

Analysis on Improving the Utilisation Rate of Commuter Railways in Mature Metropolitan Areas in China in the Context of High-quality Development

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Abstract. China's six mature metropolitan areas are facing a shortage of land resources. Commuter railways are a solution to this problem in the context of high-quality development. Nevertheless, the current commuter rail utilisation rate in these metropolitan areas is significantly lower than those in developed countries. Therefore, on the basis of analyses through the literature survey method, this paper collects the latest data on commuter railway services in the six metropolitan areas to discuss the reasons for the current low utilisation of commuter railways in terms of coverage, efficiency and operation, and to propose corresponding practicable solutions. The study found that the number of routes currently in operation is too small. In addition, there are issues including irrational station distribution, sparse train frequency and short operating hours and slow interchange in the services, all of which make the commuter railways fail to achieve the idealised time-saving effect, and serve as a reason for commuters to rely on private cars. In the foreseeable future, with the imposition of the concepts of sustainable development, transportation integration and service orientation, there is possibility that the utilisation rate of commuter railways in these metropolitan areas will be elevated.

Keywords: metropolitan area, commuter railway, operation, sustainable development.

1. Introduction

In China, the ratio of urban population set to increase by about 15% to about 80% from 2023 to 2035 [1]. While urbanisation is still at a high rate of growth, it is worth pointing out that the largest contributors to the increase are China's 34 metropolitan areas. They have a total population of approximately 900 million and a Gross Domestic Product (GDP) share of 78%, and various industries are highly concentrated in them [2]. However, the influx of population has inevitably resulted in the over-consumption of land resources for construction in these areas, and the carrying capacity of land is close to the limit. For example, as the core city of the Shanghai metropolitan area, the population of Shanghai has been in the range of 24-25 million for eleven consecutive years. Obviously, this has become a major challenge for China's territorial spatial planning and sustainable development process. Under this circumstance, the spatial structure of cities within China's metropolitan areas needs to undergo a large-scale reshaping, from developing independently around central urban areas to directing the development towards the suburbs or neighbouring towns. The existing mainstays that connect the main city to the suburbs or neighbouring cities - road transport, is highly private, which is also accompanied by air contamination issues. Without the addition of new corridors, the increase in the population carrying capacity of urban agglomerations contradicts China's goal of achieving peak greenhouse gas emissions (basically in the form of lower carbon dioxide emissions) by 2030 [3]. Although the government is rapidly deploying electric vehicles, long distances caused by road instability (i.e. congestion that could occur at any time) will still leave the suburbs or neighbouring cities highly fragmented from the core city. A high-capacity and fast public transport system, represented by railway transit, will be a key link between the future core city and its neighbours then, by drastically reducing the distance between time and space while achieving low carbon emissions per capita. In accordance with the State Council of China, by 2025, comprehensive transportation will make substantial breakthroughs in intelligence and greening, and significantly improve the comprehensive capacity, service quality, operational efficiency and overall benefits, so that the development of transportation will advance to world-class level [4]. Despite reaching world leading

levels in urban rail transit and high-speed railways, China's commuter rail transit is lagging behind. There are six mature metropolitan areas in China (Shanghai, Shenzhen, Guangzhou, Beijing, Hangzhou, Suzhou-Wuxi-Changzhou) that are supposed to represent the country's lead, but even their commuter rail systems are generally utilising below world-class standards. This paper carries out a study that explores the performance and causes of low utilisation of commuter rail transit in China's six mature metropolitan areas through literature methodology, and analyses the conceptual approach to bring the utilisation up to world-leading standards.

