An Assessment of Modes of Passenger Transportation in Beijing: Problems and Solutions

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Abstract. The purpose of this study was to analyse the historical trends of various modes of passenger transportation in Beijing with respect to planning, policies, performance, and public behaviour based on statistical data. Using Beijing’s passenger transportation data since about 2003, the discussion addresses changes in (1) Beijing’s passenger transportation supply and demand, (2) population density, and (3) the apparent causes and effects of passenger transportation policy at various stages of policy implementation. The analysis revealed that budgetary shortfalls, air pollution, population density, and lack of governmental integration are persistent problems. Specific proposals for ameliorating those problems are presented.

1. Introduction
There is a trend in the evolution of passenger transportation in most cities in developed and large cities in developing countries. The early stage of urban expansion is primarily characterized by non-motor vehicle and public transit that gradually becomes motorized and dominated by private road vehicles, which, ultimately, in response to traffic congestion and environmental pollution, reverts to public transit and restrictions on the use of private road vehicles. Between 2003 and 2013, Beijing experienced this evolutionary process. Its population of permanent residents increased from 14.56 million to 21.15 million; daily trips within the city surged from 18.32 million to 30.33 million; private passenger road vehicle ownership grew from 2.12 million to 5.44 million; and policies regarding private passenger road vehicle ownership and use were taken one another [1]. A system of sharing bicycles also emerged. Between 2003 and 2013, Beijing invested hundreds of billions of Yuan to develop its transportation infrastructure and mass transit vehicles (road, rail, and bus) to deal with traffic congestion and environmental pollution and a modal shift from private passenger road vehicles to mass transit is evident. Moreover, the use of private passenger road vehicles began to stagnate. This evolution of urban passenger transportation in Beijing is typical of cities and is being experienced in China’s second-tier cities. During its evolution of passenger transportation, Beijing implemented various plans and policies that actively or passively influenced public use of the various modes of passenger transportation in the city. Assessing the effects of the city’s efforts by concluding intrinsic characteristics of this process using panel data covering a long historical period is quite enlightening for latecomers.

This study (1) examines the long-term trends in the evolution of passenger transportation in Beijing, (2) evaluates the effects of transportation planning and policy on passenger transportation problems, and (3) discusses suggestions for future development. The problems and the corresponding suggestions that are addressed can help China’s and other developing countries’ second-tier and third-tier cities to cope with issues related to passenger transportation. These are problems that they may face during the
evolutionary process and the suggestions offer far-sighted planning guidance, which may enhance the advantages of later development.

2. Background and the evolution of passenger transportation in Beijing

Beijing has experienced rapid growth over the past decade and its permanent population is increasing. In all cities, the evolution of passenger transportation is closely related to the development of social and economic dimensions of urban growth. Therefore, the analysis of the development of urban passenger transportation and the relevant policies should account for the context of the socioeconomic environment. The changes to the geography, population, and economy of Beijing must be considered as well as the relationships of these contextual factors to the evolution of passenger transportation.

2.1. Socioeconomic background

Beijing’s gross domestic product (GDP) during the past decade increased dramatically each year. In 2013, the regional GDP was CNY 1950.10 billion, a 289.47% increase from CNY 500.70 billion in 2003. The per capita GDP also rapidly increased; in 2013, it was CNY 93.21 thousand, a 168.03% increase from CNY 34.78 thousand in 2003. Local fiscal revenues and expenditures also experienced rapid increases. In 2013, Beijing’s public financial budget income was CNY 366.11 billion, with an estimated annual rate of increase of 10.40% [1] [2]. Its completed public finance budget spending was CNY 374.08 billion and fiscal subsidies for public transportation operations were CNY 20.01 billion. Beijing’s rapid economic development has been accompanied by increased urban passenger traffic and it has simultaneously provided the financial basis of the transportation infrastructure.

