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Financial and Economic Assessment of China's High Speed Rail Investments

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The Financial and Economic Assessment of China's High Speed Rail Investments: A Preliminary Analysis

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ABSTRACT

China has suffered railway capacity constraints for more than several decades and the need for a large increase in rail capacity has been viewed as the primary challenge. The former Chinese Ministry of Railways believed that building a national wide high speed railway (HSR) network was the most efficient solution to China's rail capacity problems. By 2012, 9 000 km of HSR line has been completed which accounted more than half of the total in the World and the other 9 000 km HSR line is either under construction or in the planning stage.

This paper attempts to discuss the initial operational, financial and economic result of such a large scale HSR investment in China where the establishment of an appraisal system for a HSR project is still underway and the public data in need are not available. Based on some trial studies carried out on several HSR projects, however, the paper shows that except for a limited amount of HSR projects in the most developed areas of the country, the initial financial and economic performance of most HSR lines are generally much poorer than expected. The scale of investment seems to be difficult to justify, given that investment in HSR lines is very expensive, especially for those with design speed of 350 km/h, and the high level of debt funding. Moreover the values of time of the ordinary Chinese are still low by European standards.

For a developing country planning HSR projects, one lesson that can be learnt from China is that it would be ideal if a comprehensive appraisal can be taken into account before investing in HSR. Such appraisal includes examination of different options for technical and operational standards, timing of investment, construction scale and pace, train operational scheme and service level, pricing and regional development policy (political consideration). At the very least, a step by step development strategy should be adopted to cope with the huge uncertainties and risks.

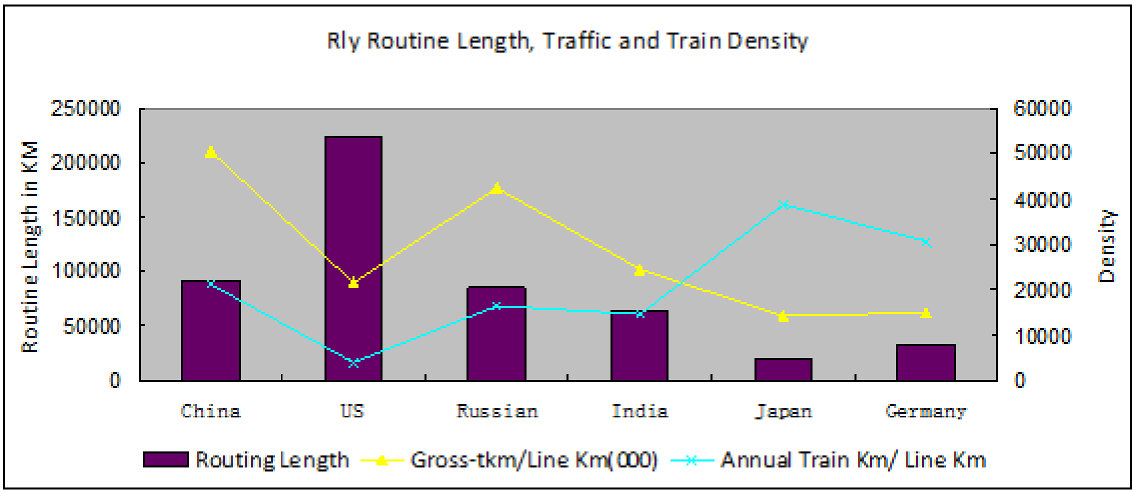
1. INTRODUCTION

In the next section we introduce the background information on HSR planning and its radical implementation by 2012 in the Chinese situation. We then consider in turn the construction costs of HSR and its composition in China, the initial operational and financial performance of the selected HSR projects. After this we assess the initial economic results of several HSR projects via their impact on mode split, the competition between HSR & air, time savings, additional capacity, reduced externalities and 3 actual project benefit analyses on a trial base. Finally the issue of wider economic benefits is discussed before reaching our tentative conclusions.

1.1 The background of building HSR in China

For more than 30 years, the extremely rapid growth of the economy in China has generated a continuing demand for basic commodities, while increasing wealth in China, where there is over 1.3 billion population, has also put extreme pressure on passenger demand. As Figure 1 shows, the net result of these trends is that Chinese Railways (CR) now has by far the highest traffic density network in terms of Gross Ton-Km per line Km in the World[1]. This capacity stress is aggravated by the fact that the coexistence of relatively fast passenger trains and slow freight trains further strains reliable operations.

