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The impact of high-speed rail on the urban economy

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Abstract. High-Speed Rail (HSR), characterized by train speeds exceeding 200 kilometers per hour, has emerged as a transformative mode of transportation, offering efficient intercity and long-distance travel. In recent years, China has developed the world's most extensive HSR network, raising important questions about its broader economic implications. This study investigates the impact of HSR construction and operation on regional economic development in China, with a particular focus on urban and peri-urban areas. Using qualitative case analysis, three representative railway lines—the Han–Yi Railway, Yi–Wan Railway, and Beijing–Zhangjiakou High-speed Railway—are examined to explore how HSR influences local economies, connectivity, and industrial transformation. The findings suggest that HSR significantly enhances regional integration, improves accessibility in underdeveloped areas, and contributes to the emergence of new economic dynamics, thereby playing a strategic role in shaping China's spatial and economic landscape.

Keywords: High-Speed Rail (HSR), regional economic development, urbanization, transportation infrastructure, China

1. Introduction

In the modern era, the development of high-speed rail has become an integral part of the global transportation network, significantly influencing economic landscapes. The construction of high-speed rail networks has not only revolutionized the way we travel but has also catalyzed economic growth in the regions they traverse. Before the advent of high-speed rail, transportation in China mainly depended on other means of transportation. But the speed is slower and the long journey takes longer. At that time, the traffic situation was relatively backward, which limited the rapid development of the regional economy and personnel flow. With the advent of high-speed rail, once distant ditties are now connected in a matter of hours, fostering a new era of regional economic integration and development [1].

The economic impact of high-speed rail networks is a multifaceted issue that demands a comprehensive analysis. This paper aims to delve into the economic ramifications of high-speed rail construction on the development of cities along the routes. Specifically, we will examine the Han-Yi Railway, the Yi-Wan Railway, and the Beijing-Zhangjiakou High-Speed Railway, exploring how these arteries have transformed regional economies and spurred growth. This study will employ panel data analysis and structural equation modeling to quantify the impact of high-speed rail on regional economic integration, employment, and income distribution. Furthermore, through case studies and comparative analysis, we will provide an in-depth look at the economic effects of these high-speed rail lines, offering insights into their role in enhancing regional economic vitality.

The Han-Yi Railway, for instance, has been a game-changer for Yichang, significantly improving its transportation conditions and economic development. By reducing the travel time to cities like Wuhan, it has facilitated the rapid movement of people and goods, attracting tourists and investors alike. As one of the most profitable lines in Central China, it has consistently ranked first in daily passenger traffic in Hubei Province since its inauguration in 2012.

Similarly, the Yi-Wan Railway has been instrumental in enhancing the economic conditions of Enshi, a region rich in natural resources but previously hindered by inadequate transportation infra-structure. The railway has dramatically reduced travel times to Wuhan, making it easier for locals to commute and for goods to be transported, thereby stimulating the local tourism industry.

Lastly, the Beijing-Zhangjiakou High-Speed Railway played a pivotal role during the Beijing Winter Olympics, enhancing the connectivity and economic integration of the cities along its route. It has not only shortened the physical distance between Beijing and Zhangjiakou but also stimulated the growth of tourism, service, and high-tech industries, providing new economic opportunities and employment for the region.

The construction of a high-speed rail network has a profound impact on the economic development of the cities along the line. It not only shortens the space and time distance between cities, promotes the rapid flow of people and materials, but also drives

the development of tourism, service, and high-tech industries, bringing new economic growth points and job opportunities to cities along the route. This study focuses on the Han-Yi Railway, Yi-Wan Railway, and Beijing-Zhang high-speed Railway, and discusses the impact of high-speed railway construction on that area through empirical analysis. The research results have important academic value and practical significance for understanding how high-speed rail can promote regional economic development and optimize re-source allocation, and also provide a reference for future high-speed rail network planning and regional economic development policy formulation [2].

2. Literature review

2.1. History development of high-speed railway network worldwide

According to the definition of the International Union of Railways, high-speed rail refers to the combination of all the elements that make up this "system", including infrastructure (new lines with design speeds above 250 km/h, increased lines with speeds of 200 km/h or even 220 km/h), high-speed EMUs and operating conditions. At present, most of the new high-speed railways in various countries have a maximum speed of 250 ~ 350 km/h. China's high-speed railway is defined as: a new passenger dedicated railway designed to run 250 km/h (including reserved) and above EMU trains, and the initial operating speed is not less than 200 km/h.

