

China's High-Speed Rail Development

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How Did China's High-Speed Rail Network Develop?

Since 2008, China has put into operation over **25,000 km** of dedicated high-speed railway (HSR) lines, far more than the total high-speed lines operating in the rest of the world. The network now has **1.7 billion** passengers per year and an arrival punctuality rate over **95%**. The FIRR of the network is estimated to be **6%**, while the EIRR is estimated at **8%**.



High-speed rail network 2008



High-speed rail network 2017

Key Takeaways from HSR Development in China

- Make a well-analyzed Long-Term Plan, supported by government, with minimal changes once decided;
- Standardize designs and procedures and apply advanced construction management;
- Design the project management structure with clear responsibilities and decision-making authority, retain management team throughout the full life of the project, and provide significant incentive compensation for managers;
- Build a competitive supply industry and develop strong technical and research capacities;
- Partner with local government with joint venture structure;
- Apply a safety system that identifies and manages risk during all project phases;
- Make the service competitive with high punctuality, frequency and speed;
- Provide good connectivity with conventional rail and urban transport to add value to HSR service;
- Price the service at a "sweet spot" that is both affordable and competitive with other travel modes, maximizing revenue while not substantially discouraging ridership;
- Find the most competitive market for HSR service, which is medium distance and high-volume;
- Offer a range of passenger rail services (high-speed and conventional) at different price points to meet different passenger needs.

World Bank and China HSR

The World Bank has provided financing for 2,600 km of HSR lines in China since 2006, and has evaluated and monitored seven projects, five of which are already in service.

Timeline

2003-2006 First two sections of HSR line (over 500 km) opened as testing grounds for various aspects of HSR construction from Shenyang to Qinhuangdao.

2004 The Medium- and Long-Term Railway Plan (MLTRP) that covers freight and passenger network development running to 2020 was approved. It was the first time an HSR network (12,000 km) was proposed.

2008 The first HSR line started operating between Beijing and Tianjin in August. MLTRP was revised for the first time, with the HSR network target for 2020 being expanded to 16,000 km.

2009 The first long-distance HSR route started operation between Guangzhou and Wuhan via Changsha.

2016 MLTRP was revised to raise HSR target for 2020, at 30,000 km. HSR network is aimed to reach 38,000 km by 2025 and 45,000 km by 2030.

2017 Over 25,000 km HSR was put into operation by the end of 2017.

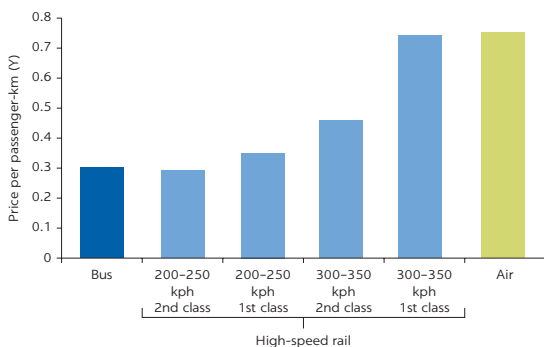
China's High-Speed Rail: Ecosystem, Construction and Operations

Service Frequency

Service frequency of HSR should balance operating cost and effective use of line capacity with appeal to potential passengers.

In China, most HSR lines have at least an **hourly service** between 7:00 am and midnight. This requires an average load of **4-6 million passengers per year** throughout its route to be operated efficiently.