2. Differences and Status Quo of China's High-speed Railway, Metro and Commuter Railway

2.1. China's Highspeed Railway and Metro

China has the most developed high-speed railway system in the world, which substitutes the majority of other transit ways for long-distance intercity journeys. For instance, merely 1.5 months after the opening of the high-speed railway connecting Zhengzhou and Xi'an in 2010, all flights connecting the two cities were cancelled until now [5]. Under the command of the China Railway Corporation, China's high-speed rail mileage had reached 42000 kilometres by 2022, while with the lifting of massive blockage of the Covid-19 transmission, China's railways are expected to return to 2019 levels with 2.7 billion passenger journeys in 2023 [6]. Meanwhile, with cities including Shanghai, Beijing, Guangzhou, Shenzhen, Chengdu, Hangzhou, Chongqing, Wuhan and Nanjing overtaking traditional metro cities such as London and New York in terms of metro mileage in recent years, the world's top ten metro systems are starting to be dominated by China with nine seats in 2022, and are predicted to remain for a long term. It is evident that China is a global leader in high-speed rail and metros. However, the problem with the former is its 'point-to-point' nature, with stations spaced standardly 30-60 km apart, making it suitable only for long-distance journeys; the problem with the latter is its over-concentration in the heart of the city. For example, in Shanghai, 60% of metro interchanges (49 out of 82) are currently located in the 'Inner Ring Elevated Road', which occupies less than 2% of the total territorial area.

2.2. China's Commuter Railway

Although there is currently no universally accepted definition of commuter railways, for the purpose of this study it has been characterised as a railway mode intermediate between the two modes described above, mostly with large capacity, moderate operating speeds and linear station spacing, and primarily serving residents with suburban commuting needs between several neighbouring urban cores [7]. In many metropolitan areas in developed countries, commuter railways are networked and widely used. For instance, in Greater Tokyo, about 30 railway operators provide more than 120 routes of suburban commuter services. They are virtually significant for densely populated metropolitan areas to restructure their industries, optimise their spatial distribution and achieve sustainable economic development [8]. Commuter railways in China originated very early, but their development has been unusually slow. For mining purposes, Fushun in northeastern China initiated China's first commuter railway system in 1904 by Manchurian Railways, but due to the depletion of coal resources, the Fushun Mining Group which took over the system suspended passenger services in 2009. Moving to the present, in the six mature metropolitan areas of China, only about 12% of commuters use railways to commute between cities. This data is only about one-third that of the Tokyo metropolitan area, and it is only the average for the entire UK. It is the commuter railways that are largely responsible for this gap.

3. Reasons behind Low Utilisation of Commuter Railway in China's Six Mature Metropolitan Areas

3.1. Inadequate Planning and Construction

Cities in China had previously failed to adequately consider future urban development and cross-city commuter population growth, resulting in an early start but late development and low coverage of commuter railways. After the Fushun Electric Railway mentioned above, China's second commuter railway, the Beijing Metro Line 13, opened in 2002, nearly a century later. To date, only 19 of China's 34 metropolitan areas (55.9%) have commuter rail systems, and 7 of these have just two or fewer, which can be considered as non-networked (see Figure 1). Of the six mature metropolitan areas in China, only the Beijing and Guangzhou metropolitan areas have more than 10 commuter railways, which is far below the standard of the Tokyo metropolitan area, which has a similar population. Although no actual data is available, it can be surmised that commuter rail mileage per square kilometre in China's major metropolitan areas is very low, making it unlikely to meet the demand for large-scale cross-city commuting.