The first high-speed railway in the world was the Tokaido Shinkansen in Japan, which opened for business on October 1, 1964. The railway connects Tokyo and Osaka, covering 515.4 km, with a maximum operating speed of 210 km/h, greatly reducing travel time between the two cities [3].

Most high-speed rail systems use wheel-rail technology, in which the steel wheels of the train run on steel rails, similar to traditional rail trains. However, in the 1970s and 1980s, a type of high-speed train called the turbo train was used in North America, which used gas turbine engines that worked similarly to those found in jet aircraft. However, this turbine train technology was eventually phased out, and electric trains became the mainstream choice for high-speed rail.

The United States began building railways in the 1830s, and the first railway opened in that decade. In 1869, the Pacific Railway was completed, connecting the east and west coasts of the country. However, with the spread of cars and airplanes, trains became less popular in the U.S. It wasn’t until the year 2000 that the U.S. got its first high-speed train called the Acela [4].

In Europe, railways started with steam engines in the early 1800s. In the early 1900s, they began to use electricity to power trains. Later in the 20th century, they started to build high-speed trains. High-speed trains in Europe developed quickly, especially in countries like France, Germany, and Japan.

The French TGV, with the full name of "train a grande vitesse", the France's high-speed rail system. It is developed by Alstom and operated by SNCF, the state-owned company, what is intriguing is that the company that provided the technology car for the CRh1 model that started the HEXIE high-speed in China is related to this. TGV trains travel between Paris and neighboring cities, and the TGV is the world's second commercial high-speed rail system after Japan's Shinkansen, which is of great significance to Western countries

last but not least, you may have heard of ICE, that’s from Germany. ICE's successful international operations have also had a huge positive impact on the development of the global rail network. ICE has not only achieved efficient operation in Germany, but also expanded to international routes, such as Zurich to Frankfurt, to achieve international direct transport. This successful international operation model provides valuable experience and inspiration for other countries to promote the interconnection of the global railway network. It can be said that ICE has produced profound historical significance for the development of railways all over the world.

2.2. History development of high-speed railway network in China

In April 1997, China Railway launched its first major speed enhancement initiative and began exploring the independent development of high-speed rail technology. This marked the beginning of rapid growth in China's high-speed rail industry. Through a strategy of technology introduction, assimilation, absorption, and re-innovation, China gradually established a comprehensive and independent research, development, and manufacturing system for high-speed trains. A series of high-speed train models were subsequently produced and successfully put into commercial operation. Notably, in December 2010, the CRH380A1-2541 train set, designed for speeds of 380 kilometers per hour, achieved a record-breaking speed of 486.1 kilometers per hour during a test run on the Beijing–Shanghai High-Speed Railway, setting a world record for the highest test speed achieved by a conventional wheel-rail train—an achievement that remains unmatched to this day.

Although China lacked high-speed railways in the early 21st century, it embarked on an ambitious development program that has since positioned the country as a global leader in this field. Today, China’s high-speed rail network spans approximately 24,000 miles and connects nearly all major metropolitan areas. Even more impressively, national development plans aim to expand this network to approximately 43,000 miles by 2035, ensuring that every province—and eventually every city within each province—will be served by high-speed rail. Some lines constructed in earlier stages continue to exert a profound and lasting influence, representing important milestones in the evolution of China’s railway system [5].

In 2003, Qinshenke, located in northern China, was put into operation, which is the "test field" of China's high-speed railway construction, and began the new journey of China's high-speed railway construction. In 2005, the Beijing-Tianjin Intercity Railway was started and opened a few years later! This is China's first high-speed train with a high standard and a design speed of 350 kilometers per hour. But we are still learning from other countries' technology. In 2011, the Beijing-Shanghai high-speed railway opened, which was the world's last completed high-speed railway with the longest track. To achieve a leap in quality and mileage! The People's Daily, China's official newspaper, commented that "the Beijing-Shanghai high-speed railway is special, it is the origin and integration of China's high-speed rail, is the carrier of China's high-speed rail technical standards, and represents the standard of China's high-speed rail." The Beijing-Xiong intercity high-speed rail currently under construction will open a new chapter in China's smart high-speed rail."

2.3. Technology of high-speed railway network

In 1842, Earnshaw introduced the concept of magnetic levitation, at the same time Lao pointed out that the permanent magnets alone could not keep a ferromagnet in free and stable suspension at all six degrees of freedom. In the worldwide race of building maglev trains, Japan and Germany are the two main competitors. In 1994, Japan set a Japanese record of 430km/h and kept it for a long while. It is the train that uses of suspension magnetic force to make the object in a frictionless, non-contact suspension of the equilibrium state. It seems simple, but the implementation took a long time. Because its principle is a set of electromagnetics and other high-tech as one of the projects.

