

Comprehensive Benefit Analysis of Urban BRT System

Mingyu Lu^(⊠)

KLAHEI18018, Traffic Engineering College, Anhui Sanlian University, Hefei 230601, Anhui, China jtlumingyu@126.com

Abstract. In recent years, the problem of urban traffic is becoming more and more serious, and it poses a serious threat to human life safety, property and living environment. In order to solve this problem, many cities are developing BRT system. It is an urgent problem to understand the comprehensive benefits of BRT correctly and comprehensively. In this paper, through the establishment of the comprehensive benefit analysis model of Urban BRT system, using the theory and method of traffic economics, taking Hefei BRT line 1 as the research object, this paper mainly takes the benefit comparison of BRT, conventional bus and urban rail transit as the starting point. The advantages of BRT system are comprehensively analyzed from three aspects of traffic benefit, economic benefit and social benefit, which makes people have a systematic understanding of the comprehensive benefits of Urban BRT system. and provides the basis for urban development and construction of BRT system.

Keywords: urban public transport · Bus rapid transit · Traffic benefits · economic performance

1 Introduction

With the increasingly prominent traffic problems in major cities, the development of public transport and the implementation of the strategy of "public transport priority" have become the wise choice of urban transportation development. However, the service level of conventional transportation in most cities is relatively low, which can not meet people's requirements for travel quality, Although urban rail transit has good service quality, its cost is too high, which affects its development to a large extent. The Urban BRT system is a new type of public transport system, which is compatible with the characteristics of conventional bus and rail transit. So, Under the situation that rail transit has not been built into a network and conventional bus can not meet people's travel needs, BRT is a good form of public transport. At present, it is necessary to make a systematic evaluation and analysis of BRT system. The significance of BRT system analysis is mainly reflected in the following aspects It provides a theoretical basis for judging whether the development of BRT system can solve various traffic problems, such as traffic congestion and traffic

safety, and promotes people to have a correct and systematic understanding of BRT system. It provides convenience for future development and operation management, and provides choices for relevant departments in urban planning, BRT planning and design, and which public transport mode to promote urban development and guide people to travel [1].

2 Composition and Characteristics of Urban BRT System

2.1 Composition of Urban BRT System

BRT is a large capacity and fast public transport system which uses modified public transport vehicles to enjoy signal priority in the special road space, which has the characteristics of rail transit and the flexibility of conventional transportation. BRT is composed of Bus Rapid Transit (BRT), including special lanes, special vehicles, special stations and information management system [2].

2.2 Characteristics Analysis of Urban BRT System

High speed and flexibility. Bus rapid transit system requires public transport vehicles to operate on dedicated roads, so it is less affected by other vehicles in the process of operation, with fast speed and time saving. Moreover, because the BRT system uses the ticket selling outside the bus, the waiting time of the bus in the station yard is greatly shortened, which further shortens the time [4].

Compared with rail transit, the flexibility of BRT also has great advantages. The successful operation of rail transit needs the interaction of four elements: line, station, vehicle and toll collection system, which are indispensable. However, the BRT system can be operated after the completion of some facilities.

Large transportation volume, little pollution and less energy consumption. Bus rapid transit (BRT) system is in the form of group cars, usually with 2–4 cars as a group, with large traffic volume, and its level can reach rail transit. New technologies have been adopted in the design and production of BRT vehicles, which effectively reduces its emissions and energy consumption.

Low construction cost and short period. Compared with rail transit, the construction cost of BRT is much lower, only one tenth of that of rail transit. Moreover, BRT can be completed in 1–2 years, while rail transit usually takes 6–8 years [5].

Although BRT has many advantages that conventional public transportation and rail transit do not have and can play an active role in solving urban traffic problems, it also has its limitations. The limitations of BRT system can be analyzed from the following points:

The requirements for bus-only roads are relatively high. The reason why BRT is fast is its dedicated lane, but it is still open to question whether to build this kind of dedicated lane on the limited land resources. Especially in the old city where road resources are limited, how to solve such problems is the basis of BRT. If it is not properly solved, it will not only solve the traffic problem, but will aggravate it [6].

To truly enjoy the signal priority system. Because of the complicated traffic conditions on the road with multiple vehicles, if BRT vehicles can't enjoy the signal priority but participate in the queue, it will increase the bus delay time, slow down the driving speed, fail to give full play to the advantages of BRT, reduce the attraction of bus travel and aggravate traffic congestion.

On the road marked with BRT without closed measures, it is necessary to eliminate the interference of other social vehicles and pedestrians, which requires higher traffic quality of the whole people. How to improve the quality of the whole people and actively abide by traffic regulations is also the key factor that affects the successful operation of BRT system.