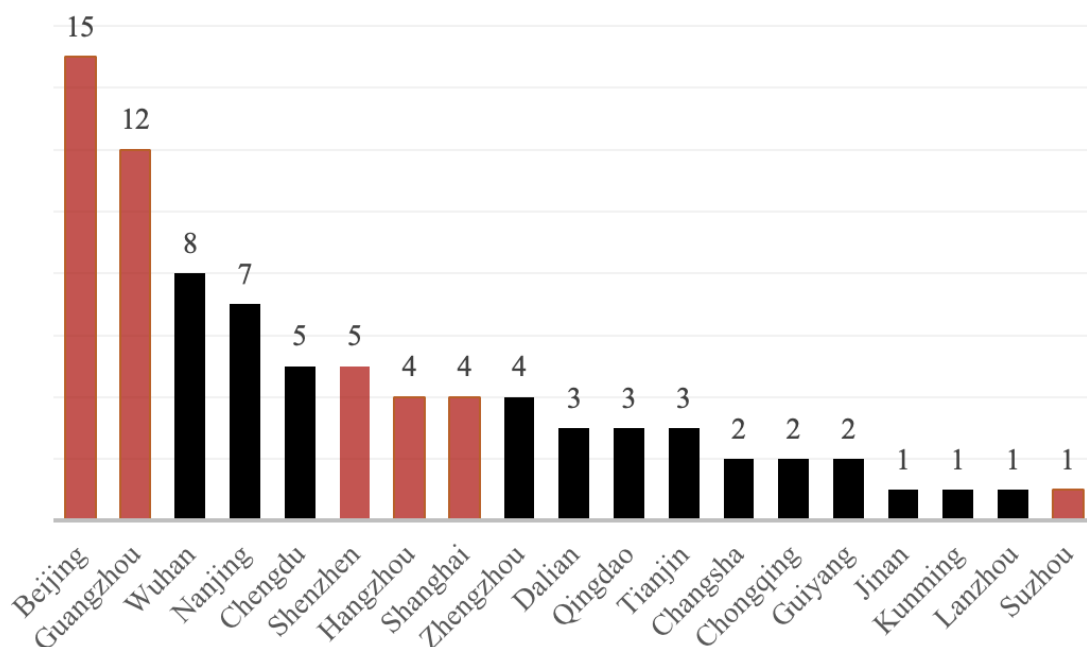


Figure 1. Number of Commuter Railways in Metropolitan Areas of China

3.2. Over-reliance on Private Vehicles

There are three modes of cross-city commuting: core-to-core, border-to-core, and border-to-border. The latter two often rely on private vehicles to a great extent. For the second mode, for example, from Huaqiao in Suzhou to Lujiazui in Shanghai, some residents' homes are more than walking distance from the commuter railway station, and also involve crossing boundaries. E-bikes, which are commonly applied as mobility tools, are difficult to use across the city due to policies (local licence plate requirement). For the third mode (like from Huaqiao in Suzhou to Anting in Shanghai), commuter rail stations across the two municipalities may be too far from both homes and workplaces, and travelling by rail takes significantly longer than travelling by car. In these cases, private cars are preferred and, correspondingly, rail transit is less utilised.

3.3. Inappropriate Operation

China's current commuter railways suffer from irrational operation management. The current commuter railways are divided into two categories according to their operators, which are managed by local metro corporations (constructs new tracks) and the China Railway (utilises existing railways).

Currently, China still lacks a national standard for commuter railways, and the current standard issued by the Beijing government states that commuter railways should have a station spacing of around 3km, a running interval of less than 6 minutes between peak hours and 15 minutes between off-peak hours (10-20 minutes for lines using existing railways), and a full day's operating time of more than 17 hours to ensure operational efficiency [9].

Almost all of the commuter railways operated by metro groups in China's six mature metropolitan areas are built according to metro technologies, which can be viewed as simply extending urban metro lines from the city to the suburbs. In fact, there are apparent differences between suburban lines and urban lines in terms of functional positioning, passenger flow characteristics, operational organisation and signalling modes [8]. The consequence of this is that the average station spacing is too short, requiring frequent slowdowns and stops and thus increasing journey time. The average station spacing of Beijing Yizhuang Line, Yanfang Line, Line S1, Suzhou Line 11 and Shenzhen Line 6 is less than 2 km, which is far below the standard (see Figure 2).

The problem is even more pronounced on the lines currently operated by the China Railway. First of all, contrary to the previous point, station spacing on lines operated by the national railway is generally too long, with the Pingshan Rapid Line in the Shenzhen metropolitan area even reaching a station spacing of nearly 40 km, which is close to that of high-speed railways (see Figure 2).

