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Bus Reform Strategies Under the Rapid Development of Urban Rail Transit System

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Abstract: At present, China's cities are generally facing the problem of the decline of the passenger flow of conventional bus transit. By analyzing the functionality of bus service under the background of the rapid development of rail transit, this paper points out that the dominant position of conventional buses in urban public transit system still has not changed fundamentally. In the new era, the focus of public transit priority should return to the field of conventional buses and actively promote the reform of buses. Based on the experience of reform measures of urban bus service, the paper points out that in the new era, the conventional public transit reform should take the structural optimization and network adjustment as the key breakthrough and the free transfer or preferential transfer as the basic premise. It is necessary to establish coordination and risk prevention mechanisms in the implementation and to adopt gradual implementation strategy of small scale, high frequency, and fast iteration. **DOI:** 10.13813/j.cn11-5141/u.2019.0010-en

Keywords: bus transit; rail transit; reform; structural reorganization; transfer discount

In 2000, the *Notice of the General Office of the State Council on Strengthening the Construction and Management of Urban Rapid Rail Transit* (GBF [2003] No.81) and the *Opinions on Priority Development of Urban Public Transportation* (JC [2004] No.38) were released. Since then, almost all cities that met the condition of rail transit development chose the strategy of leading the prior development of public transportation with the rail transit. By the end of 2017, more than 30 cities had stepped into the era of rail transit development, and about 60 cities were starting or planning to start rail transit construction [1]. Rail transit priority has become a distinctive feature of the actual implementation of the public transportation priority strategy in large cities and megacities of China over the past 10 years. Despite of the remarkable achievements in the field of rail transit, the overall situation of the development of public transportation is very severe, especially in the field of buses and trolleybuses (hereinafter referred to as "bus"), which has shown a continuous decline trend in passenger flow across many cities. The decline of bus passenger flow and the lag in bus development have seriously affected the realization of the overall goal of China's public transportation priority strategy. In the context of the development of rail transit, how to re-think and re-position the bus service, whether the decline of bus passenger flow is inevitable or accidental, whether it should be left alone or intervened actively, how to promote the development and reform, etc., are important issues to be studied urgently.

1 Current status of bus passenger flow

As of the end of 2016, there were 52 789 bus lines and 608 600 operating vehicles in cities of China's mainland, which transported 74.535 billion passengers per year. Compared with 2015, the total number of bus lines increased by 7.9%; the total mileage increased by 9.7%; the number of buses increased by 8.3%, but the total annual passenger volume decreased by 2.6% and the decline rate was more than that of 2015, which was 2.1% [2–3]. The total bus passenger volume has been declining continuously at the national level.

There are 25 cities in China that have run rail transit, including subways, light rails, monorails, maglevs, trams, urban express rails, APM, etc. In 2016, the daily bus passenger volume increased only in three cities, Wuhan, Hangzhou and Kunming, and it declined in 22 cities, among which it declined by more than 5% in 18 cities and by more than 10% in five cities. In Nanchang, the decline rate was even as high as

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31.5% [4] (Figure 1). To analyze the changes of bus passenger flow in the context of the rapid development of rail transit, this paper selected seven representative cities for further analysis (Table 1) based on the development stages of cities' rail transit. Statistics showed that in recent three–six years (two years for Changsha), the bus passenger volume in these cities declined continuously to varying degrees, with an average annual decline rate of 9.9% and 8.6% in Shenzhen and Beijing respectively. Beijing showed the largest decline among these cities: Its daily bus passenger volume declined by 5.1 million and its daily buses and rail transit passenger volume declined by 1.868 in the past five years (Table 2).

2 Positioning and understanding of buses

2.1 Structure and scale of urban public transportation system

In terms of the structure of the urban public transportation system, the proportion of bus passengers among all passengers (the sum of bus passengers and rail transit passengers) was above 50% for all cities in China's mainland that had urban rail transit in 2016, with the exception of being slightly lower or close to 50% in Shanghai, Guangzhou, and Beijing. In detail, it was in the range of 50%–60% for Nanjing (52.7%) and Shenzhen (59%), 60%–70% for Wuhan

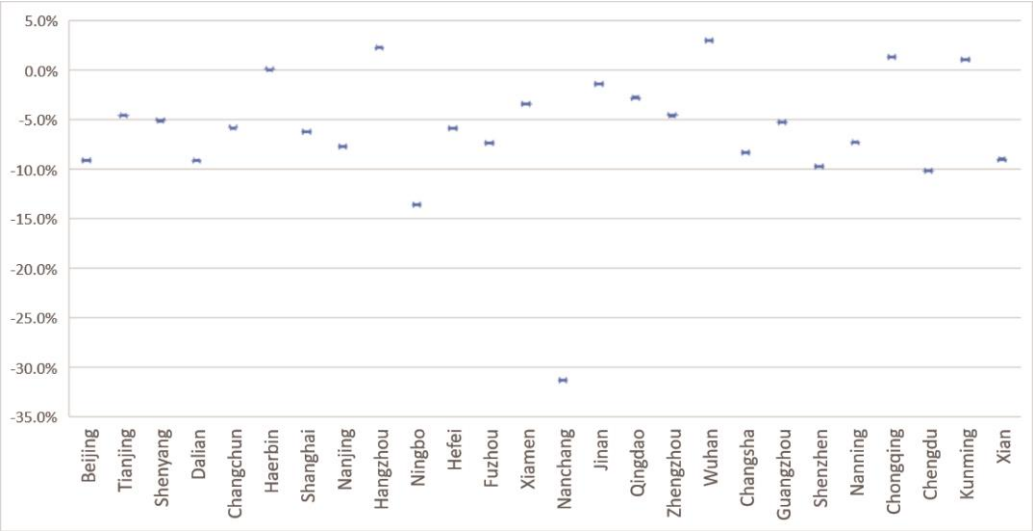


Figure 1 Bus passenger volume in 2016 compared with 2015 in the cities with urban rail transit system

Source: Reference [2].

