China's public transport in its present and future

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Abstract. The People's Republic of China is the third largest country in the world in terms of territory, behind Russia and Canada, and the first in terms of population. China is a dynamically developing country, and its economy is growing at an annual rate. Public transport is crucial to the development of China's economy, and especially railways. It is noted that the railways in China are one of the main components of the country's economy. Statistical data on the public transport system in China are analyzed in this article. It considers types of public transport and reveals their crucial role in the economic and social life of the country. It analyses the dynamics of population growth in the country and development needs of passenger transport. The ways and means of modernizing existing transport structures and the rate of construction of new ones are considered. A comparative study of the length and density of roads and railways of two countries is made, the Russian Federation and China. The prospects for the development of public transport in the PRC are considered, and the main aspects of the government's plans up to 2035, including the introduction of the latest technical and logistical developments in the field of public transport, are studied.

1 Introduction

The People's Republic of China is one of the largest countries in the world, the third largest country in the world in terms of territory and the first in terms of population. China is a dynamically developing country, and its economy is growing at an annual rate.

According to statistical data, in the People's Republic of China (hereinafter referred to as PRC) 228 cities have the population over 200 thousand people, 462 cities have population over 100 thousand people, and 912 cities have population over 53 thousand people. The total number of inhabitants of the People's Republic of China is 1 443 981 565 as of 2021. The change in the population of the People's Republic of China since 1950 is shown in Figure 1.

Since 2010, China's population has grown by almost 100 million inhabitants. Growth has been about 0.5% a year, which is negligible compared to more than 100 of the largest countries.

More than 800 million people (61%) live in China's cities, and just over 550 million people (about 39%) live in the countryside. China's population density is 150.75 people per square kilometer.

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Table 1 presents a list of the largest cities with population of millions of people in the People's Republic of China.

Table 1. List of major cities in the People's Republic of China.

<table>
<thead>
<tr>
<th>no</th>
<th>Name, city</th>
<th>Population, people</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chongqing</td>
<td>39,914,073</td>
</tr>
<tr>
<td>2</td>
<td>Shanghai</td>
<td>24,150,081</td>
</tr>
<tr>
<td>3</td>
<td>Beijing</td>
<td>21,705,021</td>
</tr>
<tr>
<td>4</td>
<td>Tianjin</td>
<td>14,425,023</td>
</tr>
<tr>
<td>5</td>
<td>Nanyang</td>
<td>12,010,049</td>
</tr>
<tr>
<td>6</td>
<td>Baoding</td>
<td>10,700,020</td>
</tr>
<tr>
<td>7</td>
<td>Harbin</td>
<td>10,636,034</td>
</tr>
<tr>
<td>8</td>
<td>Shenzhen</td>
<td>10,358,001</td>
</tr>
<tr>
<td>9</td>
<td>Wuhan</td>
<td>10,220,051</td>
</tr>
<tr>
<td>10</td>
<td>Guangzhou</td>
<td>10,000,039</td>
</tr>
<tr>
<td>11</td>
<td>Shijiazhuang</td>
<td>9,600,036</td>
</tr>
<tr>
<td>12</td>
<td>Xuzhou</td>
<td>9,468,091</td>
</tr>
</tbody>
</table>

There are 108 cities with a total of one million inhabitants in China. The largest city in terms of population is Chongqing, with 39,914,073 people. China's current million-plus cities are huge, especially those at the top of Table 1. However, in the not too distant future, truly gigantic urban agglomerations may be formed, combining several Chinese megacities at once.

The future mega-city: Jing-Jin-Ji, which scientists estimate has an expected population of 130 million. The Chinese government has long harboured plans to merge the cities of Beijing, Tianjin and Hebei. According to the World Economic Forum (WEF), "by reducing congestion in Beijing, moving polluting heavy industry out of the capital ... the authorities hope to create a more balanced economic structure." According to the WEF, the area's current population is 130 million, more than the whole of Japan. The take on "Jing-Jin-Ji" combines Beijing, Hanjin and "Ji", an alternative name for Hebei.

Together with the growth and development of cities in the People's Republic of China, public transport is developing rapidly. Public transport in China is a driver of the country's social and economic development.
1.1 Relevance

The relevance of the study is determined by the fact that China is a dynamically developing country with a large number of million-strong cities, and in this environment it is critical to continuously develop the public transport network.