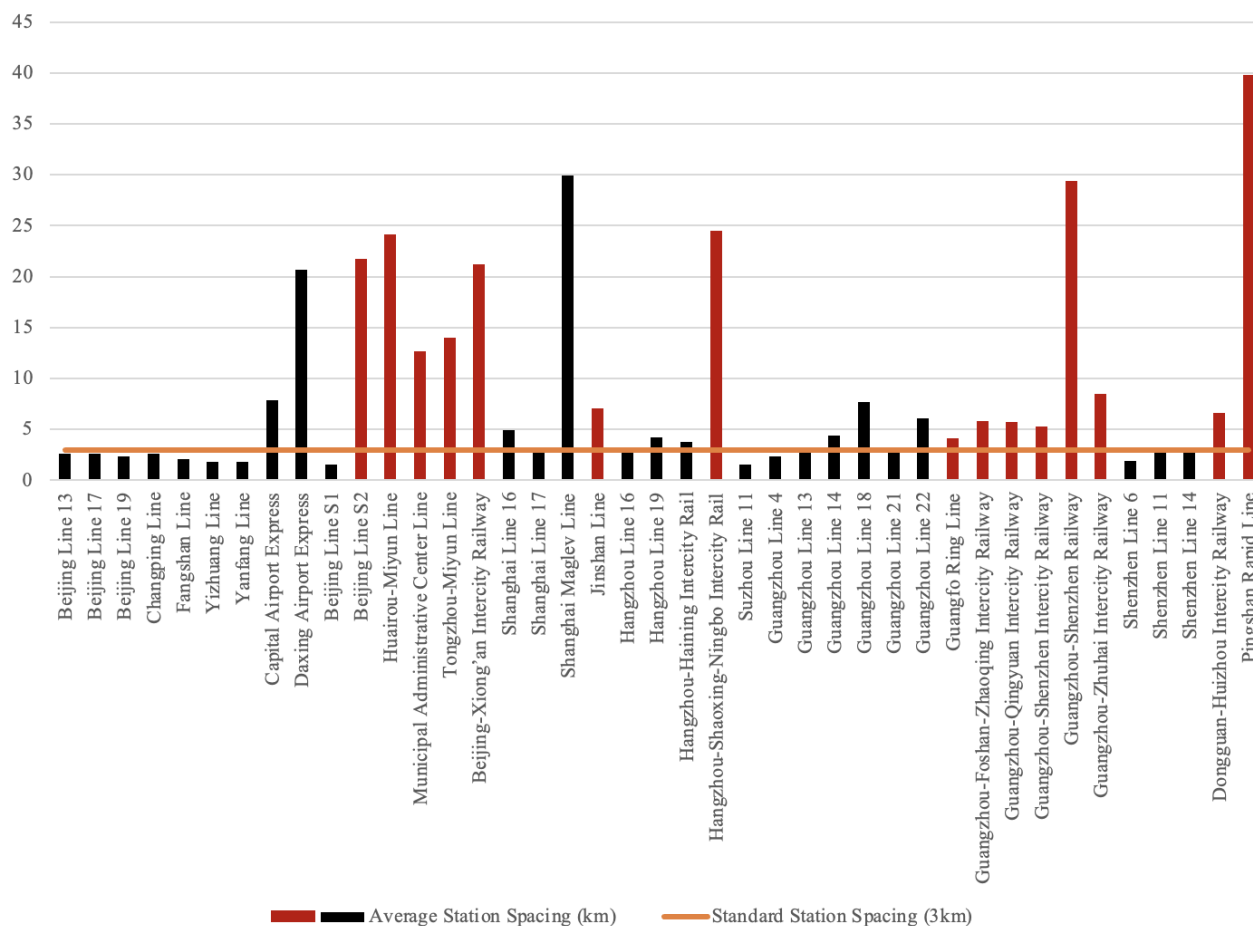


Figure 2. Average Station Spacings of Commuter Railways in China's 6 Mature Metropolitan Areas (Black: Operated by Metro; Red: Operated by China Railway)

Simultaneously, the running intervals of some lines are seriously larger than the standard. Almost all lines operated by metro groups meet the 6/15 minute headway criteria, while none of the lines operated by the China Railway meet the 10/20 minute headway criteria, and 12 of them have a maximum headway even greater than one hour (see Figure 3). This means that commuters need to travel 'on the clock' and the railways are of very little value to residents who do not commute close to the departure time of trains.