With the development of various processing components, theories and new types of electromagnetism and the further study of dynamics, it has subsequently unraveled its mysterious side [6].

For the Chinese railway that we will be discussed in this article, we are concerned about a series of research and development which is strongly related to high-temperature superconducting technology and vacuum pipe transportation technology.

High-temperature superconducting at high-speed using streamlined design. Unlike those high-speed trains that rely on onboard power to "run" on the rail, the prototype is suspended on a permanent magnet track, similar to the maglev that we mentioned earlier. CRRC's prototype vehicle uses an all-carbon fiber lightweight vehicle body and low-resistance head type, and the design speed is expected to set a new record for land transportation speed. In the future, the development trend of maglev technology is to further improve speed and reduce energy consumption. Research is ongoing, and the Chinese project has made remarkable progress to the point where the top speed may exceed 1,000 km/h, a sign that the speed of ground vehicles has approached and possibly surpassed that of passenger planes in the air.

2.4. High-speed railway types and models

China’s Hexie (CRH) and Fuxing (CR) are two generations of high-speed trains in China’s railway system.

The Hexie (CRH), is an abbreviation for “China Railway High-speed,” and the first few models mainly relied on technology introduction and cooperation. CRH is the product of China’s leapfrog development in high-speed train technology through cooperation with world high-speed rail powers between 2004 and 2016, characterized by a combination of Chinese and foreign production. The initial operational speed of CRH reached 200-350 kilometers per hour, serving a large number of newly built high-speed railways in China. The design life is 20 years, and it is divided into several major models such as CRH1, 2, 3, 5, 6, and 380.

Secondly, the recent Fuxing (CR), is a high-speed train independently developed by China, with full intellectual property rights. Among 254 important standards, 84% are Chinese standards. Fuxing has formed a complete series of high-speed trains with speeds ranging from 160 to 350 kilometers per hour, where the numbers 400, 300, and 200 represent different speed grades, which are the highest test speeds of the trains, and the actual operational speeds are about 50 less than these figures. The design life of Fuxing has reached 30 years, longer than that of Harmony.

For passengers, in terms of energy saving and comfort, there have been improvements. Fuxing adopts a brand-new low-resistance streamlined head shape and smooth body design, making the train more energy-efficient, with more spacious seat spacing, reduced operational resistance, lower energy consumption per capita per hundred kilometers, and significantly reduced noise inside the train. It is divided into several major models such as CR400A/BF, 300A/BF, 220J, and 200J. These are usually produced by two manufacturers, CRRC Qingdao and CRRC Changchun. Cars produced in Qingdao usually start with “A,” while those in Changchun start with “B.” The “F” at the end represents “power distribution,” meaning that not only the locomotive provides power in a trainset. “J” stands for “concentrated power.”

In recent years, Fuxing has begun to develop intelligently. Fuxing is equipped with an intelligent perception system and a robust safety monitoring system, with more than 2500 monitoring points deployed throughout the train, about 500 more than the previous models with the most monitoring points. It has also extended to models Z and S, which represent the initials of “Intelligent” and “Upgrade” in Chinese.

In China, different train grades are represented by different letters. Overall, there are “ZTKLAGDCS” letters, with GDC being the most common:

- G-train: Designed for speeds of 250-350 km/h, with a maximum operational speed of 300-350 km/h, generally operating on high-speed rail lines. The models used include CRH2C, CRH3C, CRH380, and CR400 series high-speed trains, with advanced internal equipment, a comfortable environment, and business, first-class, and second-class seats.
- D-train: Speeds range from 160-250 km/h, with a maximum operational speed of 200-250 km/h, capable of operating on both high-speed and regular railways. The models used include CRH1, CRH2 (excluding 2C), and CRH5 series high-speed trains, generally with first-class and second-class seats.
- C-train: Speeds range from 160-350 km/h, dedicated to short and medium-distance urban or suburban trains. The models used include CR200J, CRH1, CRH2, and CRH6 series high-speed trains, with operational speeds determined by local line conditions [7].

2.5. Economic development of China (regions)

Since China was founded 75 years ago, its economy has made amazing progress. After the year of 2012, China has been working hard to make the economy better and stronger. They have been dealing with problems and making sure the economy keeps growing in a good way.