3 Theory and Method of Comprehensive Benefit Analysis of Urban Rapid Transit System

3.1 Comprehensive Benefit Categories of Urban Rapid Transit System

The traffic benefits of urban public transport system are mainly reflected in three aspects: the ability to promote urban public transport system, the ability to relieve urban road congestion and the ability to guide residents to travel. This article also focuses on these three aspects, With the help of public transportation contribution, urban road congestion and residents' travel speed, it is analyzed and studied. Tk = $\alpha 1$ gk + $\alpha 2$ sk + $\alpha 3$ ck, where gk, sk, ck represent the public transport contribution of public transport system, the fast travel speed of residents and the congestion of urban roads, respectively, and $\alpha 1$, $\alpha 2$, and $\alpha 3$ are undetermined parameters [7].

This paper mainly analyzes the benefits of urban bus rapid transit system from the road construction cost. Road products are commodities. Although they are different from commodities in consciousness, they are unified in value and can also be expressed by value. W = C + V + M formula, C is the materialized labor value of commodities. V is the labor reward value of the laborer; The value of m for the whole society.

The external cost of transportation mainly includes: a large amount of energy consumption, land occupation, air pollution, noise, traffic accidents, destruction of natural landscape and disturbance of ecological balance of various animals and plants, etc. (Table 1).

Traffic externalities	yuan/person kilometer	Traffic externalities	yuan/person kilometer
Traffic congestion time value	0.2090	Environmental damage (greenhouse effect only)	0.0808
Environmental pollution (excluding CO ₂)	0.0517	Traffic accidents caused by public transportation	0.0640

Table 1. Comparison of cost impact of transportation externalities

The external characteristics produced by urban public transportation system mainly include: air pollution, climate change, water and soil pollution, noise and vibration, traffic accidents; External costs caused by vehicles, pollution caused by vehicle production and disposal, land occupation for vehicle parking, and crowded parking area. External cost caused by vehicle infrastructure, Visual disturbance, isolation barrier effect to community, ecological environment separation effect.

3.2 Research Model of Comprehensive Benefit Analysis of Urban Bus Rapid Transit System

Because the calculation method of OD traffic volume uses the cost change between OD pairs to calculate the use benefit. However, no matter what equilibrium method is used to build the model, all paths between OD pairs cannot be considered. Therefore, all paths need to be considered. The generalized cost of a car is as follows: GChmij = α hm × Tmij + β mij × Lmij, where, GChmij h day (weekdays or holidays), m model, Generalized cost for one car of Odij (yuan/car); α hmh day (weekdays or holidays), the time value of M model is in the original unit (RMB/vehicle); β mijm model, average original driving unit of OD to ij (yuan/vehicle/minute); Tmij m model, average driving time (minutes) of OD to one car of ij; Lmij m model, driving distance from OD to ij (km).

In BRT planning, it is necessary to consider its comprehensive benefits, and whether it can meet certain goals with the least capital investment. In this paper, when analyzing the comprehensive benefits of BRT, the method of operational research is adopted, and the model is established under the constraints of minimum capital, shortest travel time and maximum coverage area:

> $(P): \ min\Sigma ca [xa (u), u] xa (u)$ S.t $\Sigma xe (u) \ge wij, i, j, 1 \le i, j \le h, s \in s(i, j)$

 $Xa \leq [(ta - txtop - tf)/\alpha tf]1/\beta Fc(1 - f)$

In the formula, s is the arc cut set between bus network nodes I and J; Is the impedance of ca section a; Xa is the traffic volume of balanced road section a; X is the vector representation of xa; W is the set of OD pairs; Rw is a collection of paths.

4 Chapter 4 Comprehensive Benefit Analysis of Hefei BRT Line 1

Through investigation, the bus rapid transit line 1 and ordinary bus are as follows.

From the Table 2, it can be seen that the role of BRT in the public transportation system is becoming more and more prominent due to urban expansion and population expansion, and its share rate has exceeded half, which requires that more efforts should be made in the investment and construction of BRT system to form a complete transportation network. Moreover, its advantages of speed and time saving are obvious. Bus Rapid Transit Line 1 runs from Binhu Times Square-Shifu Square, with a total length of 18 km and an average time of about 40 min. Compared with other bus routes with the same

public transportation system	Public transportation sharing rate	Travel time (10,000 person hours)	Average vehicle speed (m/s)
Conventional bus	49.64%	10.08	12.4
bus rapid transit	51.09%	9.98	19.5

Table 2. Comparison of time benefit between BRT Line 1 and ordinary public transportation