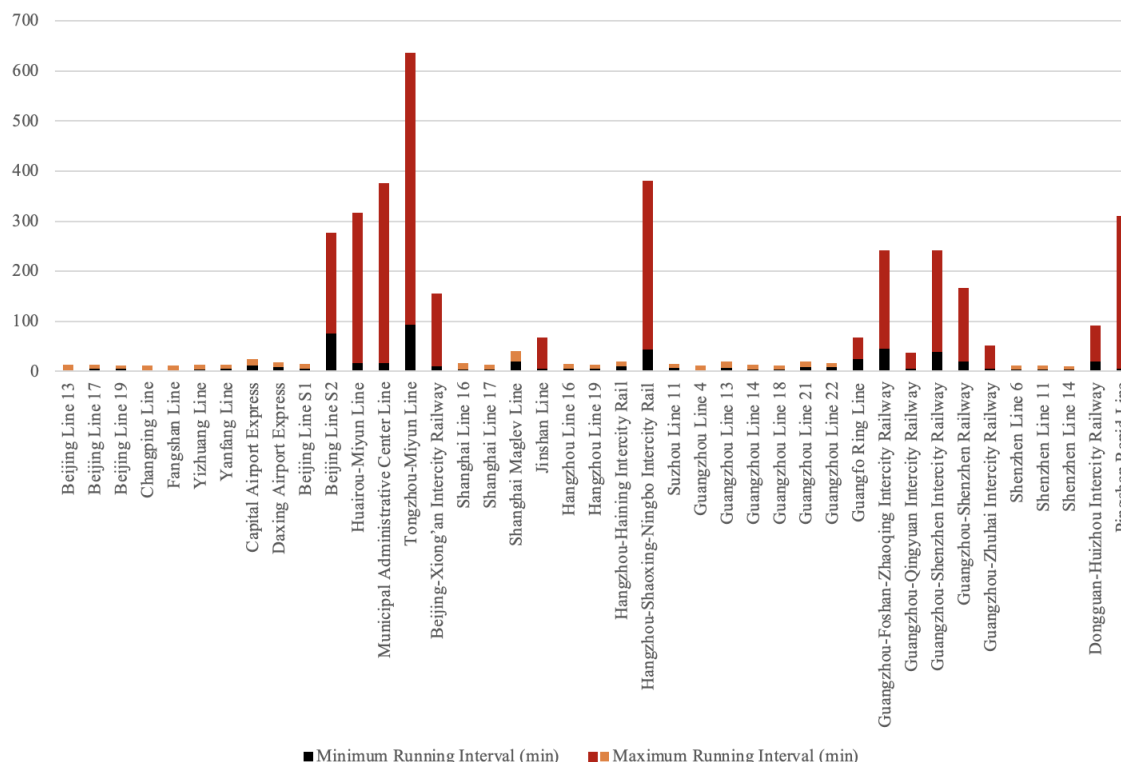


Figure 3. Running Intervals of Commuter Railways in China's 6 Mature Metropolitan Areas (Black and Orange: Operated by Metro; Black and Red: Operated by China Railway)

In addition, for the operating length, 25 out of 26 lines (96.2%) operated by metro conform to the 17 hours standard, whilst merely 5 out of 15 lines (33.3%) operated by China Railway satisfy it (see Figure 4). The short operating hours of these lines usually manifests itself in early last trains, which is unfriendly to commuters who work overtime.

