An Elastic Analysis on Urban Public Transport Priority in Beijing

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Abstract

Urban public transport (UPT) is an important part of social public welfare closely related to peoples’ daily lives and social economic development. The paper presents the detailed implementations of public transport priority (PTP) in Beijing city and analyzes the traffic operation status after the strategy. Then, an elastic analysis is conducted to measure the elasticity of UPT price demand. It also discusses the cross price elasticity of demands among UPT, car and bicycles. The results show that the UPT travel needs elastic prices. The relationship between UPT and car is complemented, and its relationship with bicycle is substitutable. The UPT demand growth is transferred from bicycle travelers. Low-price strategy in Beijing still has not achieved the expected purpose of attracting car travelers.

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1. Introduction

Urban public transport is a public welfare undertaking closely related to millions of peoples’ production and lives. It has a direct relationship with the livelihood of people and the development of social economy. During the “11th Five-Year Plan” period, China’s national economy has grown rapidly
with about 2.5% higher than the speed of planning objectives that the urbanization level increased continuously, and the process of motor speeded up. By the end of 2010, China’s urbanization rate has reached 49.68%, and the urban population of 660 million. During the “11th Five-Year Plan” period, the annual increase of urban population was about 1,500 people, the traffic flow of urban areas had increased dramatically, the contradiction between transportation supply and demand had become increasingly prominent, and the pressure of traffic infrastructure continuously raise (Liu, 2011). Urban traffic congestion, safety accidents and environmental problems have seriously affected social and economic development, and become an important bottleneck restricting sustainable urban development. Several major cities have reached an agreement that giving priority to the development of urban public transport is an effective way to solve the problem of traffic congestion and promote the sustainable development of traffic. As China’s capital, Beijing early implemented the strategy of giving priority to the development of public transport, and also has made some achievements. Taking Beijing as an example, using elastic analysis theory, this paper discusses the effect of the measures of low fares in the strategy of giving priority to the development of public transport, so as to provide references for the relevant departments to make decisions.

2. Public transport priority in Beijing

2.1. Action on public transport priority

Back in 1997, the first bus lane is employed in Beijing Chang’an Avenue, which opens the prelude of PTP (Quan et al., 2006). Afterwards, to meet the traffic demands of Beijing Olympic and improve the ever-worsening traffic, Beijing adopted too many kinds of active measures to ease congestion. The operation is divides into two stages.

(1) Pre-Olympic (Before 2008)

In 2005, the Outline of Beijing Transportation Development (2004–2020), put forward the program that construct modern advanced traffic facilities as the foundation, construct the new Beijing traffic system leaded by public transport.

As the detailing of relevant content in Outline, Beijing put forward “two determinations and four priorities” clearly in the “Opinions on priority development of the public transport”. The “two determinations” means that the government made a explicitly determination on the public transport’s strategic position in city’s sustainable development, and make sure the social public welfare position of the public transport. “Four priorities”, that is, the public transport will get priorities on land use, investment, right-of-way allocation and finance and tax support.

About the land use priority in facilities, the Opinion puts forward the planning that construct public transportation level 3 transfer stations before 2010, including comprehensive hub station adapted to different passenger flow distribution amount, interchange center station, transfer, and the car and bus interchange stations, bus comprehensive transfer facilities in more than 110.

On the investment priority arrangement, increasing public investment in transportation, the “11th five-year plan” period public transport investment accounts for 45% of transportation foundation investment to 71.5 billion yuan, increased by 18% than fifteen periods, an increase of 47.7 billion yuan. According to the characteristics of the mega city like Beijing, in public transportation in the investment, to increase the investment to the rail traffic construction, to speed up the rail traffic construction, planning to 2015, will construct 16 new rail lines, rail transportation network up to 20 line 568 km.

In the distribution right priority, bus lane from 10 km to 20 km each year speed increase in recent years. At present, has amounted to 165 km. Planning to 2010, new bus lane 285 km, the bus lane network to 450 km. At the same time, speed up the construction of bus lanes in which the bus rapid system support the
physical isolation. Has been opened south-middle axial number 1 large capacity rapid bus lines, will also establish Anli Road, Chaoyang Road and Fusi Road three lines.

In the finance and tax support priority, according to social and public welfare positioning of public transport, change the idea, and the loss of public transport will be subsidies, adjusting public expenditure used to buy public passenger service, increasing public financial support. Completed the bus companies’ asset replacement, realize the city bus unified into public expenditure. To carry out low fare policy, from January 1, 2007, unified the city bus fares ground, common card to enjoy four fold, students enjoy discount 2, since October 7, 2007, the subway put practice the single type and low fare policy which takes 2 yuan for each person every time.

(2) Post-Olympic (after 2008)

After the Olympic Games, Beijing explored the development of urban transport in a new way from a new starting point, proposed the ideas that constructing humanity transport, scientific-technology transport and green transport. On July 2009, Beijing government enacted the “Action plan for Beijing Humanity, Scientific-technology, and Green Transport”, promoting the construction of “transit city”.