Between 2003 and 2013, Beijing’s permanent resident population increased 45.26% from 14.56 million to 21.15 million people. The 2013 population density was 1289 people/km², which is more than twice the population density in 2003 (an increase of 682 people/km²). About 59.27% of the increase in total population occurred in Beijing’s central area, which constitutes only 8.34% of the city’s total land area. The downtown population density was, on average, 8972 people/km², whereas the suburban areas had a population density of 559 people/km² [2]. Without a comparably developed suburban area to absorb the population growth, the population concentrated in the central area. That condition resulted in Beijing’s development of the special passenger transportation system and major traffic overloads.

2.2. The development of demand for passenger transit

The demand for passenger transit in Beijing has soared in response to rapid economic development, the expansion of the population, and short-sighted urban planning with intensive land use for a single purpose. In 2013, the total number of daily trips (not including trips on foot) was 30.99 million in the city’s urban centre, an increase of 12.67 million at the end of 2003. The growth in the number of trips significantly exceeded population growth. In the central area, the average number of trips per person increased from 1.25 in 2003 to 1.47 in 2013. The increase in the average number of trips can be ascribed to the increasing prosperity of Beijing’s urban economic activities and to single-purpose land use. Large areas of land have been dedicated as residential or other functional zones and residents are compelled to travel to satisfy their various needs (e.g. shopping). This situation is particularly evident regarding travel from extremely large residential areas to central business districts.

2.3. The development of traffic supply

Various transportation infrastructures and transit measures were created in Beijing to attempt to meet the soaring traffic load. Regarding public (mass) transit, at the end of 2013, there were 813 bus lines with 23,592 buses covering 19,688 km. There were 17 metro lines serving 465 km with 3998 operating metro vehicles [3]. For comparison, in 2003, there were 6839 fewer bus (a total of 16,753 buses) and 3306 fewer operating metro vehicles (a total of 692 metro vehicles) in service. Travel by taxi in Beijing is regarded as a high-comfort mode that is preferred by high-income passengers. Therefore, its use is relatively low and the taxi fleet is strictly controlled. Although the number of passengers that travel by
taxi is assumed to be steadily increasing, there has been relatively little change in the number of taxis, which increased from about 62,000 in 2003 to about 67,000 in 2013.

2.4. Passenger transportation mode-share
The evolutionary trend of Beijing’s urban passenger transportation mode-share proportions between 2005 and 2013 suggests that public transit’s share steadily increased and private passenger road vehicles’ share was effectively controlled (likely by the enforcement of legislative regulations), as shown in Figure 1. With regard to the transportation modes in 2013, rail transit’s share was about 20.60%, an increase of 3.80% over 2012. Buses’ share was about 25.40%, a decrease of about 1.80% and private passenger road vehicles’ share was about 32.70% of the total trips. Private passenger road vehicles’ share increased only 0.10%, whereas taxis’ trip share decreased by 0.20% to 6.50%. Bicycle’s share increased by 12.10%.

![Figure 1. Evolutionary trends in passenger transportation mode-shares, 2005–2013.](image)

3. Passenger transportation policies
Passenger transportation policies can influence the transportation demand as well as the supply and, thus, play a significant role in the evolution of passenger transportation. The history of the evolution of metropolitan areas in the world demonstrates that logical and coherent transportation policies can guide consumers’ purchases and uses of private passenger road vehicles, optimize passenger transportation mode-sharing, and promote mode-shifts to modes with lower carbon emissions. For example, Beijing has implemented a series of transportation policies to emphasise public transit and regulate private passenger road vehicle purchases and use.

3.1. Private road vehicle ownership and use regulations
Passenger transportation regulations were temporarily implemented before the Beijing Olympic Games (July through September 2008) to reduce the number of private passenger road vehicles on the roads and improve air quality. After the Games concluded, in October 2008, Beijing changed the policy into a formal and permanent regulation. The new version forbids a private passenger road vehicle to be used on one day per work week (Monday through Friday) between the hours of 7:00 and 20:00 (CST). The restrictions were intended to partially mitigate Beijing’s traffic congestion and they were successful in that the reduction of private passenger road vehicles in the city reduced the congestion index from 7.70 in 2007 to 5.40 in 2009. However, the improvement lasted only two years because the total number of motor vehicles continued to increase and the effects of use regulations were offset by increases in road vehicle ownership.