Table 1 Characteristics of buses and rail transit in typical cities (by the end of 2016)

Development Stage	City	Urban rail transit mileage / km	Number of lines	Urban population / 10000 people	Bus passenger volume / (10000 passengers·d^{-1})	Rail transit passenger volume / (10000 passengers·d^{-1})	Proportion of bus passenger volume /%
Late stage of rail transit network	Beijing	574	19	2 172.9	1 008.2	1 002.6	50.1
	Shanghai	628	15	2 419.7	653.3	931.8	41.2
Middle stage of rail transit network	Guangzhou	308	10	11759.5	660.0	704.4	48.4
	Shenzhen	280	8	1 190.8	510.4	355.4	59.0
Early stage of rail transit network	Chongqing	211	4	2907.4	683.8	190.0	78.3
	Wuhan	181	5	1121.6	402.7	196.3	67.2
Early stage of rail transit development	Changsha	50.3	2	351.5	223	58.2	79.3

Source: Reference [2].

Table 2 Passenger volume decline period of buses and rail transit in typical cities

City	Decline period of bus passenger volume		Changes in bus passenger volume		Changes in rail transit passenger volume		PT[1)] passenger volume
	Start and end year	Duration (years)	Growth/ (10000 passengers·d^{-1})	Annual growth rate /%	Growth/ (10000 passengers·d^{-1})	Annual growth rate /%	Growth/ (10000 passengers·d^{-1})
Beijing	2013—2017	5	-510.5	-8.6%	323.7	7.9%	-186.8
Shanghai	2012—2017	6	-173.7	-4.2%	406.8	9.3%	233.1
Guangzhou	2015—2017	3	-77.4	-3.7%	143.8	7.2%	66.4
Shenzhen	2015—2017	3	-166.2	-9.9%	164.5	16.5%	-1.7
Chongqing	2015—2017	3	-63.6	-4.1%	61.9	12.8%	-1.7
Wuhan	2013—2015	3	-42.2	-3.3%	132.0	88.6%	89.8
Changsha	2015—2017	2	-30.3	-6.7%	40.0	65.5%	9.7

1) Public transportation refers to buses and rail transit. Source: Each city's annual report on transportation development and the statistical data from the government website

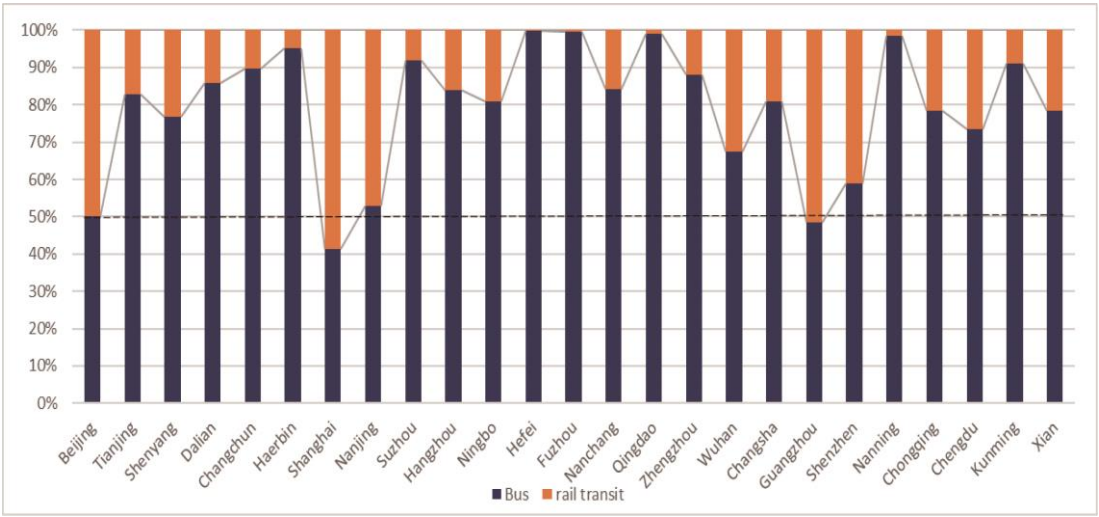


Figure 2 Proportion of bus passenger flow in cities with rail transit (in 2016)

Source: Reference [2] and China Urban Rail Transit Annual Report (2016).

(67.2%), and 70%–80% for Chongqing, Chengdu, and three other cities (Figure 2). Therefore, most of China's cities are still in the development stage where buses account for the majority or even the vast majority of the urban public transportation system.

In terms of the scale of the passenger flow, the daily bus passenger volume was over 2.4 million in 18 cities and over 4 million in 10 cities, among which it was as high as 10 million in Beijing. The total resident population of these cities was about 240 million, accounting for 1/3 of the national urban population. The total bus passenger volume of these cities was more than 44% of the national total, so they had a crucial impact on the overall development pattern and the trend of urban public transportation in China.

In terms of the number of trips, buses play a more prominent role. An unavoidable fact is that although the daily passenger volume of rail transit is huge in many cities, e.g., it is more than 10 million, 9 million, and 7 million in Beijing, Shanghai, and Guangzhou respectively, the transfer rate is also high, e.g., it is 1.91, 1.72 and 1.67 respectively in these three cities. The general rule is that the larger daily passenger volume of rail transit indicates the higher transfer rate. Among the top 10 cities with the longest operational rail transit lines in China, the minimum transfer rate of rail transit is as high as 1.38, whereas bus transfer rates are usually below 1.2 and rarely exceed 1.3. Therefore, from the perspective of the number of trips (the ratio of passenger volume to transfer rate), rail transit only carries about 4.2–5.4 million trips per day even in cities with the most developed rail transit system such as Beijing, Shanghai and Guangzhou, much lower than buses, which carry 5.4–8.4 million trips per day. At present, the main role of buses in the urban public transportation system has not fundamentally changed.