Figure 1. **International Comparison on Routing Km vs. Traffic and Train Density**



Main source：UIC, 2009 and 2010

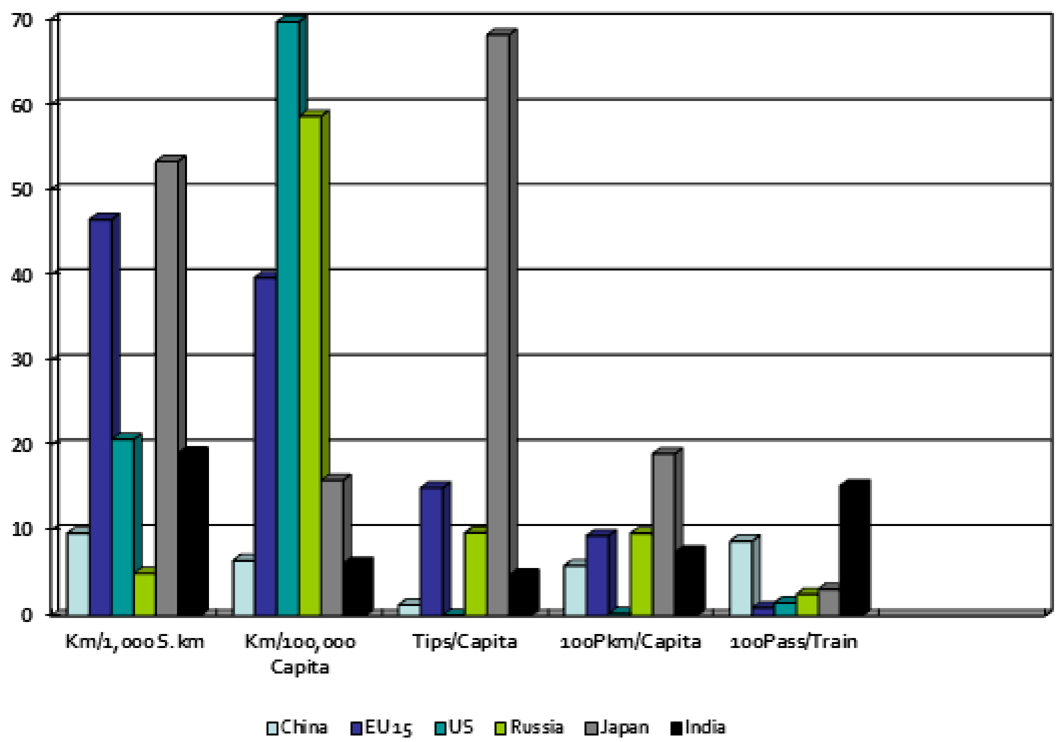
For example, in China there are Six Artery Lines, namely Beijing-Shanghai Line, Beijing—Guangzhou Line, Beijing-Harbin Line, Beijing-Hong Kong Line, Longhai Line and Zhejiang-Jiangxi Line. For those lines, capacity is almost saturated. Also there are restricted corridors for entrance and exit in some areas. Further, CR has been facing seasonal capacity constraints for many years, esp. during Chinese New Year and Summer Holidays.

International comparison shows that in terms of railway network density, trips and pass-km per capita, China is far lower or lower than the major railways in the world, while the average load of conventional passenger train is much higher. Figure 2 indicates that:

- China has less than half the ratio of rail line-km/1 000 square km of land area than India has, and is even farther below Japan and the E.U.
- China has less rail line km/100 000 population than India, and only half that of Japan, to say nothing of the U.S.
- Chinese people take only one-third the rail trips/capita of India, and one-seventieth that of Japan.

1. The train density in the truck lines in China is 2-3 times higher than that of the average.

Figure 2**. Network Density, Average Annual Rail Trips and Pass-Km per Capita**



Main source : UIC, 2009 and 2010

Finally, international experience also shows that railway transport is a powerful tool to support sustainable development. A study (INFRS/IWW 2004) illustrates that in the E.U. the average external cost of railway is less than 1/4 of the road for freight and is only 1/3 of the car for passengers. In China's case, a trial study (Nash C., Shires J. etc., 2008) has been finished with the help of the World Bank. The preliminary conclusion showed the average external cost of railways in China was only 1/25 of that of road for freight and was 1/8 of that of autos for passengers.