The Plan points that we should deepen the policy measures that priority to the development of public transport all-round, the purpose of the plan is to facilitate the public to travel and minimize the network traffic load, promoting the green travel system construction, in which rail traffic is the backbone, the ground bus is dominant and multiple transport modes such as walking and bicycle coordinated operates, achieving the harmonious development between transport and urban. There are five projects inside the public transport:

(i) The rail transit network services project. Establish the rail traffic’s backbone status in urban public passenger transport systems, promote the construction of new rail lines, expand the proportion, increase the line density in central city, exert its role of guiding and supporting urban spatial structure optimization adjustment. The rail transport operation mileage is 300 km in 2010, 420 km in 2012 and 561 km in 2015, forming the network of “three links, four horizontals, five verticals and eight radiations”, the line density in less than the fifth ring road is 0.51 km/km², one can reach a rail transit sites walking an average 1000 m only, during peak hours, the minimum service interval of main lines is 2min.

(ii) The ground bus network service project. Give full play of the main role of ground bus, build fast-line network for skeleton and general lines network for foundation, the extension network for supplementary, covering the center of the city, the newly developing city and town public (electrical)-automotive services network. Achieving the object that the total mileage of bus lanes is more than 450 km; the distance that 90% of the central city passengers walk to the nearest bus station is less than 500 m, the main lines’ waiting time in peak hours is 3 to 5min, the average load rate during peak hours is controlled in 70%.

(iii) The convenient transfer of traveling service project. To ensure the convenience of passengers, the transfer facilities of rail traffic, ground bus and multiple transport modes should be synchronously planed, constructed and operated. Completed 13 integrated passenger hubs, optimize the bus station layout, construct and retrofit more than 50 central transfer stations, construct car park for transfer together with the construction of new rail transit lines.

(iv) Walking and bicycle traffic service project. Construct bicycle and pedestrian lines network, strengthen the management of road rights. Build bike parking lots at passenger concentrated areas, set about 1000 bicycle rental points relying on rail transit stations and bus hubs, forming the rental scale that is of more than 50,000 bicycles, planning to construct some walking and bicycle demonstration blocks.

(v) Traffic travel accessibility service project. Promote the construction of the barrier-free transportation facilities and the service system, general compete the central city barrier-free travel network. Promote construction and modification of barrier-free of bus and rail transit stations, platform and vehicle. Severe punishment should be given to the behaviors of encroaching or damaging barrier-free facilities.
2.2. Effect of PTP

PTP has been employed for 5 years in Beijing, and a series of achievement has been obtained. Main show is in the following respects:

- Public transport (buses and rail transit) contribution rate keeps rising. Fig. 1 presents that public transport contribution rate has increased from 28.2% to 40.9% from 2003 to 2011. Especially since 2006, public transport contribution rate has increased 10.7%, and the growth is marked. Especially in 2011, car contribution rate dropped for the first time.

- Traffic congestion has been eased. From Fig. 2, we can see that since 2007 Beijing traffic index has dropped gradually. In the first quarter of 2011, the average traffic index was 4.48 on the peak of workday. It decreased by 16.6% compared with that of 2010 and by 37.3% compared with the fourth quarter of 2010. Full-time heavy traffic congestion time has dropped from 165 min in 2007 to 20 min in 2011.

- It should be noted that the contribution rate of bicycle has recently dropped obviously. The contribution rate of bicycle is 16.3% in 2011, and decreased by 46.1% compared with that of 1986. The ratio of travelling distance below 5 km by cars is as high as 44% and walking and bicycle’s travelling distance is suitable for this part of travelers. When this part of travelers turn to cars, they will cause the waste of traffic resources and increase the traffic pressure. So we should think deeply whether PTP has achieved the original purpose.
3. Elasticity of demand of public transport priority

Elasticity of demand is employed to analyze the reaction degree of demand changing with its effect factors, that is to say it is the ration between the percentages of demand changing to the percentage of effect factors changing. There are many scholars implementing elastic analysis model into transportation research field, such as Wang et al. (2004) studied the elastic relations between volume of traffic to economic quantities. Tian et al (2009) analyzed the demand elasticity of railway transportation capacity and GDP. Lane (2011) employed elastic analysis method to discuss the relationship between oil prices and public transport, and the results showed that traffic volume of bus and rail transit increases 4% and 8%, respectively when the oil price rise 10%. Litman (2011) put forward the price elasticity of public transport and elastic demand value for public transportation planning from the view of trip distance, trip purpose, travel time, etc. Elastic analysis method is employed to discuss the effect of PTP, especially low-price strategy.