Passenger road vehicle ownerships soared from 2.12 million vehicles in 2003 to 4.81 million vehicles in 2010. The congestion index rebounded to 6.10. In response, the Beijing municipal government introduced several measures in December 2010 intended to alleviate traffic congestion, including a lottery registration for road vehicle purchases, increased parking fees in the downtown area, and accelerated construction of the public transit system. Some large cities in developed countries set limits on private passenger road vehicle ownership and have vehicle use policies to combat traffic congestion.
For example, in February 2003, London began collecting a fee (congestion charge) from private passenger road vehicles entering a section of the city centre. The effects of that policy are apparent in a report by Transport for London indicating that the number of private passenger road and minicab vehicles entering the ‘charge zone’ decreased by 30%, the number of vans and lorries decreased by 13%, and the number of trips on buses and, particularly, on bicycles increased [4]. A congestion charge is likely to be implemented in Beijing.

In 2011, the regulations limiting private passenger road vehicle ownership were implemented in Beijing. The purchase quota per month of 10,000 vehicles was allocated in a license plate lottery. The result has been a dramatic decline in the growth rate of private passenger road vehicle ownership. In 2013, the annual growth was 4.56%, much lower than the 19.70% growth rate in 2010. Under the pre-2011 conditions (without controls), private passenger road vehicle ownership in 2013 would exceed six million.

Despite this success, traffic congestion and pollution problems differ by region and different approaches should therefore be taken to account for those differences. A blanket policy across the country would likely be inconsistent in its effectiveness. Regulations on ownership are likely effective and should be implemented in central and high-population density areas to counter rapidly increasing private passenger road vehicle ownership. However, in suburban areas where public transit service is not very effective and private passenger road vehicles may be a necessary supplement, regulating ownership may cause economic hardship. Thus, big cities should devise flexible policies regarding the technical, economic, legislative, and administrative aspects of transportation management. The current blanket policy cannot accommodate the diversity in demand for number and length of trips in different areas and at different times. In fact, almost one-half (47.8%) of drivers sometimes ignore the use control rules [5]. Specifically, those drivers whose destinations are far from the city centre or metro stations and who travel during peak hours are relatively more likely to violate the use control rules.

3.2. Public transit incentives
Beijing has long regarded its public transit system as a public welfare infrastructure. Government subsidies have historically resulted in bus and metro fares that were significantly lower than in other major Chinese cities. Fares were further reduced in 2007 so that buses had a base fare of CNY 1 and passengers who hold the IC card (a discount card that is swiped to pay the fare) enjoyed a 60% discount. In addition, the student card provided an 80% discount. This policy was intended to attract travellers to the bus or metro to promote public transit and make public transit more affordable to low-income people. With the stimulus of lower fares, metro ridership increased from 654.93 million in 2007 to 1.22 billion in 2008. However, there were negative unintended consequences. First, although the 2007 policies attracted more passengers, public transit’s overcrowding problem worsened and the density of passengers standing in metro cars exceeded seven persons/m² [6]. Second, the extraordinarily low fares triggered invalid demand that resulted in ever-increasing governmental subsidies of public transit operations.

To address the crowding problem and tight budget, a new fare policy for the bus and metro systems was launched in December of 2014. A flat fare of CNY 2 for metro use was replaced with a distance-based fare structure with a base fare of CNY 3 for trips within a six-kilometre radius. The base fare for bus trips was increased to CNY 2 for trips within a 10-kilometre radius plus CNY 1 charged for each additional 5 km travelled. However, bus fares were 50% discounted for IC cardholders and the student card discount was 75%.

3.3. Public transit subsidy
The Beijing government provides large subsidies to public transit because it is state-owned, fares are kept low, and the public transit system is growing by adding new bus and rail lines. In 2009, the public transit subsidy was about CNY 12.93 billion; four years later in 2013, it had increased to CNY 20.01 billion. Increasing subsidies created persistent financial pressures and the Beijing government launched a reform of its investments in the public transit infrastructure by integrating private financing through a
public–private partnership scheme. The reform is expected to mitigate the financial pressures on the government, boost the efficiency of transit operations, and improve the desirability of public transit by increasing the level of services.