All the reasons mentioned above can conclude that China has the most heavily used rail network in the world and that railway will have to keep a major share of both passenger and freight markets for China's sustainable development. The former Chinese Ministry of Railways (MOR)[2] viewed the primary challenge as simply being a lack of capacity.

1.2. The key role of HSR plan in China's Rapid Railway Development Plan

Accordingly, a mid-and Long-term Railway Network Program (MLRNP) in China was drafted by former MOR and approved by the State Council in 2004. The MLRNP was further modified in 2008 to accommodate the various kinds of demands from the provincial governments. The major content of the MLRNP can be summarized as follows (see Figure 3):

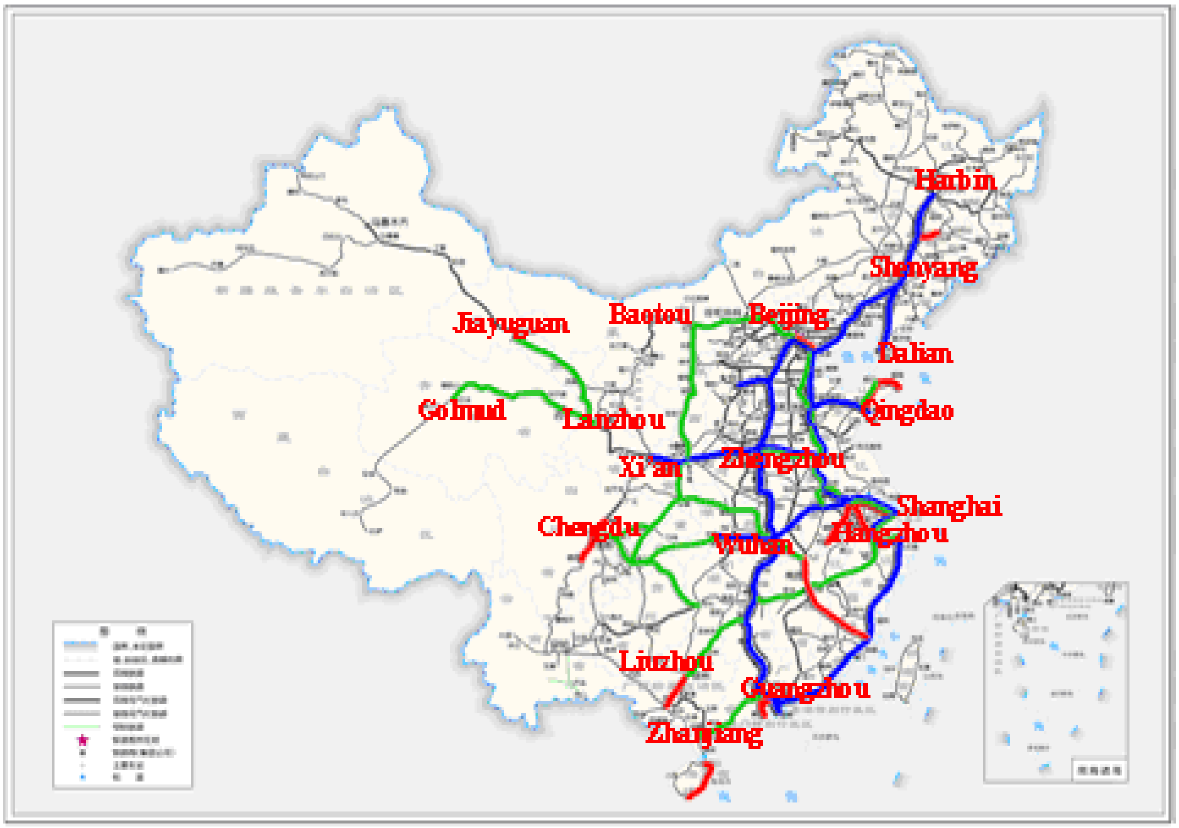
2 Chinese government decided to dismantle the Ministry of Railways into administrative and commercial arms in the annual session of the country's top legislature on March 10, 2013

(1). By 2020, railway operating route will exceed 120 000 km, of which the high speed railways (HSR) and the intercity high speed lines will take 1 8000 km, and both the ratio of double-track and electrified line will be increased to 60%.

