to be built there. It is important for NMT and motorized transport to work together to promote the growth and development of both of these necessary transportation systems.

REFERENCES

1. Y. Suzuki. *Eight Countries Colonial Concessions Map of Old Tianjin.* Suzuki Publisher, 1940.
2. *Tianjin City Plan.* Tianjin Urban and Rural Construction Commission, 1990.
3. *Research Report on Land Use and Traffic Model in Tianjin City.* City Traffic Program Team of Tianjin Science Committee, 1990.
4. X. Gong. *Analysis on the Traffic Status of Tianjin City.* Tianjin Urban Plan Bureau, 1990.
5. J. E. Gibson. *Designing the New City—A System Approach.* John Wiley and Sons, Inc., 1977.