4. Current issues
Although Beijing’s passenger transportation complex is evolving in a positive direction, many of the transportation management policies have achieved initial success, and the mode-share of private road vehicles appears to be at a historical stagnation or may even be in a declining trend, salient problems threaten the sustainability of Beijing’s passenger transportation systems.

4.1. Aspects of passenger transportation needing improvement
First, the mode-share of public transit still has potential for improvement and road traffic congestion and public transit crowding problems are still serious. Public transit’s and bicycling’s mode-shares are relatively low and residents are relying less and less on bicycles. Second, private passenger road vehicles are still the main travel mode not only because ownership is large; their use is not effectively regulated. The average daily number of trips is 1.86, which is much higher than in Tokyo or Paris. Road congestion is a major problem in Beijing’s central area and the average travel speed of private road vehicles is low. Third, the urban public transportation systems have some urgent issues. For example, public transportation congestion seriously influences mode-shifts during a trip. Currently, Beijing’s public transportation has an in-vehicle (bus or metro) passenger density during the morning peak hours that exceeds 7 people/m² [6]. Suburban railways, which have an important role in dispersing the central area populations to the suburbs by providing convenient long-distance commuter travel options in cities such as London and Tokyo, have not been well developed in Beijing.

4.2. Need for planning and design integration
The planning and design of changes made to the different transportation modes are not integrated, which results in inconvenience to the riders when they make transfers between modes. At present, the rail network and the bus line network cannot achieve a high level of mutually beneficial operations due to the inconvenient interchanges and the competing demands between bus lines and metro lines that service the same corridors. The distance between feeder bus stations and the corresponding metro stations is generally too great. Moreover, confusion is added to the problem because of unclear signage. Suburban park–and–ride facilities, which are crucial for transitioning the public from private road vehicles to public transit, are not always included in land-use planning.

4.3. Budgetary problems
The low-fare policy and inefficiency of the station-owned public transit operation companies create significant pressures on Beijing’s fiscal budget. In addition, the total dynamic investment in the urban rail transit construction expected before 2035 was estimated as CNY 627.70 billion [7]. A variety of investment modes were attempted, but only CNY 23 billion was obtained from the private sector between 2000 and 2014 [7]. This shortfall is worsened by the financial problems of the bus and metro lines’ operating companies in covering current operational costs with revenues, which fall far short, requiring more than CNY 20 billion annually in subsidies. The deteriorating financial situation of the public transportation infrastructure is likely primarily attributed to the low public transit fares. However, the inefficiencies of the state-owned corporations also contribute. The situation is complex: The government cannot distinguish one influence from the other without effective financial assessing indicators and subsidies are provided based on the financial statements of the operation companies.

4.4. The underlying fundamental problem of population density
The problem of overwhelming trip demands in space (land area) and time (peak hours) is generated by high-density and single-function land use. This is the fundamental issue and it is seldom considered in Beijing’s urban planning. The extremely large residential areas that have been developed, such as
Tiantongyuan and Huilongguan, create very uneven traffic demands across time and the current transportation options in these areas are insufficient at peak hours yet exorbitant during off-peak hours. Although this problem is obvious, planners apparently did not learn from the mistakes. About 50% of the central business district (or the equivalent in trip generation districts) was developed in the existing centralized area of Beijing during the past five years, which almost completely offsets the benefits derived from the rapid development of the metro and bus systems for transporting passengers to outlying suburban areas.

4.5. Air pollution
Urban passenger transportation is the primary cause of Beijing’s air pollution. In 2013, motor vehicles (of all classes) emitted about 22.20% PM2.5 (particulate matter), 58% NO₂ (nitrogen oxide), and 40% VOCs (volatile organic compounds) [8]. During the Asia-Pacific Economic Cooperation (APEC) Conference in Beijing, strict restrictions on road vehicle use were implemented and large institutions in central Beijing were given short vacations to reduce the amount of traffic. The ‘APEC blue sky’ seen during the event was evidence that private passenger road vehicles in Beijing are a crucial element of environment problems.