Figure 3**. Mid-and Long-term Railway Network Development Map**

(2). Through construction of HSRs and upgrading of existing lines, an express passenger transport network with a total length of more than 40,000 km(including 18 000 km of HSRs) will be formed to serve 90% of cities with population over 500,000 (Figure 4) .

Figure 4. **Map of an Express Passenger Transport Network in China**



(3). Completion of the Backbone of Large-capacity Freight Transport Corridors, namely: Coal transport corridor, South-North corridor, Northeast corridor, Southwest corridor and Northwest corridor

Without examining sufficient alternatives to solve the capacity problem[3], the decision makers of former MOR believed that building a national wide HSRs network was the solution to maintain present and future economic development. Further, the decision maker also believed that passenger trains could be transferred from existing lines to the HSRs to realize the separation of passenger trains from freight ones, resulting in a great increase of the freight transport capacity on existing lines. So completing the HSRs network has been a top priority task for former MOR since 2005.

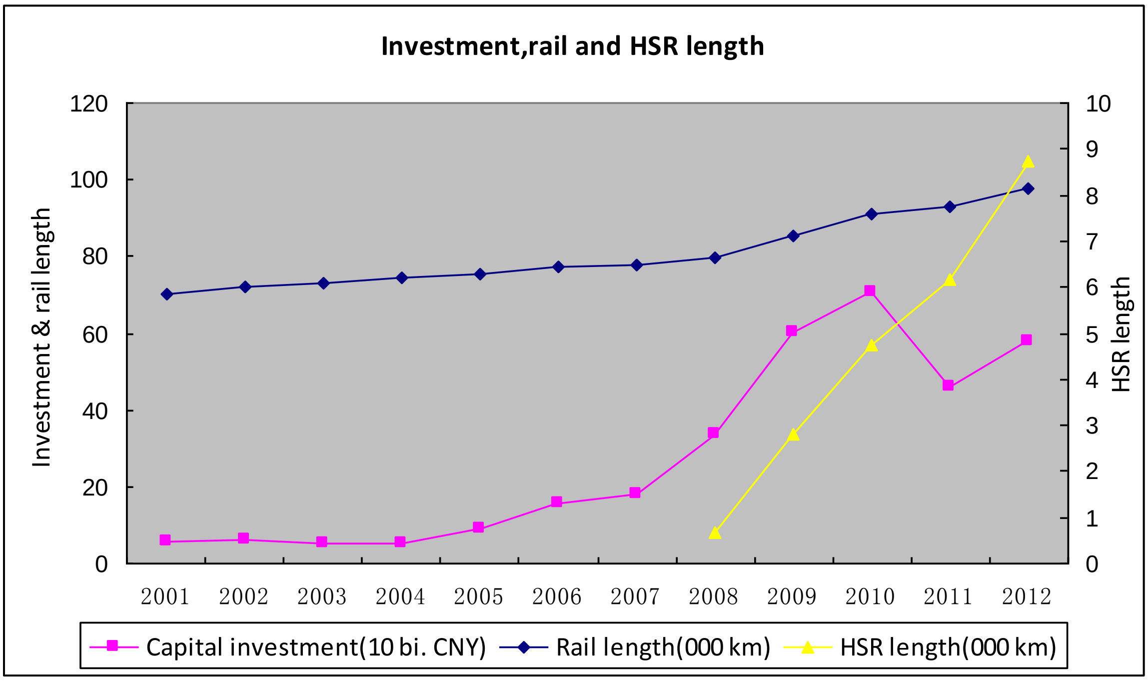
1.3. HSR construction and its implementation by 2012

The development of HSR lines is seen as the most significant task in the long-term development plan of former MOR and has been the key part of the 11th FYP (2006-2010) and 12th FYP (2011-2015) of the railway sector. The 1st round of HSR construction with two kinds of technical standards in terms of design speed, i.e. 250 km/h and 300 km/h or above was initialized in China since 2005 (Appendix 1). The construction process and

3. Unlike the twin desire for building a new high speed line Worldwide (Nash, 2009), the competition from air is not so server in the major railway corridors, e.g. the passenger market share of different modes in Beijing-Shanghai corridor was 78.7% for road, 18.8% for rail and only 2.5% for air in 2009.

engineering period were radically accelerated to serve as a strong tool to stimulate the Chinese economy and to cope with the global financial crisis (Keynesian policies). Accordingly, a "Great Leap Forward" Railway Expansion was implemented. The total capital investment in the 11th FYP (2006-2010) approached nearly 2 trillion RMB[4] (Figure 5), with capital spending reaching an all-time record of 700 billion RMB in 2010, which is 9 times the level of investment in 2005. The investment in HSRs will account for around 70% of the total railway investment between 2006 and 2015, while the length of new HSR line increased from 410 km in 2008 to 5143 km in 2010, ranking No.1 in the world only within 3 years. By 2012, the routine length of HSR in China reached 9000 km which accounted for more than half of total HSR line in the world, including 5700 km of lines for speeds above 300 km/h (Figure 6).