Public transport provides access to education, medical care, economic activities, and enables all areas of China's economic life to function effectively. As the country's economy develops, the transport industry must change in line with the dynamics of demand for transport services.

1.2 Literature review

Research on public transport in the People's Republic of China, development and environmental issues has been devoted to a significant number of scientific works [1 - 13]. Scientific papers [1-3, 10] emphasise that urban development is inextricably linked to the growth and modernisation of public transport. The study [4] proves that traffic congestion and accidents on the roads have a negative impact on urban development. In [5], data on how COVID-19 has changed life, as well as travel, in cities is considered. In [6], the impact of electric buses on improving urban air quality is examined. And a study [7] shows that electric mobility has led to a reduction in carbon emissions. However, one cannot fully agree with this statement, as the study does not analyse the harmful environmental impacts of the production and disposal of batteries for electric vehicles. An article [13] states that pollution associated with road construction and maintenance is becoming an obstacle to sustainable development of large cities. In [8] the author points out the outrunning importance of subways in modern cities of the 21st century. In [9,11] it is noted that railway systems are developing as an efficient mode of transport and also play an important role in the transport system. A study [12] points out the fact that rail transport can be called the "Transport of the Future". As a result of analysis of the cited and other scientific works in the area under study, it is established that the development of public transport is of the highest importance. Environmental aspects of transport operation and ways of reducing its harmful impact on the environment are given.

1.3 Problem statement

The analysis of the cited and other scientific papers in the area under study has established that the global challenge in developing public transport lies in combining its intensive growth with the application of modern technology and minimising its impact on the environment.

1.4 Aim, objectives and hypothesis

The aim of the study is to examine China's public transport experience.

The objectives of the research are as follows:
1. To analyse statistical data on the territory of the PRC, population dynamics, road construction dynamics and the development of public transport in China.
3. To examine the prospects of China's public transport development until 2035.

Research Hypothesis - Public transportation is crucial to China's economic development, and the Chinese government has paid a lot of attention to this issue. Since the mid-1990s, investment in transport in China has been seen as a crucial component of economic policy. The significant investment in public transport has resulted in an unprecedented increase in the length and density of road and rail routes. In addition, since 2021, the Chinese government has focused on
introducing the latest developments to ensure that public transport is not only safe, but also environmentally friendly and intelligent.

2 Methods

In order to carry out the research, relevant material from various sources was selected for the topic. On the basis of these, the topic was analysed, problems were identified, solutions to the problems were provided and conclusions were drawn. Empirical-theoretical research methods were used, in particular the method of analysis, the method of analogy, the method of comparison and induction.

3 Results and discussion

Since 1990, the government of the People's Republic of China has put great emphasis on the development of public transport, and in 2021, the Chinese government is emphasising green and intelligent public transport. In the article "Transport Network Construction and Integrated Development of Chengdu-Chongqing Urban Agglomeration: A Study Based on Transport Infrastructure Network and Transport Demand Network", Huang Y stresses that "The transport network is one of the most important driving forces for the integrated development of urban agglomerations" [1]. Also, Jiang Y in his article "High-Speed Railway Opening and High-Quality Development of Cities in China: Does Environmental Regulation Enhance the Effects?" states that "The continuous improvement of transportation infrastructure is an important support for achieving high-quality development, while the high-quality characteristics of development will inevitably promote the process of economic and social sustainability" [2].

A popular Chinese proverb states - "If you want to get rich, first build a road". This popular saying underlines the decisive role of transport in developing the economy and improving people's quality of life.

Gu Y. and Wang Y. in their article "Using weighted multilayer networks to uncover scaling of public transport system" notes that "The public transport system is considered as one of the most important subsystems in metropolises for achieving sustainability objectives by mediating resources and travel demand" [3].

As of 2021, the length of roads in PRC is 160,000 km. China ranks first in the world on this indicator. China has the world's third-largest railway network with a total length of 141,400 km. Table 2 shows the length and density of roads and railways in PRC and RF.