5. Conclusions and suggestions
This study employs Beijing as a case study from which to derive suggestions for general application in late-developing cities. Based on Beijing’s patterns of passenger transportation development over the past decade, transportation mode-sharing was evaluated, causes and effects of implemented transportation policies were analysed, and the persistent problems were described and summarized. Based on the conclusions drawn from the analysis and discussion, planning strategies and suggestions for the development of passenger transportation systems in big cities in developing countries emerged. First, urban spatial growth and urban population increases are the inevitable outcomes of emerging economies. As residents’ incomes increase, private passenger road vehicle ownerships and the extent of use will increase. This is the most important issue for urban passenger transportation. To address the problems that necessarily occur as a result, cities must take a two-pronged approach. They must improve and expand their public transportation systems as the population grows and they must regulate the ownership and use of private passenger road vehicles. In addition, regulations should be implemented before serious problems arise as opposed to after the fact and regulations should be flexible enough to be effective in diverse contexts. Beijing’s regulations were too late and too rigid to be thoroughly effective. The blanket policy was unnecessary on low-traffic roads in the suburbs. Nevertheless, the regulations achieved positive results and the share of trips by private passenger road vehicles has been decreasing. The Beijing government is now assessing ways to enforce a congestion charge on private passenger road vehicles used in the central area to further cut their mode-share as well as ways to increase the flexibility of regulations placed on use.

Second, developing the transportation infrastructure and improving the service level of the public transit systems are essential to transition the public from reliance on private passenger road vehicles to public transit. Convenient and comfortable alternatives to private passenger road vehicles should be offered. The large-capacity public transportation systems should be oriented at the corridor-level mode. In the case of Beijing, the metro system effectively contributes to the mode-shift. However, so long as the level of service provided by the metro suffers from the overcrowding problem, residents will tend to use private passenger road vehicles or taxis. If the long-term rail transit plan of 1000 km lines, which includes metro, light rail, and suburban railway, is implemented, the public transportation service level may dramatically improve and thereby attain the dominant mode-share.

Third, the primary challenge to providing more and better public transit is financing. At present, the average annual investment in metro construction in Beijing is about CNY 20 billion, of which almost 60% is bank loans [7]. The lack of money creates a great deal of pressure on the government’s future financial allocations. Moreover, to maintain the low fare policy, the government must provide subsidies of more than CNY 20 billion annually to public transit. Therefore, cities in developing countries with
tight budgets must reform their investments in and financing of their public transportation infrastructure construction needs and focus as much as possible on private capital. One possible way to attract private funding is by adopting new financing modes, such as franchises.

Furthermore, to reduce high operating subsidies, a reasonable transit fare structure should be established based on daily transportation expenditures and residents’ or users’ incomes and abandon unrealistically low fares. To control operating costs of and subsidies to public transit, competitive bidding among operating companies and effective operating assessment schemes should be adopted. Beijing has implemented investments and financing modes such as BT, PPP, and sale-leaseback in the metro system. This action raised capital for public transportation infrastructure construction and introduced new metro operation companies, which created a competitive relationship among state-owned enterprises and private companies that should drive down costs. Although these measures are at their initial phases, the level of service has improved and operating subsidies are lower. In the future, these measures should be more widely and extensively implemented.

Urban traffic problems in large cities primarily result from rapid economic and population growth and the corresponding land development. In the case of Beijing, the over-concentration of development in the central area, particularly large-scale residential development in the downtown area, has generated a high and uneven demand for passenger transportation. The only way to meet this need is to increase the supply of transportation options on a grand scale, which often requires major investments that have limited effects. Therefore, emerging large cities in developing countries must integrate their urban planning with the development of their passenger transportation systems. Land-use planning should be based on the relationship between land use and traffic. By doing so, passenger transportation concerns can be pre-emptively handled before they become major problems for the government, the public, and the environment.

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