Figure 5. **Dramatic increases of rail capital investment and HSR length since 2005**



Source：Former MOR's documents on issuing railway bonds.

4. At January 2011 rates, that was equivalent to USD 316 billion

Figure 6. **HSRs network plan and its implementation in China by 2012**

Source: CR & UIC

2. THE COST OF BUILDING HSR INFRASTRUCTURE AND ITS COMPOSITION IN CHINA

As shown in Appendix 1, two kinds of HSR lines, defined as either a rail system having a maximum speed of 250 km/h or having a maximum speed of 350 km/h, have been developed in China since 2005. Appendix 2 lists the unit cost of building HSR infrastructure based on public data. The construction cost per km of 12 projects with design speed of 250 km/h ranges from 6.03 to 18.10 million Euros, with an average cost of 8.84 million. While the construction cost per km in 10 projects with design speed of 350 km/h or over varies between 12.07 and 27.57 million Euros, with an average value of 16.50 million.

In most projects with design speed of 350 km/h, stations in big cities such as those in Beijing, Shanghai, Tianjin, Wuhan, Guangzhou, Jinan, Shenzhen and so on, are independent projects with an architectural design, huge space and associated costs far beyond the minimum needs for train operating purposes. The total infrastructure cost of HSR with design speed of 350 km/h or over could be increased by from 10% to 30% if the construction cost of the big stations is included.

Appendix 2 also shows that the average unit construction cost of high speed rail with design speed of 350 km/h was about 90% higher than that of 250 km/h. The major reason for the so high incremental cost is because it has to be elevated to accommodate the common use of slab (ballastless) tracks: many parts of China have soft soils, and thus bridges/viaducts are used instead of road bed at ground level (Wu and Rong, 2013). The average ratios of the bridges (including viaducts) and tunnels length to the route length was 74% for the HSR with design speed of 350 km/h (Liu, J, 2010) and it raised as high as 90% for some specific projects(Wang Y., 2009). This is much higher than in the EU.

The cost composition of HSR infrastructure includes the infrastructure, superstructure, land and other costs. The average cost ratio of the infrastructure and superstructure are respectively around 60% and 20% (Liu, J., 2010), of which the bridges (including viaducts) and tunnels are over 45% of the total cost. This is well above than in the EU, where it usually represents between 10% and 25% of the total HSR infrastructure cost (Campos, and De Rus, 2009).