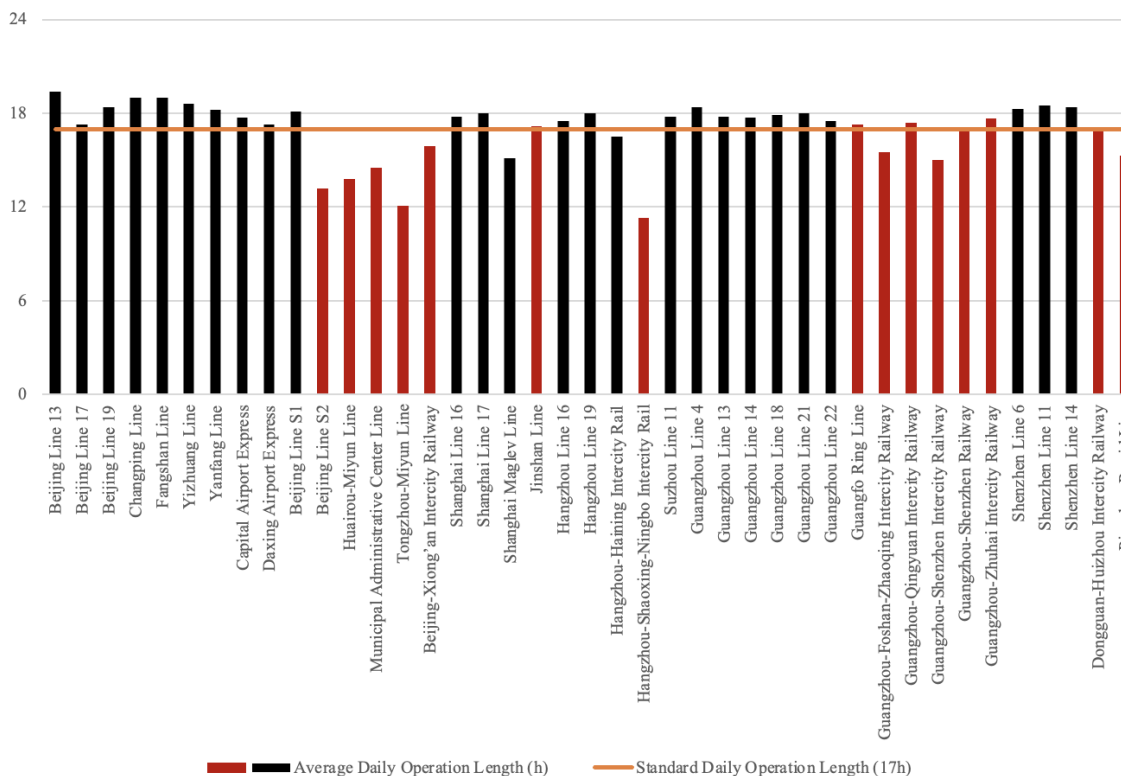


Figure 4. Average Daily Operation Lengths of Commuter Railways in China's 6 Mature Metropolitan Areas (Black: Operated by Metro; Red: Operated by China Railway)

3.4. Inconvenience of Transferring

It is time-consuming to transfer from other modes of transport to the commuter railways. Firstly, the frequency of buses travelling between residential areas and stations is low. Secondly, the service area of shared bikes, which are widely used in urban areas to solve the ‘last mile’ problems, sometimes does not include suburban areas. Lastly, all lines operated by metro groups require baggage screening, while lines of the China Railway have even more cumbersome security measures, with steps such as scanning ID cards for face recognition and full-body security checks on top of this. These standards are largely unchanged from those of long-distance trains. The time taken to transfer to commuter rail lines largely offsets their high operating speeds, which becomes another factor that keeps time-sensitive commuters from travelling by train.