Since China started to open up and change its economy, it has grown very fast. It moved from a system where the government planned everything to one where people and businesses could make their own choices. After joining the WTO, China became more part of the world's economy and started making things for everyone. Lately, China has been trying to make its economy even better by changing how it works and encouraging new ideas and inventions. Now, China is a strong and energetic country that stands tall in the east part of the world. This paper will talk about four rail line which is located in Hubei Province and the northern area of China.

Hubei Province, located in central China, has demonstrated strong economic performance and steady growth. In 2000, the province's GDP reached 427.632 billion yuan, representing a year-on-year increase of 9.3%. By 2023, Hubei made 5,580.3 billion yuan, and Wuhan made over 2 trillion yuan. This shows Hubei is growing fast and has a lot of potential. Lately, Hubei has been focusing on new industries and making more factories, with a plan to have five big industries by 2025, like technology, cars, chemicals, health, and farming [8].

After a new railway started running, Zhangjiakou in Hebei province got closer to Beijing's one-hour travel area. Zhangjiakou uses a lot of clean energy and follows the idea of "doing research and making plans in Beijing, and keeping data and computers in Zhangjiakou". They built things along the train line. Now, 29 computer centers are done or partly done, and over 1.5 million computers are working.

The fast train also helps with snow and ice businesses and tourism in the Beijing-Zhang area. With winter coming, the snow business is getting ready, and more people are expected to travel.

For the whole China economy, China's economy is currently doing reasonably well, with a GDP growth of 5% in the first half of this year. However, we are also facing some challenges, such as a sluggish global economy, a lack of willingness among consumers and businesses to spend and invest, instability in the real estate market, and significant borrowing by local governments. In the future, we need to find ways to upgrade our industries, focus more on high-tech, and protect the environment by reducing pollution. We also need to encourage people and businesses to spend more to invigorate the market. This way, China's economy can continue to move forward steadily.

3. Discussion

3.1. Transportation's impact on cities and towns

Transportation changes how cities grow. Good transportation helps people live better and makes different areas work together. It can also help businesses grow and change the way cities look.

High-speed trains have many effects on how society and the economy grow. First, building and running high-speed trains helps cities along the lines grow faster. High-speed train projects make city economies grow more and also help nearby cities. On average, cities with high-speed trains grow their economies more than other cities. Second, high-speed trains help cities grow bigger. For example, the area around Shanghai that can be reached in one hour gets bigger, which helps connect different areas and makes their economies grow. High-speed trains also change how city groups work together and share resources. Then, working with other countries on high-speed train technology gives China more chances to grow. China can share its technology and work on projects around the world, which makes China more important in high-speed trains.

In summary, transportation systems, especially high-speed trains, have a big impact on how society and the economy grow. These effects are seen in more economic activities, changes in society, and better quality of life. As technology gets better and the world becomes more connected, transportation will keep being very important in the global economy [9].

Specifically, for Hanchuan, its secondary and tertiary industries, especially tourism, have developed rapidly. The economic relations between Tianmen, Xiantao, Wuhan and Jingzhou were strengthened. Qianjiang City attracts about 3 million tourists every year to taste crayfish and promote the development of characteristic industries; Jingzhou's tourism revenue increased significantly,

reaching 1.411 billion yuan during "May Day" in 2021; Yichang tourism resources have been promoted to attract enterprise investment too.

However, the opening of high-speed rail may increase the economic imbalance between regions. For cities with poor economic development levels, high-speed rail may have a negative siphon effect, resulting in the transfer of economic development factors such as people flow, logistics, capital, and information from small and medium-sized cities along the high-speed rail to regional central cities

3.2. Hankou-Yichang High-Speed Railway

The Hankou-Yichang High-Speed Railway is 291.83 kilometers long and is a key part of the Shanghai-Wuhan-Chengdu fast railway. It's in the middle of Hubei Province, starting at Hankou Station in Wuhan and ending at Yichang, passing through several cities like Hankou, Tianmen, Xiantao, Qianjiang, Jingzhou, and Zhijiang. Before this railway was built, no main railways or passenger trains were going east-west in the Jianghan Plain. After it was built, the travel time from Yichang to Wuhan was cut from over 4 hours to 2 hours. This railway also connects the Hefei-Wuhan Railway and the Ning Rong line, making a big railway line that links Shanghai, Wuhan, and Chengdu.