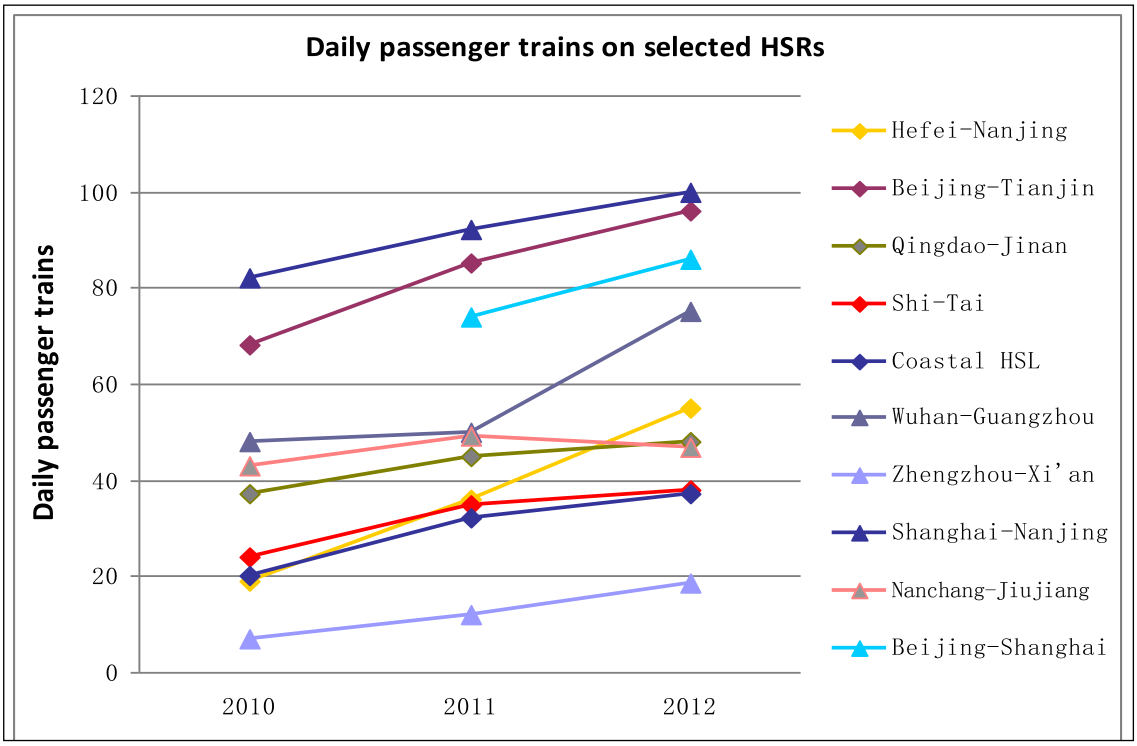
In general, the unit construction cost of HSR line in China varies enormously, between 8 and 30 million Euros, and depends mainly on the technical standards adopted and other circumstances. This is not as low as some people supposed when compared with European standards as 12–40 million Euros (Nash, 2009) and adjusted by purchasing power parity (PPP).

3. THE INITIAL OPERATIONAL PERFORMANCE OF HSR IN CHINA

So far, there is little public data on line-by-line operational performance of HSRs in China. However, based on the number of pairs of trains available on an electric train time table named JPSKB, the load factors and the seating capacity of different kinds of trains and the initial operational performance of 15 HSRs can be estimated as shown in Appendix 3, Figure 7 and Figure 8. The traffic density of the HS lines in 2012 can be classified in 3 groups. The first group is composed of 8 HS lines whose traffic densities are more than 20 million passenger trips per annum[5]. Among them, 4 are lines with design speed of 350 km/h and located in the richest and densest population area in China (such as Beijing-Shanghai HS line and Shanghai-Hangzhou HS line), and 4 are lines with design speed of 250 km/h and mainly located in the East part of the country or linking its middle part with the East (such as Qingdao-Jinan HS line, Nanchang-Jiujiang HS line and Hefei-Nanjing HS line). The 2nd group is composed of 3 HS lines whose traffic density is greater than 10 million passenger trips per annum, but less than 20 million, including Wuhan-Guangzhou HS line and Coastal HSL. The 3rd group is composed of 4 HS lines with traffic density less than 10 million and mainly located in the less relatively developed areas of China, such as Zhengzhou-Xi'an HS line, Chengdu-Dujiangyan HS line and Changchun-Jilin HS line.

5 It is defined as there are 20 million passenger trips running through per km of route line per year.

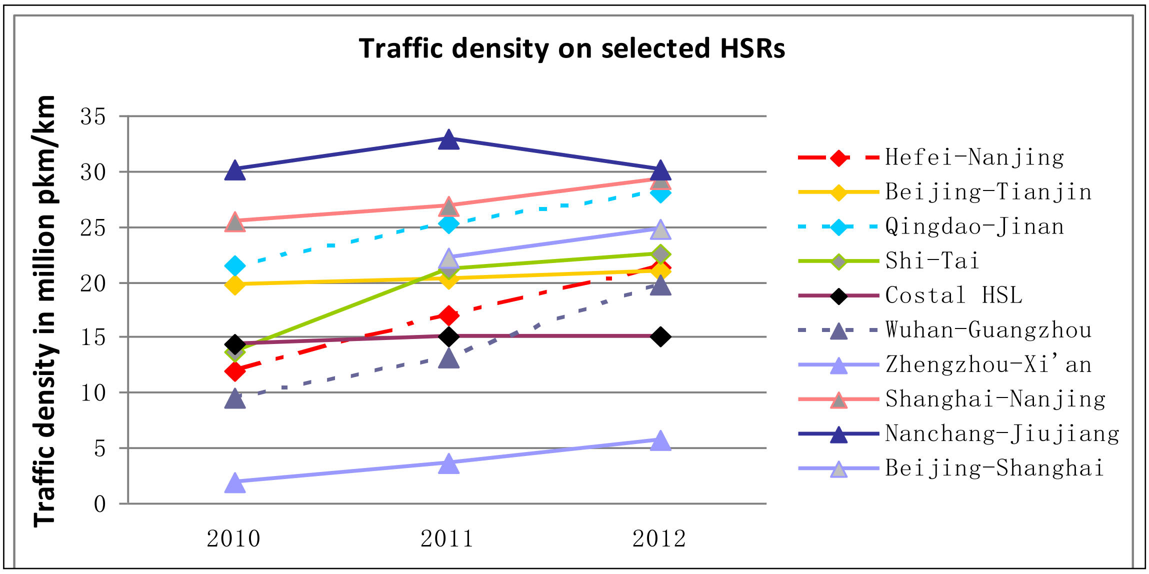
Figure 7. **Daily average number of passenger trains on selected HSRs from 2010-2012**