2.2 International development experience

Most international cities have adopted a cautious and objective attitude towards the development of rail transit. The overall development of rail transit and buses is relatively balanced. For example, buses account for more than 50% of public transportation trips in Hong Kong, Singapore, Taipei, and London, more than 40% in Seoul and New York, and nearly 40% in Paris (Figure 3). However, there are few exceptions, such as Tokyo and Osaka where buses only account for about 5.9%, which is an extreme development mode. This paper will not discuss the advantages and disadvantages, historical causes, and costs of these two modes. As far as the current situation of Chinese cities is concerned, it is a very challenging goal that cannot be achieved on one stroke to reach the level of Seoul, London, and even Paris, i.e. the so-called "60/60" of megacities, and let alone the Tokyo mode. "60/60" refers to that public transportation accounts for 60% of all modes (excluding walking), and rail transit accounts for 60% of all modes of public transportation. Therefore, it is neither realistic nor desirable to solve all problems or replace buses with rail transit. The strategic tendency of the relative balance between rail transit and buses or the slight advantage of rail transit will still be the basic judgment and orientation that most of China's rail transit cities should adhere to at present and for a period in the future. Therefore, it is neither realistic nor desirable for rail transit to completely replace buses in the future.

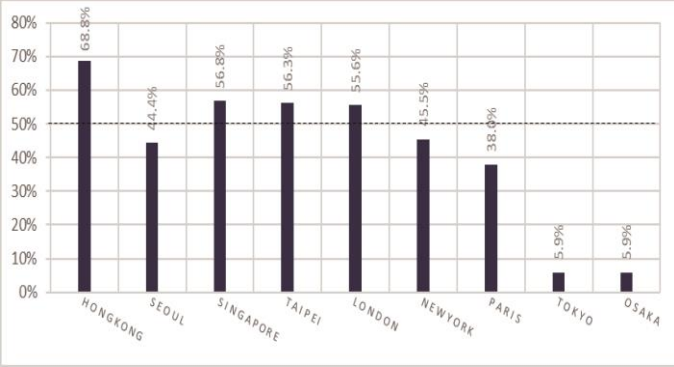


Figure 3 Buses accounting for the proportion of public transportation trips in typical international cities

Source: Reference [5]

2.3 Coordinated development of rail transit and buses

Although Chinese cities are generally facing the decline of bus passenger volume and most cities begin to see the reduction of bus passenger volume in the first or second year after opening the first complete rail transit line, this phenomenon is not inevitable. For cities where rail transit has entered the stage of network operation, most of them have experienced simultaneous growth of rail transit and bus passenger flows (Table 3). Especially in Guangzhou and Shenzhen, the continuous growth period lasted for six–seven years. All of these cities, without exception, did not pay less attention to buses and promoted bus reforms actively and effectively while rail transit was developing by leaps and bounds. Under the background of rapid development of rail transit, strong intervention of new transportation modes such as bicycle sharing, and general decline of bus passenger volume in China, Wuhan reversed the 3-year downward trend and realized the growth of bus passenger volume for two consecutive years, which is a result of increased attention to buses and radical reforms.

In addition, the growth of rail-transit passenger volume in cities across the world generally showed an S-shaped pattern, namely that the growth is slow first, then speeds up, and finally slows down and becomes stable (Figure 4). Currently, the rail-transit passenger volume is still at the initial stage or the rapid growth stage in most cities of China with rail transit, but it has begun to show a trend of slower growth in Beijing. With the increase in the scale of the rail transit network, it is a general rule that the passenger flow intensity and marginal effect will gradually decrease. On the other hand, it has become the new normal for some urban rail-transit systems to restrict passenger flow. Beijing Subway started to restrict passenger flow at stations as a normal operational measure as early as July 2012. As of January 2018, the number of stations where passenger flow restriction is implemented regularly has reached 96 in Beijing [6] and 51 in Guangzhou [7]. In the whole development process of rail transit, the integration and cooperation of buses are indispensable. The more advanced rail transit system needs the support of a higher level of bus services. Therefore, from the perspective of dynamic development and making up the shortfall, the focus of China's urban priority strategy of public transportation needs to return to buses urgently. The development of rail transit and buses should adhere to the principle of "both issues to be addressed actively". It should also focus on the development of buses by paying more attention, increasing investment, and establishing a coordinated relationship.

3 Bus reform experiences of cities

3.1 Cities not in China's mainland

Under the background of continuous development of rail transit, some cities had once faced the problem of continuous decline in bus passenger volume, and the trend was reversed through a series of reforms. The most typical cities are Seoul and Taipei.