High-speed rail fares compared to bus and air



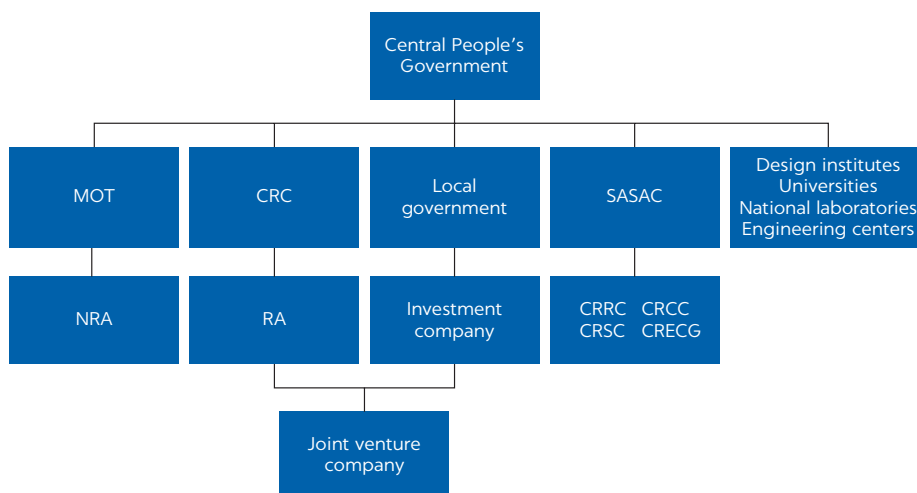
Low Fares

HSR ticket prices are low compared to other transport modes and other countries. While half the trips are made for business purpose, the low fares enable HSR to attract passengers from all in-come groups.

HSR fares are competitive with bus and air fares so that it attracts passengers from other modes, including conventional rail. In 2015, about half HSR passengers in China were transferred from conventional rail, 25% from bus and car, 10% from air. It also generates 10-20% new trips that were previously not made by any mode.

HSR Sector Ecosystem

Structure of China's high-speed rail sector

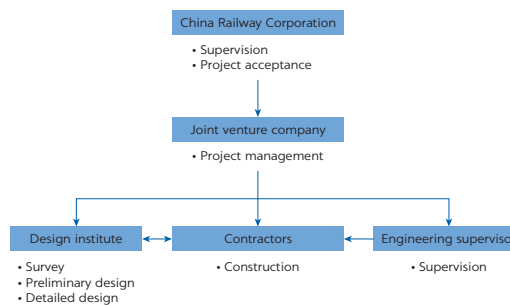


Note: CRC = China Railway Corporation; CRCC = China Railway Construction Corporation; CRECG = China Railway Engineering Corporation; CRCC = China Railway Rolling Stock Corporation; CRSC = China Railway Signal & Communication Corporation; MOT = Ministry of Transport; NRA = National Railway Administration; RA = Regional Administration; SASAC = State-Owned Assets Supervision and Administration Commission.

The rapid and effective implementation of HSR plans largely benefits from the **complete and self-sustained HSR sector ecosystem** in China. The lines have been constructed from the start through special-purpose asset construction and management companies, normally joint ventures between the central and provincial governments. Cooperation among all stakeholders enables capacity development, rapid technological advancement and localization of technology.

Standardization of Designs and Procedures

Construction management structure



Construction of HSR network in China adopts standardized designs and procedures, contributing to its low cost. The network was built at about **two-thirds** of the cost in other countries.

The steady stream of HSR projects also encouraged creation of a capable and competitive supply industry, while allowing gradual amortization of capital costs.

HSR project managers have clear responsibilities and delegation of authority to carry them out. They typically stay through the project and a large portion of compensation is related to performances.

Life-cycle Safety Management

China manages safety risks throughout the project life cycle, by assuring appropriate technology in the design phase, quality construction in the building phase, and thorough inspection and maintenance in the operational phase.

China's High-Speed Rail: Markets and Finance

Traffic Growth & Density

Since the opening of the first HSR line in 2008, total rail passenger volume has grown at a rate of **8.5%** per year, leading to a significant change in traffic composition. Conventional rail traffic has grown at an annual rate of 0.5%.