<table>
<thead>
<tr>
<th>Total length of roads thousand km.</th>
<th>Density of roads per 1 km of area</th>
<th>Road density per capita km/person.</th>
</tr>
</thead>
<tbody>
<tr>
<td>People's Republic of China</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automobile roads</td>
<td>160</td>
<td>0.0167</td>
</tr>
<tr>
<td>Railways</td>
<td>141.4</td>
<td>0.0147</td>
</tr>
<tr>
<td>Russian Federation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Backbone network road</td>
<td>138</td>
<td>0.0081</td>
</tr>
<tr>
<td>Railways</td>
<td>130</td>
<td>0.0076</td>
</tr>
</tbody>
</table>

Table 2 shows that Russia is inferior to China in total length of roads and railways. According to the latest data, 26,000 km of high-speed roads are built in China per year. Of these, 10,000 km are motorways (4 or more lanes, speed up to 110 km/h), Class 1 highways (4 or more lanes, speed 80-100 km/h) - 5,500 km, Class 2 highways (no more than 41 lanes, speed 60 km/h) - 11,000 km. The service life of the road bed is 15 to 25 years.
Comparing road construction in China and our country, it turns out that in China 70 times more roads are built per year than in Russia. In the PRC the figure is 26 thousand kilometres, in Russia it is 300-350 kilometres.

According to official data, since 2012 more than 2.36 million kilometres of rural roads have been repaired and built. 84.3% of the total length of the country's roads were built in rural areas and reached 4.38 million kilometres.

According to the Ministry of Transport of the People's Republic of China, the volume of passenger traffic by public transport increased significantly in the country's 36 largest cities in 2021, reaching 52.95 billion people-per-hour, a 19.9% increase from 2020. The number of bus, trolleybus and tram passengers increased by 11.4% and the number of people using urban rail transport increased by 34.3%. China's public transport system is very safe, with no major railway accidents recorded since 2012. Considerable attention is also being paid to improving traffic logistics. Chang H. in the article "Tracking traffic congestion and accidents using social media data: A case study of Shanghai" notes that "Traffic congestion and accidents take a toll on commuters' daily experiences and society" [4].

In "Travel changes and equitable access to urban parks in the post COVID-19 pandemic period: Evidence from Wuhan, China," Zhang W. wrote, "Owing to its large scale and scope, COVID-19 has profoundly changed our lives, society and living environment. One important change is residents' mobility, which is impacted by the worry of infection when traveling as well as the travel restrictions proposed by the government, such as social distancing, encouragement to stay home, and self-isolation during the outbreak of the pandemic" [5]. During the COVID-19 WeChat pandemic in China, special QR codes were introduced to track people on public transport. Passengers in buses, subways or taxis had to provide information about themselves by scanning a special QR code. This is how the system synchronised their ID with the vehicle number, boarding time and other information. If a passenger from that transport was subsequently found to have a coronavirus infection, everyone in the vicinity who might have been infected received a warning about it.

Alibaba Group introduced a colour-coded QR code system that told people whether they should go into quarantine. The system assigned the user one of three QR codes: red, yellow or green. Only those with a green code could move freely around the city. People with a yellow code had to stay home for a week. Those with a red code had to go into quarantine for two weeks.

### 3.1 The main modes of public transport in China is considered to be bus

The People's Republic of China is the world's largest producer of electric buses. According to Elektrek, up to 99% of electric buses currently operate in China. The electric buses that run in China are exclusively domestically produced. The government has spent more than a billion dollars on subsidies, which has made a huge expansion of the fleet possible.

According to China's Ministry of Transport, there were more than 340,000 electric buses on the streets of Chinese cities at the end of 2018, meaning that one in two buses was powered by electricity.

In the article "Multi-depot Electric Bus Scheduling Considering Operational Constraint and Partial Charging: A Case Study in Shenzhen, China", Jiang M. and Zhang Y. note that "Electric buses (e-buses) demonstrate great potential in improving urban air quality thanks to zero tailpipe emissions and thus being increasingly introduced to the public transportation systems" [6]. According to statistics from Bloomberg, the use of electric buses has reduced diesel fuel consumption in the People's Republic of China by 41 million litres per day. By comparison, all electric cars on the planet save three times less fuel.

Tsoi K. H. in "Pioneers of electric mobility: Lessons about transport decarbonisation from two bay areas" notes that "The results illustrate that electric mobility has led to carbon reductions of
1.73 Mt CO₂ and 0.25 Mt CO₂ in 2018 in GBA and SFBA respectively, contributing to a relative decoupling status in both regions (e = 0.85 & e = 0.14) [7].

According to a 2018 Bloomberg New Energy Finance study, the PRC puts 9,500 new electric buses into service every 5 weeks (the equivalent of the entire London fleet). The study also points out that of the 385,000 electric buses in operation worldwide, 99% are in China. In Europe, only 1.6% of vehicles are electric, while in the US the figure is just 0.5%.