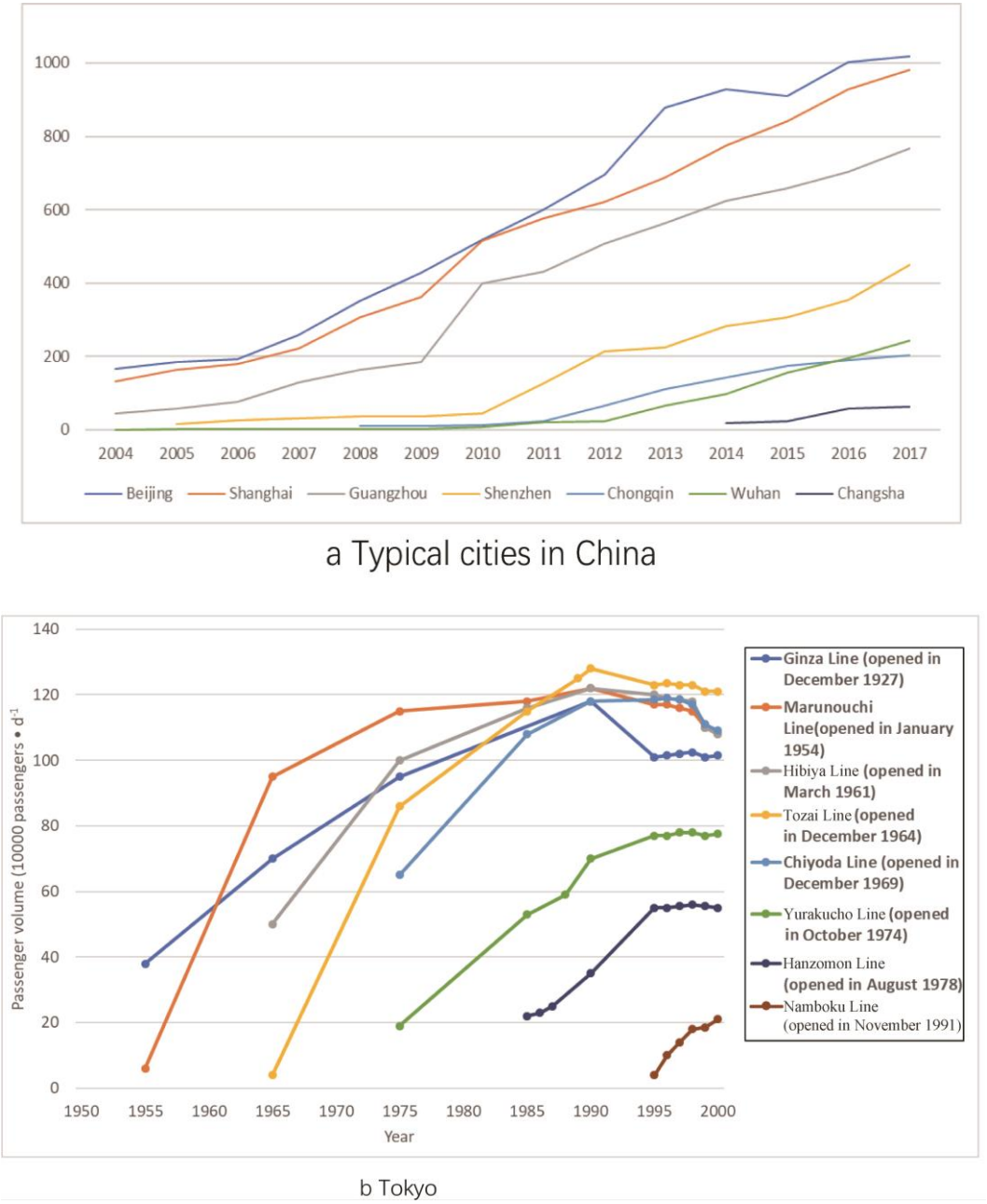


Figure 4 Trends of rail transit passenger volume in typical cities

Source: Figure 4a is based on cities' annual reports on transportation development and the statistical data from the government website, and Figure 4b is based on Reference [8].

Seoul was internationally known for its 2004 public transportation reform, whose biggest feature is that it carried out a package of reforms in multiple fields simultaneously [9–10] and had achieved remarkable results. At the beginning of the reform, Seoul's rail transit system was in a stage that was equivalent to China's middle stage or mature stage of urban rail transit network: It had eight lines with the daily passenger volume of more than 9 million passengers per day. Seoul's bus passenger volume dropped by half between the late 1980s and the 1990s while the previous piecemeal traditional reforms had not achieved expected results, so Seoul resorted to restructuring its reform strategies. In addition to adopting a new management structure and a new operation supervision and assessment mechanism, Seoul proposed three core measures: 1) strategic restructuring of the bus line network in one–three months, which divided it into four levels of

"suburban express line + trunk line + branch line + loop line", renumbering bus lines by regions and differentiating line levels by colors and bus models; 2) establishment of a brand new fare system by adopting distance-based pricing within the public transportation system, unifying the buses and rail transit rates, and implementing five free 30-min transfers between buses and between the buses and rail transit (at present in China, only Beijing required passengers to swipe cards to get on and off public transportation, which therefore has met the implementation conditions of distance-based pricing and uniform rates); 3) building the central bus lane network. After the implementation of the bus reform in Seoul, the bus passenger volume and the service level have been significantly improved, and a win-win situation has been achieved with rail transit, which laid the foundation for sustainable development.

In the early stage of rail transit development, Taipei, like most cities in China, suffered from the difficult situation in which metro construction led to a sharp decline in bus passenger volume, and this period was called "dark period of transportation". Therefore, after the opening of the first metro line in 1996, Taipei made a one-time effort in time to promote the formation of a gird bus lane network that consisted of seven lines and was 41 km long. Taipei also added connecting buses and public minibuses to provide connecting service and promoted discounted transfer between buses and metro. As a result, the bus passenger volume stopped the decline trend and rebounded. In the second stage of large-scale metro construction, Taipei strictly protected the bus right-of-way and the integrity of the bus lane network, preserved bus speed, reduced the impact of metro construction on bus operation, and built five new transfer stations to realize the reorganization of the bus line network by regions. In addition, expressways were also opened to public transportation by installing an inside high-load lane for passenger buses, tourist buses, etc. to connect the passenger flow in the remote urban area. Therefore, under the background of continuous growth of rail transit passenger volume, bus passenger volume had been stable for a long time (Figure 5).