The Hankou-Yichang Railway starts at Hankou Station and ends at Yichang East Station, which is 292 kilometers away. It makes the trip from Hankou to Yichang only take 2 hours, bringing cities closer together. People can use this railway to visit places like Qianjiang, Jingzhou, and Yichang. From any station on this railway, it takes about 5 hours to get to big cities like Beijing, Shanghai, Guangzhou, and Xi'an, and about 3 hours to get to Zhengzhou and Changsha.

Since it started running on July 1, 2012, the Hankou-Yichang Railway has been a very important way to travel in the Jianghan Plain area. It has helped the region grow quickly and has made life better for people. Over ten years, it has carried 215 million passengers, showing how important it is for travel in the area. The number of people traveling each day has gone up from 16,000 to 37,000, and the number of trains has gone up from 32 to 123, showing that more and more people are using this railway.

The Hankou-Yichang Railway has also had a big effect on the economy in Hubei Province. The total money made by the cities along the railway went up from 1.1 trillion in 2011 to 2.87 trillion in 2021, which is 1.6 times more. The railway has helped bring more business and investment to these cities, making them grow faster. It has also changed how cities in Hubei are connected, making Yichang more important and helping other cities like Hankou, Tianmen, Xiantao, Qianjiang, and Jingzhou join the Wuhan city group. This has made the cities work together better and given them new chances to grow.

The Hanyi Railway has made it easier for non-central cities along the route to connect, which helps the whole area grow economically. It brings cities closer together, makes them work better together, and shares resources more efficiently. This railway also makes cities more active economically and helps them grow faster. In short, the Hanyi Railway is good for the economy of the cities around it and makes them work together better.

3.3. Yichang-Wanzhou High-Speed Railway

For many years, there had been a vision to construct a major railway connecting central and western China, traversing regions inhabited by diverse ethnic groups. The Yichang–Wanzhou Railway, completed after seven years of construction at a cost exceeding 22 billion yuan, stands as one of the most challenging, longest, and most expensive railway projects in China's history. Passing through ethnically diverse areas such as Enshi and Changyang in Hubei Province, the railway has, since its opening in 2010, significantly contributed to regional development—stimulating economic growth, population mobility, and cultural exchange.

The Yichang-Wanzhou Railway is 377 kilometers long and is a key part of a fast railway that connects Shanghai, Hankou (a part of Wuhan), and Chengdu. It starts at Yichang East Station, goes through many cities in Hubei, and ends at Wanzhou in Chongqing. Before this railway, no main trains were going east to west in the Wuling Mountains. Now, it takes about 8 hours to travel from Yichang to Wanzhou, which used to take more than 10 hours.

The railway goes from Yichang East Station, through Enshi, Lichuan, Jianshi, and Badong, to Wanzhou North Station. It's made it easier for people to visit these places. Since it started on December 22, 2010, it has become a very important road for the Wuling Mountains area, helping the region grow fast and making people's lives better.

Specifically, for Enshi. First, it improved public traffic conditions in cities such as Enshi and ended the history of no train services there, at the same time the rail line improving regional accessibility. This not only facilitates the travel of residents, but also provides convenience for foreign tourists and investors, promoting the development of tourism and business. For example, the number of tourists in Enshi Prefecture increased from 10.8 million in 2010 to nearly 50 million in January 2019, and the comprehensive tourism revenue also increased from 5.5 billion yuan to more than 33.6 billion yuan.

In the 10 years since it opened, the Yichang-Wanzhou Railway has been one of the busiest in Hubei and Chongqing. It acts as an important part of the whole china rail map system, for this period has carried 215 million passengers, showing how important it is for moving people, things, and money around. "Also, it fills the gap between Longhai Railway and Zhejiang-Jiangxi Railway, which has no cross railway for 700 kilometers, and the border area of Hubei, Chongqing, and Guizhou.

3.4. Beijing-Zhangjiakou High-Speed Railway

The Beijing-Zhangjiakou High-speed Railway, also known as the Intercity Railway, is an intercity high-speed line, connecting Beijing and Zhangjiakou in Hebei province. It is one of the most important key parts of the "eight vertical and eight horizontal" high-speed rail network of the "Beijing- Hunan Lanzhou Channel" in the national rail system map". The railway, which is crucial for transportation support for the 2022 Winter Olympics in Beijing, marks another breakthrough in China's high-speed rail sector:

It is not only the first intelligent high-speed railway designed at 350 km/h using the domestic Beidou navigation system, but also the first high-speed railway in the world with a design speed of 350 km/h, which can adapt to extreme cold and strong wind and sand environment. Also, it is the only one that has the speed of 350km/h among the three rails that we talk about in this paragraph.