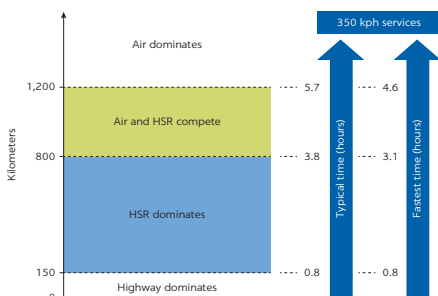
At **1.7 billion** passengers and **600 billion** passenger-km, China now produces more than **four times** as many passenger-km per year as the European or Japanese high-speed rail networks.

HSR Competitiveness

HSR is highly competitive with other modes for trip distances **between 150 and 800 km**. Because of its high speed and service frequency in China, HSR remains competitive up to 1,200 km.

In corridors, HSR typically captures up to half of the conventional rail traffic most of the intercity bus traffic (except for short distances), and a large share of air traffic up to 800 km, with many such air services being either suspended or reduced.

Competitiveness of high-speed rail



HSR Line Financial Performance

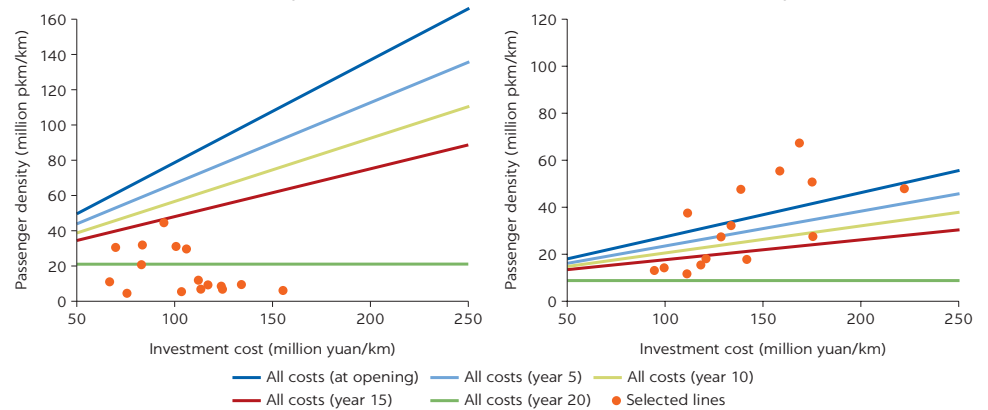
Some heavily used 350 kph lines are able to generate enough ticket revenue to pay for train operations, maintenance, and debt service. These are all lines with average traffic densities of over 40 million passengers per year and average revenue per passenger-km of Y 0.5 (US\$0.075).

Many lines in China with traffic density of 10 to 15 million passengers per year, especially 250 kph lines with revenue per passenger-km of Y 0.28 (US\$0.042), can barely cover train operations and maintenance, and will be unable to contribute toward their debt service costs for many years unless their fares are significantly increased.

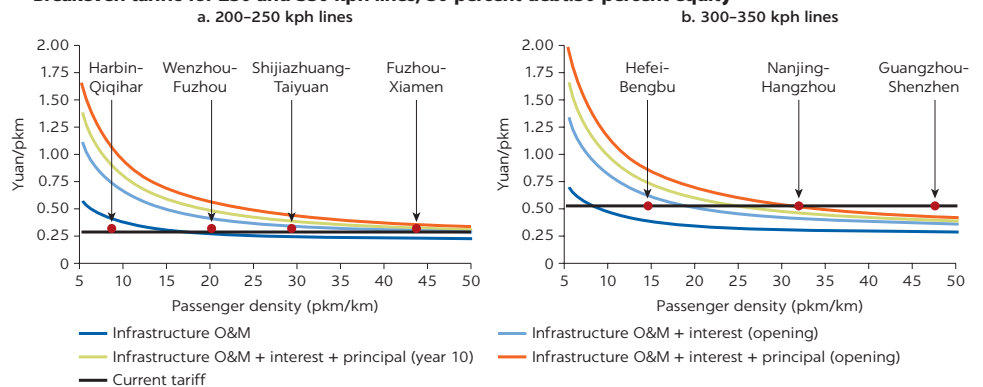
HSR Network Financial Performance

The financial internal rate of return (FIRR), considering the HSR revenues and costs alone (excluding the residual value), is estimated at 6 percent over 30 years.