4. Suggestions for Increasing Commuter Railway Utilisation in China’s Six Mature Metropolitan Areas from a Conceptual Perspective

4.1. Sustainable Development Concept

The concept of sustainable development is central to attracting residents to commute between urban and suburban areas or across cities, and this is reflected in intensive development represented by the TOD (Transit Oriented Development). In 1993, Peter Calthorpe introduced the TOD concept, which is the replacement of urban sprawl with new multi-point community patterns centred on railway stations. At the moment, the urban development boundary delimited by the government has become the bottom line for controlling urban sprawl and ensuring ecological benefits in China [10]. In China’s 14th Five-Year Plan, a major focus is on accelerating the construction of commuter railways as a basis for promoting compact development characterised by integrated functions, three-dimensional development and the coordinated use of space above and below ground [11]. This corroborates the government’s endorsement of the TOD concept. Laying out compact neighbourhoods along train stations can effectively respond to policies and stimulate the potential of existing land, and the dense mixed-use concept allows private developers to subsidise the residential portion from profits on commercial space, while the government is able to invest more into commuter rail construction from land sales. At present, the use of TOD for urban metro in China has become commonplace, but the TOD based on commuter railways has yet to be boosted. Formed in 2020, the Hangzhou Metro Line 16 Qingshan Lake Science and Technology City is one of the few examples of application of TOD to a commuter railway in China’s six mature metropolitan areas. With such policy support, this development is highly viable and reproducible, and it can also transform suburban neighbourhoods from dreary ‘dormitory towns’ into attractive complexes.

4.2. Integration of Transportation System Concept

China’s six mature metropolitan areas should take the lead in expanding the concept of multimodal transport systems in the suburbs. First, for commuter railways that use existing railways, China Railway could open up more rights of way to commuter railways by optimising the signalling system, so that running intervals can reach idealised standards and resources are fully shared. However, the marketisation involved needs to prevent the railways from being monopolised by the rich and thus preventing further improvements in services [12]. Secondly, against the backdrop of the public transport priority development strategy, the management of the metropolitan area can use the commuter railways as the backbone, and can effectively connect the railways to the residential areas by means of high-density buses with small capacities, and at the same time increase the right of way of the buses by means of setting up special lanes [4][13]. The speed advantage of commuter rail can only be demonstrated if other transport is thoroughly integrated with it.

4.3. Service Orientation Concept

It is vital to take the interests of the public as an important basis for decision-making, provide high-quality rail transport services, and place the public's experience at the centre of services. While extending the daily operating hours of commuter railways operated by China Railway to the 17-hour standard is an important step in optimising the operation of the service, in the future the six mature metropolitan areas should aim for the 20-hour daily operating standard in world's top metropolitan areas such as Tokyo and London, and provide overnight services on popular routes during weekends. Simultaneously, more commuters will be attracted if the current China Railway commuter rail fares are replaced with a shared fare system with the metro network [13]. Furthermore, from a safety perspective, the health status of rail facilities can be monitored in real time by a rail intelligent operation and maintenance system, reducing the reliance on traditional manual judgement [14]. Service enhancement implements high-quality development and can improve the competitiveness of commuter railways.

5. Conclusion

This study finds that in China's six mature metropolitan areas, commuter rail is generally underutilised compared to urban metro and high-speed rail, with long-distance commuters relying heavily on carbon-intensive cars and failing to keep pace with international standards. In addition to the late initiation and few lines, a major reason for this situation is that lines of metro groups suffer from overly dense stops due to unclear positioning between conventional metro and commuter railway, while lines of China Railway fail to adapt to the potential demand in terms of operation and transferring convenience on a wider scale. In the context of high-quality development, the government should adhere to the concepts of sustainable development, integration of transportation systems and service orientation, and guide more residents to be willing to relocate from the urban core to commuter rail coverage areas and make long-distance trips via commuter railways. This study provides statistics and analyses of the latest running intervals and operating hours of commuter railways in China's six mature metropolitan areas, which contributes to identify the shortcomings of the current services more comprehensively. Finally, although digitisation has opened up networked global spaces where mature metropolitan areas can learn from each other, this study fails to offer more contextualised recommendations for commuter rail development in China's 28 remaining developmental and nascent metropolitan areas, which are less globally influential. In the future, the issues and solutions of low commuter rail utilisation in metropolitan areas can be studied in depth on a national scale through more precise qualitative and quantitative methods like questionnaires, interviews and data modelling.

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