Appendix 3 also shows that in terms of annual traffic increase rate from 2010 to 2012, the selected 15 HSR s can be also grouped into 3 categories. Category one is composed of 7 HS lines whose average annual traffic increase rate is greater than 20%. Most of them suffered from heavy rail capacity constraints before the opening of HSR, which are the case for the HS lines of Wuhan-Guangzhou, Hefei-Nanjing Shijiazhuang-Taiyuan and Beijing-Shanghai (except for that of Zhengzhou-Xi'an[6]). Category two is composed of 3 HS lines whose average annual traffic increase rate is greater than 7%, but less than 15% while category three is composed of 5 HS lines whose average annual traffic increase rate is less than 4% or stable, whose demand for high speed services develops more slowly than expected. The reasons for the lines with the lower traffic increase rate are either due to the parallel line competition, e.g. between Beijing-Shanghai HSL and Beijing-Tianjin HSL or Shanghai-Nanjing HSL, or due to the lower economic growth rate, which is the case for HSLs of Changchun-Jilin and Nanchang-Jiujiang.

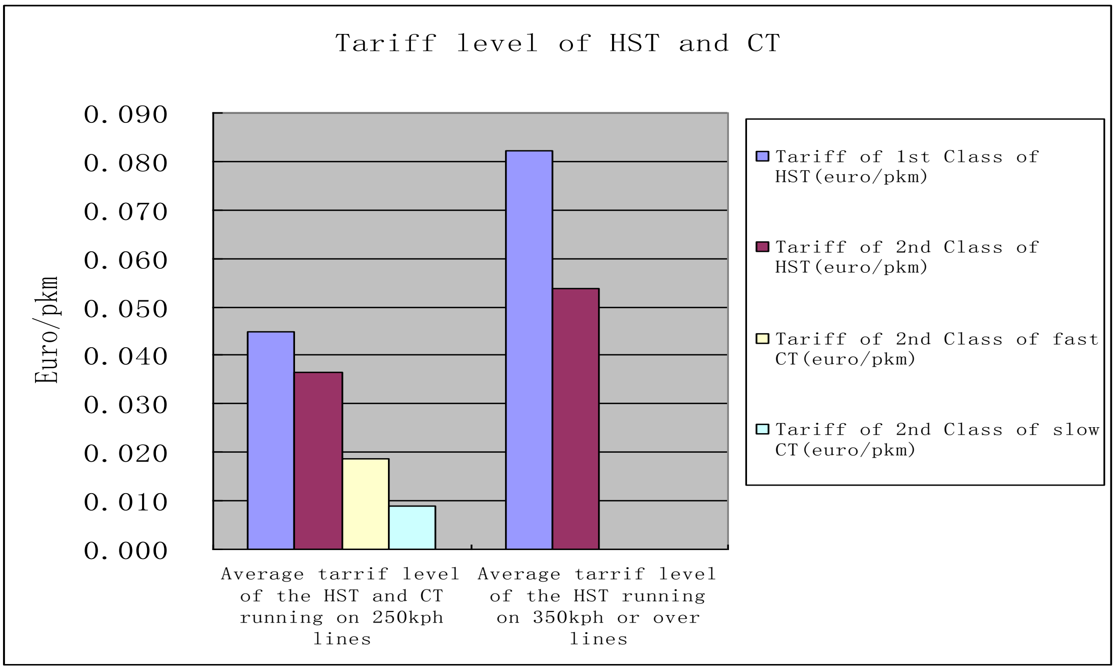
6. The high annual increase rate of Zhengzhou-Xi'an HSL is mainly due to the network effect which caused by the opening of Zhengzhou-Wuhan and Zhengzhou-Beijing HSL in 2012.