110 years ago, Zhan Tianyou built China's first railway here, the Beijing-Zhangjiakou Railway at a low speed. This special railway helped power steam trains climb mountains successfully by using two engines, one pulling and one pushing. But now, we have the Beijing-Zhangjiakou High-Speed Railway, which is a big step from the start to the world's best level.

The high-speed train makes travel much faster. It reduces the time from 3 hours to just 56 minutes to get to Zhangjiakou city significantly, enlarging the "one-hour travel circle" between Beijing and the whole Hebei province. This helps connect the areas better and brings many new projects worth 55.6 billion yuan to Zhangjiakou, which helps the ice and snow business grow significantly.

Chongli District, a popular place for skiing, now has 169 high-quality ski trails. This has brought many more tourists, with an 83% increase in visitors from 2020 to 2021. The high-speed train also helps the economy in the Beijing-Tianjin-Hebei area and makes the Winter Olympics and future development better.

Generally speaking, during the 2022 Beijing Winter Olympics, the construction of the Beijing-Zhangjiakou high-speed railway significantly improved the transportation convenience of the area along the route. It not only makes the distance between Beijing and Zhangjiakou much shorter, but also promotes regional economic integration. By enhancing the flow of people and logistics transportation, the Beijing-Zhangjiakou high-speed railway has driven the fast-path development of tourism locally, service and high-tech industries, bringing new economic growth points and job opportunities to cities along the route.

Specifically, for Zhangjiakou city, the end of this high-speed rail line, also have a significant impact after the 2022 Winter Olympic, in addition to the snow and ice economy and the Olympic economy, economic development highlights also included relying on wind energy and solar energy resources. The formation of renewable energy as the core of the new energy industry cluster.

Bring Zhangjiakou's 2023 operating income as a topical example. In this respect reached 22.25 billion yuan, an increase of 14.7% compared to before, Shangyi town area in the rural part of the city developed wind power, photovoltaic, pumped storage, the annual electricity generation reached about 716 million KWH that year, As the Beijing-Tianjin-Hebei big data intercity hub; Zhangjiakou is committed to building an industrial base for elderly care services, with a total investment of 36.91 billion yuan in 2023; Explore the transformation of the hydrogen energy industry to inject new impetus into the high-quality development of the regional economy.

4. Conclusions

This study reviewed the historical development of high-speed railway networks globally and in China, explored their technological evolution, typologies, and models, and examined their relation-ship with regional economic development in China. In the discussion section, particular attention was given to the impacts of high-speed rail on cities and towns along selected key lines, namely the Hanyi Railway (Wuhan to Yichang), the Yiwan Railway (Yichang to Wanzhou), and the Beijing–Zhangjiakou High-speed Railway.

Empirical findings suggest that the Hanyi Railway has significantly enhanced connectivity between the eastern and western parts of Hubei Province, promoting resource sharing and regional economic integration. The Yiwan Railway ended the historical lack of railway access in the Yangtze River basin–Enshi area, improving transport infrastructure and facilitating the socio-economic develop-ment of the region. The Beijing–Zhangjiakou High-speed Railway, by incorporating Zhangjiakou into Beijing's "one-hour economic circle," has contributed to the growth of the winter sports econ-omy and the digital economy, strengthening regional economic vitality.

Beyond these three representative examples, other landmark railways in China have also demonstrated substantial socioeconomic impact. The Beijing–Guangzhou High-speed Railway, the longest of its kind globally, connects the North China Plain to the Lingnan region, reducing travel time across nearly 30 cities and enhancing economic integration along the corridor. The Qinghai–Tibet Railway has ended Tibet's historical isolation from the national railway network, with profound implications for regional economic development and cultural exchange. Similarly, the Lanzhou–Xinjiang High-speed Railway, traversing deserts and grasslands, serves as a vital transport link be-tween Xinjiang and the Chinese mainland, fostering economic and cultural connectivity [10].

To further optimize the utility and inclusiveness of China's high-speed railway system, especially in rural and underdeveloped regions, several strategies are recommended. First, the construction of intercity and urban rail networks should be strengthened.

This includes expanding metro and suburban rail systems, utilizing existing trunk railways for intercity services, and enhancing commuter rail options through high-frequency and small-formation operations. Second, efforts should be made to promote the integrated development of trunk railways, intercity railways, urban (suburban) railways, and metro systems. Achieving seamless intermodal connectivity will improve overall transportation efficiency and maximize the socio-economic benefits of high-speed rail infrastructure.

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