3.2 Cities in China's mainland

3.2.1 With the development of rail transit, carry out large-scale optimization and adjustment of bus network, even structural reorganization

Beijing mainly adopted the optimization idea of optimizing the duplicate lines in urban areas, moving the transportation capacity from urban areas to periphery areas, and expanding the coverage of the bus line network. Beijing successively removed 93 lines that ran across the central urban area and reduced duplicate bus lines in urban areas by 1 927 km. It opened or adjusted 72 bus lines to connect to rail transit, 25 night bus lines, and more than 40 branch lines and loop lines in communities. Moreover, Beijing added 88 express bus lines running on freeways and expressways, which also operated express buses that only stop at major bus stops and community commuter express buses to meet the multi-level needs of passengers. Especially in 2007, Beijing's average bus line length decreased from 29.8 km to 26.9 km, with a drop of 9.5%. Bus passenger volume continued to rise until 2009, with an average annual growth rate of 9.1%.

Guangzhou carried out two large-scale bus network optimizations in 2003 and 2008, among which 217 bus lines were involved in 2008, which is the largest adjustment ever. Guangzhou opened 74 medium and small bus lines and 28 peak-period express bus lines, optimized 96 bus lines, and reallocated transportation capacity for 19 bus lines. After optimization, the nonlinear coefficient (ratio of the bus line length to the direct-line distance) of the bus network reduced from 1.9 to 1.73; the density increased from 3.81 to 3.93; the proportion of urban areas within 500 m of bus stops grew from 92% to 95.3%. After the optimization of the bus network, the daily bus passenger volume increased by 12.1% in 2009 compared with 2008, which maintained the growth trend until 2014 (excluding the abnormal fluctuations during the 2010 Asian Games).

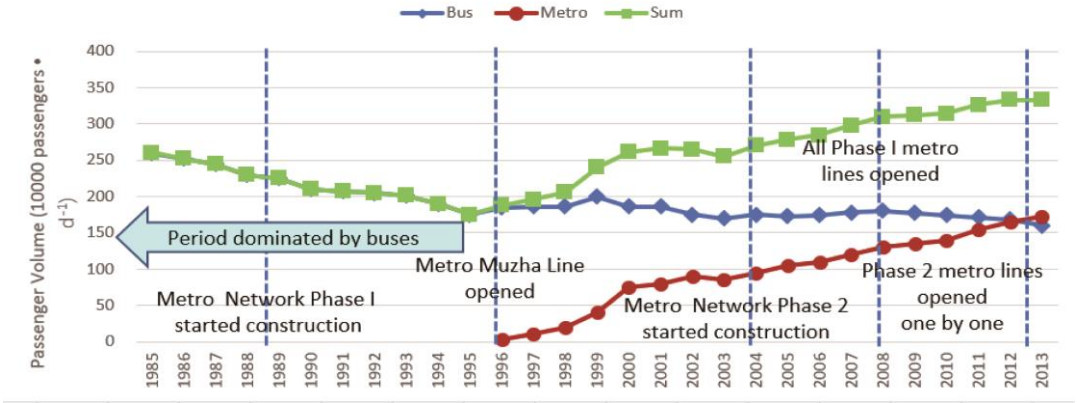


Figure 5 Taipei bus and subway passenger volume in different years

Source: Reference [11]

Shanghai adopted the strategy of optimizing the network structure by regions and functions: "reducing load" within the inner ring, "bridging" between the inner and outer rings, and "expanding the network" outside the outer ring. A network with a clear three-level structure and function was established, consisting of backbone lines, regional lines, and shuttle lines, and the bus network and the rail transit network were integrated into one network. According to statistics, from 2005 to 2009, Shanghai opened 270 new bus lines, extended 101 bus lines, adjusted 647 bus lines, and removed 89 bus lines. The average length of bus lines decreased from 23.4 km to 20.4 km, and the duplicate coefficient decreased from 4.6 to 3.41. The bus passenger volume increased continuously for four years from 2008 to 2011 (Figure 6).

In contrast, Wuhan has carried out a more centralized and vigorous reform. There were 371 bus lines in Wuhan in 2014. However, from September 2015 to the end of 2016, Wuhan intensively adjusted 234 bus lines, added or restored 70 bus lines, and suspended 28 bus lines in batches. Therefore, the reform involved more than 60% of existing bus lines, which was the radical structural optimization and reorganization of the bus network.

3.2.2 Implement fare reform widely to reduce the burden on passengers and promote the integrated transfer of buses and rail transit

Beijing started to issue "Yikatong" in 2007, which was a stored-value smart card that gave 60% bus fare discount to normal passengers and 80% discount to student passengers (the fares were CNY 0.4 and CNY 0.2 respectively after the discount). This measure improved the attractiveness of public transportation, which has led to a rapid growth in bus passenger volume with an annual rate of 9.1% for three consecutive years. A new round of fare reforms was carried out since December 28, 2014. Beijing then became the first city in China that required passengers to check in and check out on buses and implemented the distance-based tiered fare policy, which laid foundation for the reform of integrated fare of buses and rail transit.

Shenzhen started to reduce bus fares on December 1, 2007. The base bus fare was reduced from CNY 0.25 per kilometer to CNY 0.22. Paying by "Shenzhen Tong" smart card gave 20%, 25%, and 35% discounts to bus fares below CNY 3, between CNY 3 and CNY 6, and above CNY 6, respectively, besides the CNY 0.4 discount per transfer.

Guangzhou has carried out two rounds of fare reforms. First, the monthly bus pass was introduced on November 1, 2008. A 90-ride bus pass costed CNY 88, and a 2-bus-line monthly pass costed CNY 88 (student fare is CNY 50). Available metro passes were the 20-ride pass for CNY 55, the 35-ride pass for CNY 88, and the 50-ride pass for CNY 115, and students can enjoy additional 50% discounts. Starting from January 1, 2010, a monthly pass gave 5% discounts for the first 15 rides in a month and 40% discounts for subsequent rides. This discount policy was extended to metro passes after May 1, and students enjoyed additional 50% discounts.