Breakeven passenger density for full debt service for future years, 50 percent debt:50 percent equity



Breakeven tariffs for 250 and 350 kph lines, 50 percent debt:50 percent equity



Financial Sustainability and How to Solve Financing Issues

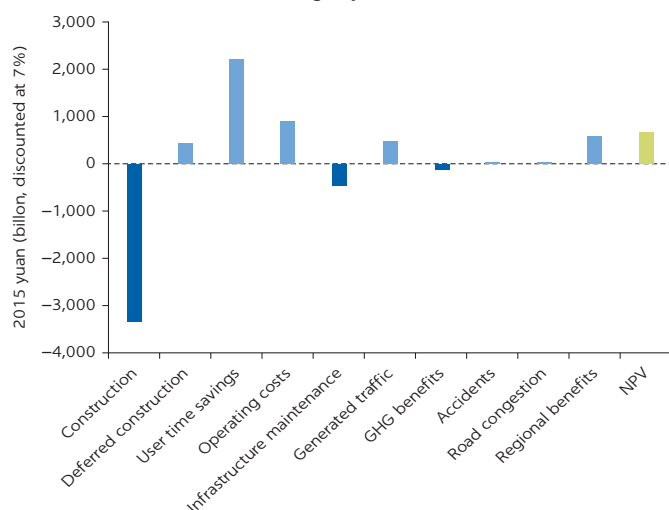
A final financial threshold is earning high enough returns to attract equity investment. At current HSR fare levels, only the 350 kph lines with a density of over 35 million passengers are profitable enough to reach this level.

The options for addressing the HSR financing issues include:

- Improving cost coverage through increasing fares for 250 kph lines, increasing non-fare revenue; providing government subsidies; and
- Restructuring debt by grouping lines and by re-profiling principal repayment to shift payments to later years when travel volumes increase.

China's High-Speed Rail: Economics

Economic costs and benefits of high-speed rail



Note: GHG = greenhouse gas; NPV = net present value.

An **economic evaluation** considers the costs and benefits to society. It includes the costs and benefits incurred by the railway, as well as by other transport operators.

HSR provides major benefits to users in terms of reduced travel time, increased service frequencies, greater availability of seats and improved comfort. Economic benefits also accrue from reductions in operating cost, as users of air and bus transfer to HSR. These transfers also generally reduce externalities (accidents, highway congestion and greenhouse gases).

Benefits also derive from the deferral of the need to invest in the expansion of the capacity of other modes as a result of demand transferring to HSR. Other economic benefits are associated with improved regional connectivity. HSR can contribute to rebalancing growth geographically to reduce poverty and enhance inclusiveness.

The full report is available for download at:

<http://documents.worldbank.org/curated/en/933411559841476316/Chinas-High-Speed-Rail-Development>

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Economic Rate of Return

The economic rate of return is estimated at **8%**, well above the opportunity costs of capital for such major long-term infrastructure investments in China and most other countries. User time savings are the largest single contributor to the project benefits but operating cost savings and externalities together represent about 30%.

Indicative results for the two types of line are that the 350 kph lines have an economic internal rate of return (EIRR) of about **9%** (including regional benefits) and the 250 kph and below lines have an EIRR of about **6%**.

Economic returns for China's high-speed rail

The World Bank has financed parts of six high-speed rail projects in China. Postproject evaluation for the four completed projects show positive economic returns (table B7.1.1).

Economic rate of return

LINE	ECONOMIC RATE OF RETURN (%)
Shijiazhuang–Zhengzhou	15
Guiyang–Guangzhou	18
Jilin–Hunchun	8
Nanning–Guangzhou	16

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EIRR sensitivity to passenger density