Table 3. Comparison of social benefits between BRT Line 1 and ordinary public transportation

System	Average capacity	Ticket price	Fuel consumption	distance time (s)	Vehicle emission (g/km)		on
					VOC	CO	NOx
Conventional bus	70	1.5	6.9	2280	9.78	69.05	15.19
Rapid transit	180	1.5	1.6	1500	8.85	62.21	14.69

starting and ending points, it takes 1 h and 25 min for No. 14 to No. 509, 1 h and 30 min for No. 117 to No. 63 and 1 h and 40 min for No. 1 to No. 63 This will guide residents to travel by public transportation, Solving urban traffic problems and promoting the development of new urban areas have positive effects. At the same time, BRT also has great advantages in speed, which also reduces energy consumption and the possibility of road congestion to a certain extent.

On the whole, BRT has a better effect than conventional bus in terms of traffic benefit, which urges that in today's urban planning strategy, priority should be given to developing BRT, and the awareness of urban development guided by BRT system should be added to the planning thought (Table 3).

It can be seen from the table that the average capacity of BRT is close to three times that of conventional bus. For Hefei, where the population is expanding, BRT can meet the travel needs of residents in terms of capacity, which is forward-looking for new areas like Binhu, and can adapt to the future development of Binhu New Area. With the same average fare, speed has a great advantage. This will enable residents to give priority to BRT when traveling for a long distance, such as from the new urban area to the city center and from the school gathering area to the railway station and bus station. Moreover, after adopting the new public transportation system, BRT greatly reduces energy consumption and environmental damage in environmental protection, which is conducive to the effective implementation of sustainable development policies. It also promotes the construction of a harmonious society. Today, with the rapid development of industry, people pay more and more attention to energy demand and environmental protection. The development of bus rapid transit is beneficial to environmental protection and the implementation and development of new energy policies advocated by the government, and it has merit in solving environmental problems such as sustainable development and smog weather (Table 4).

public transportation system	Comprehensive effect value	Traffic impact value	Environmental load value	Economic benefit value
Conventional bus	0.213188	0.225535	-0.27382	0.144141
bus rapid transit	0.259547	0.243681	-0.249669	0.291576

Table 4. Numerical table of comprehensive effect of BRT

It can be seen from the table that in terms of comprehensive benefits of urban public transportation, BRT has a better comprehensive effect than conventional public transportation. In terms of travel demand, residents are more and more inclined to choose BRT, and the traffic impact value of BRT is higher than that of conventional bus. Today, with the increasing awareness of environmental protection. The development of BRT is also forward-looking. No matter in air pollution, noise pollution and vibration pollution, it can be effectively alleviated and solved. In terms of economic benefit, the economic benefit value of BRT is more than twice that of conventional bus. Giving priority to the development of BRT will greatly promote the regional and regional economic development. From the perspective of long-term urban development, BRT has great advantages.

The investment in urban rail transit is huge. At present, the average cost of urban subway is 200–700 million yuan/km, the first-phase rail construction cost of Hefei is 670 million yuan/km, the total investment is 16.4 billion yuan, and the average cost of urban bus rapid transit is 20–70 million yuan/km. Moreover, urban bus rapid transit can be completed in a short time, while urban subway takes 6–8 years. Although the subway has many advantages after the formation of the transportation network, before that, the construction cost of BRT was low, the investment was quick and the benefit was good, so; It is a practical and feasible measure suitable for the development of medium-sized cities.

The flexibility of rail transit is worse than that of BRT. However, as a medium-sized city, we can give consideration to rail transit as the main line, bus rapid transit as the main line and develop the flexibility and convenience of bus rapid transit. Urban planning should give overall consideration to the functions of rail transit, bus rapid transit and ordinary public transportation. And BRT also plays a very good complementary role between conventional bus and rail transit.

5 Conclusion

This paper describes the importance of bus rapid transit system in urban construction, highlights the advantages of bus rapid transit system by comparing with conventional bus and rail transit, and emphatically expounds the importance of building bus rapid transit system under the current situation of increasingly prominent contradiction of residents' travel demand. This paper briefly analyzes the current situation and existing problems of public transport construction in Hefei, Taking BRT Line 1 as an example, this paper

expounds the definition, composition and related characteristics of BRT system. With the help of traffic economics theory and operational research model, this paper compares and analyzes the advantages of BRT system in traffic volume, freight rate, fuel, travel sharing, travel efficiency and emission. In short, in order to better induce residents to travel, Promoting the development of cities, rationally planning the construction of BRT system, and truly and effectively solving traffic problems need to be studied in the later period.

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