Shanghai launched a pilot project on discounted transfer policies in November 2006 on some bus lines (air-conditioned vehicles only) and gradually expanded it to the main urban area. Staring from October 2007, rail transit was included in the discounted transfer program, and the discount increased from CNY 0.5 to 1 CNY. From April 1, 2009, the discounted transfer policy was further expanded to all public transportation in the city, and the transfer window was increased from 90 min to 120 min.

When Wuhan carried out the structural optimization reform of the bus network in 2015, it launched a bus discounted transfer policy at the same time. The core idea was that the first transfer was free if the transfer was within 90 min of fare payment by an IC card, and the second and third transfers enjoyed 40% and 30% discounts respectively. From the perspective of implementation effect, the per capita travel

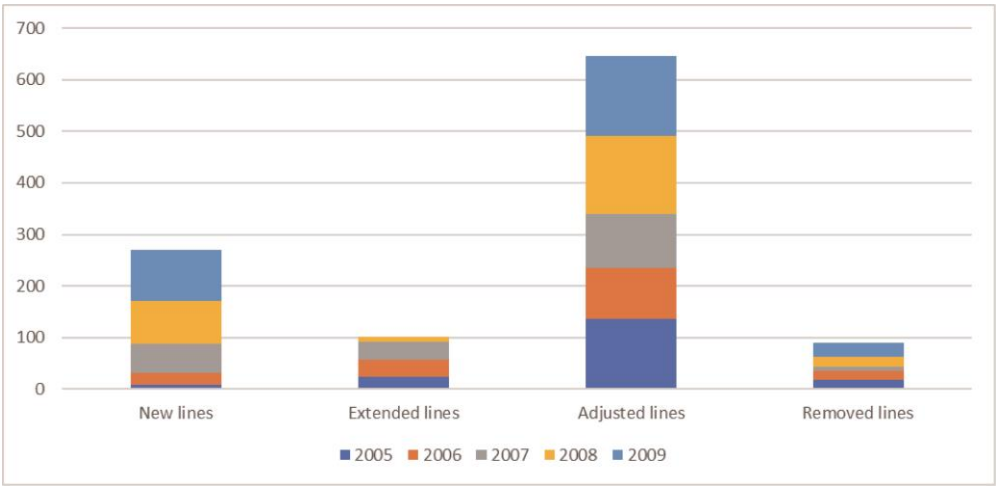


Figure 6 Bus network optimization in Shanghai

Source: Shanghai 2010 Annual Comprehensive Transportation Report

cost decreased by 11.2% per trip compared with 2016; the proportion of fare payment by public transportation IC cards increased from 78% to 82%; the proportion of transfer passengers increased from 15% to 22% (based on the number of times an IC card was used within 90 min). The fare policy has shown a significant impact on the cultivation and guidance of residents' travel habits. However, at present, the discounted transfer policy is only applied to buses, which is not applicable to rail transit.

The feedback of passenger flow showed that bus passenger volumes in the above-mentioned cities had all achieved substantial and sustained growth after the implementation of fare reforms. In addition, construction of bus lanes and transit hubs, intelligentization and informatization of public transportation, and promotion of clean energy are also some common measures taken by most of these cities. However, these measures are far less significant than the two measures mentioned above (network optimization and fare reforms) in terms of the scope of influence, the impact on the growth of passenger volume, and the effect of promoting the long-term development of buses.

4 General strategy and suggestions for bus reforms

4.1 The structural optimization and reorganization of the bus line network should be the key area of the bus reform, which will bring enormous benefit

The bus network is the basis of public transport operations. For passengers, the bus network is the carrier of public transportation services and determines the overall service level of public transportation, which is the key to improving the attractiveness of public transportation in the new era. For operation enterprises of public transportation, the bus network is related to the overall operating cost. In the past 10 years, with the continuous expansion of urban land use and urban scale, the bus network layout in most cities of China has still been in the natural development state of sprawl and cumulative superposition. In fact, the optimization and reorganization of the bus network structure is a process of manually intervening in the existing bus network layout and its operation organization structure through scientific methods and seeking a system optimal strategy based on the goals of passengers and bus enterprises. The bus GPS operation scheduling and the card-swiping big data exactly provide the practical carrier and technical means for this optimization. They also provide necessary support for the rapid insight into and continuous study of the impact of network adjustment on the operating cost and the passenger volume. Under the background of low transit fares, the function positioning of public welfare, the general trend of declining passenger volume and fare revenue, and the continuous increase in price level, the adjustment of bus network layout to optimize vehicle and staff scheduling has opened up a new development idea for bus enterprises to reduce the overall operating cost. This reform model needs less investment, shows effect quickly, and generally has huge potential. It can achieve multiple benefits such as significantly reducing enterprises' operating cost, improving service levels, and improving operational reliability. It is also an important breakthrough point for public transportation enterprises to move towards scientific and refined management.

Wuhan's experience can be summarized as the following three core measures. 1) An inclusive network structure and operation system composed of four levels of "express, trunk, branch, and microtype" were established. The traditional coopetition between buses and rail transit had been broken down, and rail transit was integrated as a part of the express lines into the bus network. In other words, buses and rail transit were allowed to coexist in the same corridor to meet different levels of passenger needs, and departure frequencies were adjusted according to the size of the passenger demand. This measure not only ensured the integrity and flexibility of the bus system itself but also flexibly met the needs of rapid expansion and effective integration of the rail transit system and promoted the integration of the two networks. 2) Long bus lines were dramatically split and simplified, and the transfer mode rather than the direct mode was adopted to organize the operation. After optimization, the average length of bus lines reduced by 8.1% from 18.3 km to 16.8 km; the economic efficiency of operations was significantly improved; the average daily number of bus departures increased by 13.6%; the average bus mileage decreased by 4%; the operating cost of enterprises was significantly reduced. 3) Multiple measures have been taken simultaneously to proactively adapt to and meet different levels of public transportation needs, including launching direct express bus lines that run on freeways (or expressways) to connect to new cities, opening branch bus lines to serve communities and microcirculation bus lines to connect to the metro, optimizing the matching of bus schedules with rail and metro schedules, starting night bus services, and employing internet technology to develop customized buses and mobile payment. As a result, the bus network density and coverage and passengers' satisfaction levels have all been optimized.