In 2018, the city of Shenzhen became the first metropolitan area in the world to completely convert its public transport to electricity. The host city of the Beijing Winter Olympics used 655 hydrogen-fuelled buses to provide transport and logistics services for the games. Most of these hydrogen buses are owned by the Chinese company BAIC Foton AUV. The buses can convert hydrogen and oxygen directly into electricity through a chemical reaction.

In 2021, a smart public transport line opened in Shanghai's new Lingan district, which is 8.5 kilometres long. The smart unmanned buses run on a circular route for 30 minutes and require the download of a mobile app to use them.

Tickets are paid either by a special card (like the underground) or in cash, which is dropped into a special box near the driver when entering the bus. Keep the change. Often drivers do not keep track of the fare. Fares are small and depend on the city, usually 1 - 3 yuan ($0.2 - 0.5) but can be more expensive on some routes. Some buses have conductors. Entrance to the bus is through the door next to the driver, and the fare is paid there, while exit is through the second door in the middle of the bus.

3.2 Metro

In the article "System dynamics: A new approach for the evaluation of urban underground resource integrated development" Zhao P. refers to the history of "On December 3, 1991, the first International Conference on Urban Underground Utilization was held in Tokyo, Japan. The conference delegates agreed that the 21st century is expected to be the era of underground utilization. Since then, urban planners, architects, geologists, and engineers have called for a greater inclusion of the urban underground" [8].

In the last decade, the construction of underground systems in the People's Republic of China has been ahead of schedule. A new trend is the construction of fully automatic lines.

The Beijing and Shanghai subways are the longest in the world, and the Beijing underground is also the busiest in terms of passenger traffic (the Tokyo and Moscow subways compete with them). At peak hours (8-9am and 5-6pm), the Beijing metro has the longest queues. The underground system in Beijing, China's capital city, is the first in the country. The first 21 km line with 16 stations began operations on 1 October 1969.

In January 2021 the Shanghai Metro surpassed Beijing in line length to become the world's largest metro network with the opening of a 42.3 km long automated line. As of 2021, Line 15 is the longest metro line in China with automatic train control. There are 54 six-car A-series electric trains manufactured by CRRC Changchun Railway Vehicles, each carrying up to 1,860 passengers. The inter-train interval is 5 minutes during rush hours on weekdays and 6 minutes - at other times, the maximum speed is 80 km/h.

The underground is always clean and well signposted in English to make it easy for tourists to get around. The platforms are all closed to avoid accidents. Transitions between stations are clear, with many coloured signs.

Fares depend on the distance between stations and from the city ($0.3 - $3). The subways in major cities have English-language machines where you can buy a ticket by selecting your destination station.
3.3 Railway transport

China's high-speed rail network is the longest in the world at 22,000 km of track. Every year the length of the country's railways increases. The Chinese government allocates substantial funds for new construction - more than 2 trillion yuan a year. The most recently commissioned section is the railway between Beijing and Xiong'an district, Hebei province.

Wang H. in his article "Bi-Objective Subway Timetable Optimization Considering Changing Train Quality Based on Passenger Flow Data" states that "As an effective transport mode, rail systems have been developing rapidly in recent years" [9].

In 2022, China continues to develop its domestic rail network at a rapid pace. The Chinese government is focusing on introducing the latest technology in train design, creating a railroad bed with special features, informatizing the ticketing process, and transport management.

Yang X. in "Does high-speed rail promote enterprises productivity? Evidence from China" notes that "The overall goal of Chinese government is to achieve that the most provincial capitals are scheduled to arrive in Beijing within 2-8 hours and large and medium-sized cities that are close to each other are contacted within 1-4 hours" [10].

The development and production of new generation trains (high-speed, medium-speed magnetic cushion trains) is a special area of introduction of new technologies in China. In 2017, the country launched the new Fuxing train, which connects Beijing and Shanghai, reaching speeds of 350 km/h. The train has a top speed of 400km/h, a length of 415m and a capacity of more than 1,000 passengers.

In the article "The impact of high-speed railway on China's regional economic growth based on the perspective of regional heterogeneity of quality of place", Lin S., Dhakal P. R. and Wu Z. stated, "The development of high-speed railways has dramatically improved the connectivity between regions and promoted the flow of factors between regions. With the rapid development of global passenger high-speed rail technology, it plays an essential role in the transportation system" [11].