3.1. Elasticity of price

According to the basic concept of elastic analysis, elastic demand of public transport price:

\[ E_{\text{Busd}} = \frac{\Delta Q_{\text{Bus}} / Q_{\text{Bus}}}{\Delta P_{\text{Bus}} / P_{\text{Bus}}} \]  

where \( Q \) and \( \Delta Q \) are resident trips and variation respectively; \( P \) and \( \Delta P \) are ticket price and the variation of it, respectively.

The paper takes the price descending after the implementation of PTP for example. According to the Beijing transportation development the annual report, by the end of 2010, within six ring roads of Beijing, population’s total average daily travel was 29.04 million (walking not inclusive). It is increased by 5.8% (158 million) compared with 2009’s. Public transit is 818 million per day, which is increased by 3.2% (25 million) compared with 2009’s. Car transit is 993 million per day, which is increased by 6.3% (59 million) compared with 2009’s.

By the end of 2010, Beijing permanent population was 19.622 million, among them 982400 students, 5% of the total population. Supposing that the proportion of the students’ average daily travel is similar to its population proportion, the number of students travelling by bus is 409000. Supposing that the proportion of the adults getting bus card is half of adult travelers, the number of getting bus card travelling by bus is 389 million, and the cost of every transit is 0.4 yuan. The number of travelling with ticket is 389 million, and the ticket price is 1 yuan. All the students get bus cards, and the price is 0.2 yuan per time. The average ticket price is 0.67 yuan. Therefore, \( P_{\text{Bus}} = 1 \) yuan, and \( \Delta P_{\text{Bus}} = 0.55 \) yuan. According to the Beijing transportation development reports, the amount of daily transits of public transport was 623 million in 2006, and the contribution rate of bus is 24.4%. Thus daily bus transits \( Q_{\text{Bus}} = 503.4 \) million, and \( \Delta Q_{\text{Bus}} = -314.6 \) million.

Generating related data into above formula, the results can be obtained, \( E_{\text{Busd}} = -1.8938 \). So the conclusion that bus demand has the elasticity to fares can be drawn.

3.2. Cross elasticity of demand

To deeply study the origin of bus transits increment, the following discusses the cross price elasticity of demand among UPT, car and bicycles. Low-price strategy in Beijing whether achieving the purpose of attracting the car travelers to public transport.

The cross price elasticity of demand between public transport and other modes:
where $E_{PY}$ is the sensitivity of demand changing of $Y$ mode causing by bus price changing; $Q_Y$ and $\Delta Q_Y$ are demand and variation of traffic modes $Y$ respectively; $P_{bus}$ and $\Delta P_{bus}$ are ticket price and the variation of it respectively.

According to BJTRC (2011), the amount of car transits is 654 million in Beijing in 2006, and $Q_{car}=654$ million. The amount of car transits is 993 million in 2010, and $\Delta Q_{car}=993-654=339$ million. According to Eq. (2), $E_{car}=-1.5708<0$, and the result means the relationship between bus and car is complementary.

The amount of bicycle transits is 650.4 million in Beijing in 2006, and $Q_{bike}=650.4$ million. The amount of bicycle transits is 476.3 million in 2010, and $\Delta Q_{bike}=650.4-476.3=174.1$ million. $E_{bike}=0.8112$, and the result means the relationship between bus and bicycle is substitutability.

From the computing result of the travel demand price elasticity, bus demand is lack of elasticity. The bus transits do not increase widely after bus ticket price dropping, so the stage misses fire.

3.3. Results

According to the results above, it can be seen:

- Public transport demand has elasticity to price. When bus price descends every 1%, public transport demand increases 1.8938%. It declares that low-price strategy in Beijing has effect on attracting more travelers to travel by public transport.
- The demand price elasticity between public transport and car is negative, and the relationship between public transport and car is complementary. Low-price strategy in Beijing has not attracted car travelers, and it means the strategy has not achieved the original purpose.
- The demand price elasticity between public transport and bicycle is positive, and the relationship between public transport and bicycle is substitutability. Low-price strategy in Beijing has attracted a large number of bicycle travelers turning to bus, and public transport substitutes bicycle. It means the strategy has achieved the purpose.

4. Conclusions

This paper presents the details of public transport priority (PTP) in Beijing, and analyzes it traffic status after implementation of the strategy. Then, an Elastic Analysis is employed to analyze the elasticity of UPT price demand. The paper also discusses the cross price elasticity of demand among UPT, car and bicycles. The results show that:

1) Through the phased PTP, public transport contribution rate keeps rising, and traffic index drops gradually. Full-time heavy traffic congestion time significantly shortens, and PTP has achieved obviously effects. But it’s worth thinking about the fact that the contribution rate of bicycle lowers.

2) The demand of UPT is elastic to price. But the relationship between UPT and the car is complementary, and the relationship with the bicycle is substitutability. The amount of UPT’s demand growth is transferred from the demand of the bicycle. Low-price strategy in Beijing has not achieved the original purpose of attracting the car travelers.

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