4.2 Free or discounted transfer for public transportation is the inevitable trend of reform in the new era

Among all the reforms in the field of public transportation, the reform of the fare system and fares is the basis of all reforms, which plays a central and regulatory role. Most cities in China still use the one-ticket fare system in public transportation, and transfers result in multiple increase in fares, which directly leads to passengers' widespread reluctance to transfers and becomes the pusher of the overstaffed and inefficient bus network. With the expansion of the urban

area and the increase in the radius of residents' activities, the multi-mode integrated transfer has gradually become one of the inevitable links in the travel of residents, and the one-ticket fare system is obviously difficult to meet the development needs. In 2009, a large-scale public transportation reform was also planned in Wuhan, but it was eventually rejected by the public. The fundamental reason is that the reform of the fare system was not included in the plan [12]. Therefore, in order to promote the reform of the bus system, we should first implement the policy of free or discounted transfers among buses to remove the fundamental constraints on the optimization and reorganization of the bus network. Then, to promote the overall effectiveness of public transportation, we should improve the discounted transfer between buses and other transportation modes, such as rail transit; or we should establish an integrated charging mode based on mileages and a reasonable price relationship of different service modes.

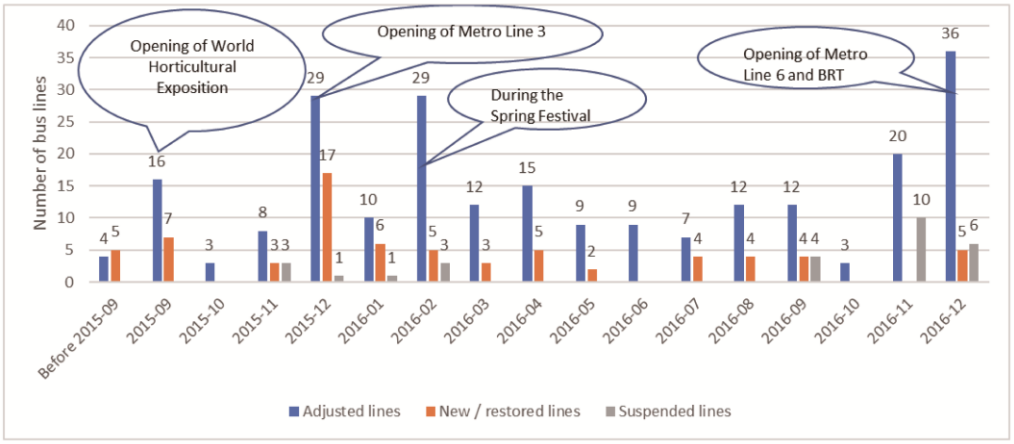
The practice of Wuhan showed that although free or discounted transfers caused the decline of farebox revenue, the improvement of the overall operational efficiency and service level of the bus network would induce new passengers and increase farebox revenue. At the same time, the current bus transfer rate is low in China, so discounted transfer policies will not put too much financial burden to the government. However, after these policies are adopted to promote the reorganization of the bus network and the optimization of the operating organization, the comprehensive cost of public transportation enterprises would be substantially reduced, which would fully cover or even exceed the loss in farebox revenue and finally achieve a win-win situation of passenger flow growth and operating cost decline.

4.3 Comprehensive communication, risk prevention mechanism, and gradual implementation strategy are important guarantees for the implementation of the reform

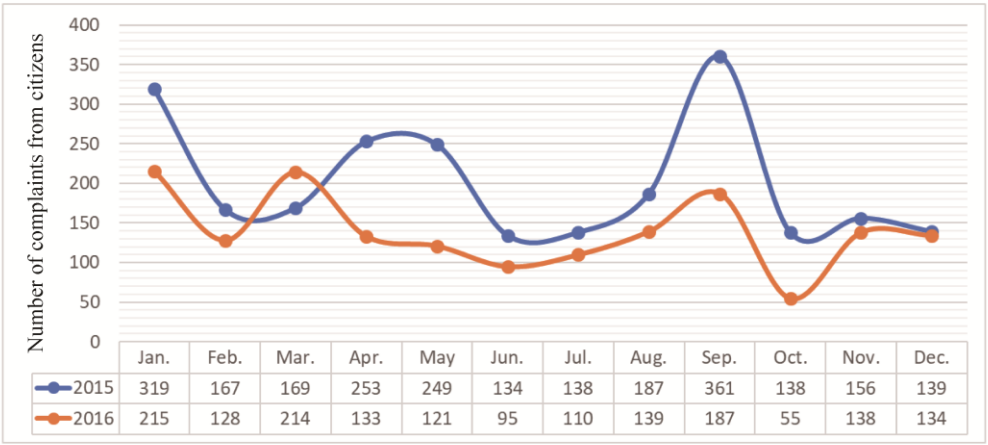
Although the reform with the bus network as the core needs less investment and shows effect quickly, it involves a wide range of people, which is closely related to the long-term travel habits of the residents and often involves the travel of millions of passengers every day. Therefore, the path, strength, and implementation strategy of the reform are extremely important. In short, it has two modes, the radical mode and the gradual mode. The radical reform mode is represented by Seoul, South Korea. Its typical feature is to adjust more than 460 bus lines in one to three months and to re-number all bus lines and establish a new vehicle color identification system at the same time, which is equivalent to disassembling the original bus network and reorganizing it. The whole work was presided over and supervised by the former mayor at that time, which required a government with strong mobilization and organization capabilities. Therefore, although Seoul's public transportation reform has achieved great success, few cities have been able to fully replicate it. The gradual reform mode is applicable to many cities. It divides the structural optimization and adjustment of the whole bus network into several parts and implements some of the parts in batches within a period of time. For the better implementation effect and less interference to the travel of the public, small-scale high-frequency adjustments are preferred. After each adjustment, feedbacks should be followed up and public opinions should be collected in time, which are used to locally optimize the previous plans in the next batch of bus line adjustment to achieve rapid iteration and dynamic feedback (Figure 7). The success of bus reform in Wuhan lies in two reasons. On the one hand, the policy of the first transfer being free was implemented. This policy allowed the government to pass benefit to the public, clear the way for the reform and reduce the resistance. On the other hand, in the process to restructure the bus network, the network optimization was promoted quickly by taking the favorable opportunities such as the Horticulture Expo, the opening of new rail transit lines, and the low passenger flow during the Spring Festival [13]. At the same time, opinions were solicited extensively from all sectors of society before and during the reform, and risks were prevented timely through multiple mechanisms, such as independent third-party risk assessment, satisfaction evaluation, and dynamic tracking of residents' complaints, to ensure the smooth implementation of the plan. All these experiences are worth summarizing and learning.