Railways in China are one of the main components of the country's economy. Trains in China are divided into several types - according to the degree of comfort of the carriages and the speed of travel:

- High-speed trains (category G). They have the most expensive tickets, the carriages have seats only. Speed of these trains varies from 250 to 480 km/hour;
- Category C and D trains have significantly lower speed - 250 km/hour. They are comparable to G trains and Russian compartment cars;
- Only trains connecting Beijing to other cities are labelled Z. These are trains with parcels, compartments and seats;
- T and K trains are the cheapest. The most common carriages and seats are available, but there is also a small number of coupes. The length of the journey can be longer than a day.

China's railways are world leaders in new technology, especially in extreme cold or high altitude conditions, and this also applies to high-speed and heavy rail transport. Intelligent high-speed rail technology has achieved full autonomy. Also Smirnov A., Smolokurov E. and Fir Y. in their article "Features of The Development of High Speed Railway Communications" note that "High-speed rail transport reduces the harmful emissions of pollutants to air, water and soil, and also has a lower noise level compared to road or air transport" [12].

Informatization of railways was further developed in 2021. A study on the use of 5G network technologies on railways has been initiated. The Ministry of Transport of the People's Republic of China stated that it will continue to promote the use of new technologies, new materials and new processes to produce low-maintenance equipment and structures.
3.4 Outlook

In March 2021, the PRC published a detailed plan for the transport sector for 2021-2035. By 2035, the country's transport network should be convenient, cost-effective, green, smart and safe. The document notes that the transport system will become more environmentally friendly. Du W. in the article "Deciphering urban traffic impacts on air quality by deep learning and emission inventory" states the fact that "Air pollution is a major obstacle to future sustainability, and traffic pollution has become a major drag on the sustainable developments of future metropolises" [13]. According to the plan, by 2025, the country will have established a basic ecosystem for Chinese standard unmanned vehicles, aiming to achieve large-scale production of conventionally automated unmanned vehicles. It is planned that by 2025, the length of railways will increase from 146,000 km to 165,000 km; the number of civilian airports from 241 to 270; and the length of metro lines in cities from 6,600 km to 10,000 km. In 2025, the length of highways will be 190,000 km, whereas in 2020 the total length of roads was 161,000 km.

Extensive work will also be carried out to improve the integration of railways with other modes of transport. This includes developing more multimodal hubs; improving integration with road, sea and air transport; and optimizing and adjusting networks to reduce the distance between different modes, creating seamless logistics links.

4 Conclusions

The following conclusions support the hypothesis of this study:

1. The analysis of statistical data has determined that there is a steady upward trend in the population of the People's Republic of China. In the People's Republic of China, 228 cities have a population over 200,000, 462 cities have a population over 100,000, and 912 cities have a population over 53,000. The total number of inhabitants of the PRC in 2021 amounted to 1,443,981,565 people. There are 108 cities with a population of one million people in the PRC, and in the future several Chinese cities with a population of one million may be combined into urban agglomerations. With the growth of the population the need to develop public transportation increases.

2. A comparative study of the length and density of roads and railways of the PRC and Russia reveals that Russia is inferior to China in the total length of roads and railways, as well as the density of roads per 1 km of territory. The development of public transport is a determining factor in the country's economic development. The Chinese government has invested more than 3.28 trillion yuan (around US$ 514.98 billion) in the transport sector in 2021. It is noted that railways in China are one of the main components of the country's economy. In recent years, China has enjoyed a high rate of development of its domestic railway network. The Chinese government is focusing on the introduction of new technologies in train design, the creation of a railway bed with special features, the informatisation of ticketing and transport management. Also, the Shanghai Metro has taken over as the operator of the largest metro network in the world in 2021. As for ground-based public transport, according to China's Ministry of Transport, there were more than 340,000 electric buses on the streets of Chinese cities at the end of 2018, meaning that one in two buses was powered by electricity.

3. Whereas since 1990 the PRC government has placed great emphasis on the development of PRC public transport, in 2021 the PRC government is emphasising green and intelligent public transport. In March 2021, a long-term strategic plan was drawn up to realize the objectives of public transportation modernisation and development. By 2035, the country's transport network must be convenient, cost-effective, green, smart and safe. By 2025, the country will have 165,000 km of railways, more than 270 civilian airports, metro lines in cities will increase to 10,000 km and motorways to 190,000 km.
References