5 Conclusion

This paper studies the problem of the widespread continuous decline of bus passenger flow under the rapid development of urban rail transit in China. It elaborates the importance of bus development for the public transportation priority strategy in the new era and clarifies the understanding and positioning of buses, which emphasizes that the focus of the public transportation priority strategy should return to buses. Based on the analysis of the measures taken in urban public transportation reforms, the paper proposes that in the new era, the bus reform should take the structural optimization and adjustment of the bus network as the key breakthrough point and take the free or discounted transfer policy as the basic premise. The bus reform should also establish the comprehensive communication and coordination mechanism and the risk prevention mechanism in the implementation and adopt the gradual implementation strategy of small-scale, high-frequency, and fast iteration. What needs to be added is that public transportation enterprises are actually the most important participants of the bus reform. How to stimulate the enthusiasm of public transportation enterprises to participate in the reform is very important to the effectiveness of the reform, the improvement of operational efficiency and service level, and the reduction of enterprises' comprehensive operating cost. In particularly, big data and methods of



a Implementation



	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
2015	319	167	169	253	249	134	138	187	361	138	156	139
2016	215	128	214	133	121	95	110	139	187	55	138	134

b Complaints after implementation

Figure 7 Implementation of structural optimization and reorganization of bus network in Wuhan

Source: Reference [13].

operations should be employed to optimize the scheduling of vehicles and staff to change the extensive management mode that is based on persons and experience.

References

[1] Tian Shimo, Lu Fang, Yang Ke, et al. China's Operational Urban Rail Transit Lines, 2017: Statistics and Analysis [J]. Urban Rapid Rail Transit, 2018, 31(1):16–20 (in Chinese).

[2] Ministry of Transport of the People's Republic of China. China Urban Passenger Transport Development Report (2016) [R]. Beijing: People's Transport Press Co., Ltd., 2017 (in Chinese).

[3] Ministry of Transport of the People's Republic of China. China Urban Passenger Transport Development Report (2015) [R]. Beijing: People's Transport Press Co., Ltd., 2016 (in Chinese).

[4] 2016 Annual Statistics and Analysis Report of Urban Rail Transit [J]. Urban Rail Transit, 2017 (01): 20–36 (in Chinese).

[5] Aguilera A, Grebert J. Passenger Transport Mode Share in Cities: Exploration of Actual and Future Trends with a Worldwide Survey [J]. International Journal of Automotive Technology and Management, 2014, 14(3/4): 203–216.

[6] Xinhua News Agency. Passenger Flow Restriction Is Implemented Regularly at 96 Subway Stations in Beijing [EB/OL]. 2018[2018-01-07]. http://www.bj.xinhuanet.com/bjyw/2018-01/07/c_1122222127.htm (in Chinese).

[7] Xinhua News Agency. Guangzhou Metro Started Regular Passenger Flow Restriction Today at Three Stations [EB/OL].2018[2018-01-08]. http://www.gd.xinhuanet.com/newscenter/2018-01/08/c_1122227155.htm (in Chinese).

[8] Ye Xiafei, Ming Ruili, Li Renxiang. Rail Transit in Tokyo and Seoul: Development Trends & Characteristics of Passenger Flow [J]. Urban Transport of China, 2008, 6(6):16–20 (in Chinese).

[9] Kim Gyeng Chui. Toward Better Public Transportation Experiences and Achievements of Seoul [J]. Translated by Jin Fan, Fang Yuwei, Liu Daizong. Urban Transport of China, 2006(3): 27–32 (in Chinese).

[10] Kim Gyeng Chui. Toward Better Public Transportation Experiences and Achievements of Seoul [J]. Translated by Jin Fan, Fang Yuwei, Liu Daizong. Urban Transport of China, 2006(4): 35–40 (in Chinese).

[11] THI Consultants (Shanghai) Inc. Special Topic on Public Transportation Integration in Wuhan Comprehensive Transportation System Planning Revision [R]. Wuhan: THI Consultants (Shanghai) Inc., 2015 (in Chinese).

[12] Zheng Meng, She Shiying. Plight and Strategies of Wuhan Public Transit Reform [J]. Urban Transport of China, 2012, 10(1): 61–67 (in Chinese).

[13] Wuhan Transportation Development Strategy Institute. Structural Optimization and Adjustment Plan of Wuhan Public Transportation Network [R]. Wuhan: Wuhan Transportation Development Strategy Institute, 2015 (in Chinese).

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