Figure 8. **Estimation of traffic density on selected HSRs from 2010-2012**



Further, the 250 km/h HS lines with ballasted tracks can accommodate both the HS train (HST) and the conventional train (CT), while the 350 km/h HS lines with slab track and lower axle load limitation (≤17t) prevents the CT, whose axle load is≥21t, to run on it. This important technical characteristic made the 250 km/h HS lines gained higher traffic volume and better train load factor than those of the most 350 km/h HS lines, given that the tariff level for the HST running on 350km/h lines is about 2 or 4 times higher than that of the CT (Figure 9 and Appendix 6).

Figure 9. **Average tariff level of HS train and conventional train in China**



4. FINANCIAL ASSESSMENT OF CHINA'S HSR INVESTMENT

4.1. A preliminary analysis for the initial financial performance of HSRs

It is rather difficult to have a precise financial assessment of China's HSR investment at current stage, not only because most of HSRs have been opened less than 3 years ago, but also because very little information is publicly available on the financial performance of the HSRs. However, a brief analysis or projection can be made based on some empirical data disclosed by media, author's professional knowledge and international experience so far.

From the financial performance point of view, international experience shows that so far only Tokaido-Shinkansen and Paris-Lyon TGV are financially profitable worldwide. In China, due to the limited financial investment from the government, 50%-60% of HSL investment was from market borrowing. Therefore, very large traffic volumes are needed to support the high financial, depreciation, and operating and maintenance costs when a HSL is put into operation. For most of the HSRs listed in Appendix 1, the initial financial performance was poor when compared with the ex-ante appraisals. Indeed, the actual construction cost of most lines was about 30-50% higher than expected in the feasibility study stage, while the actual traffic volumes were far lower than the forecast. An estimation of the initial financial performance of four HSR projects has been made and is described in Tables 1- 4.

Table 1. **Estimation of the financial performance of Beijing-Tianjin HSL**

Item	2009	2010	2011	2012
Total traffic volume（m pass-km）	2 244	2 640	2426.4	2 522.4
Interest payment(m. CNY)	600	600	600	600
Depreciation(m. CNY)	613	613	613	613
O & M cost(m. CNY）	600	705.93	648.82	674.49
Total cost (m. CNY）	1 813	1 918.94	1 861.82	1 887.49
Average rate（CNY/Pass-km)	0.49	0.49	0.49	0.49
Total ticket sale (m. CNY）	1 110.41	1 306.36	1 200.66	1 248.18
Financial result (m CNY)	-702.59	-612.59	-661.16	-639.32
Annual average repay of the principal（m. CNY)	854	854	854	854

Source: Author's own computation mainly based on information from WENG Shuping, 2010-04-05"The Financial Result of Leap Forward: The Annual Operation of Beijing-Tianjin HSR Cause a Loss of 700 million CNY", Economic Observer Newspaper

Table 1 indicates that the financial loss of Beijing-Tianjin HSL mainly comes from very high capital investment (20.51 m. Euros/km)), high financial costs and lower annual traffic increase rate at 3.05%. This situation is difficult to be changed unless there is a rather high traffic increase in the next few years.

Table 2. **Estimation of the financial performance of Wuhan-Guangzhou HSL**

Item	2010	2011	2012
Total traffic volume（m pass-km）	1 0870	16 304	21 087
Interest payment(m. CNY)	2 600	2 600	2 600
Depreciation(m. CNY)	3 000	3 000	3 000
O & M cost except energy (m. CNY）	2 000	3 000	3 880
Energy for Train(m. CNY)	655	946	1 223
Total cost (m. CNY）	8 255	9 545.65	10 703.04
Average rate（CNY/Pass-km)	0.46	0.46	0.46
Total ticket sale (m. CNY）	5 000	7 500	9 700
Financial result (m CNY)	-3 255.00	-2 045.65	-1003.04
Annual average repay of the principal（m. CNY)	5 000	5 000	5 000

Source: Author's own computation mainly based on information from SONG Jing, 2010-11-29, "5 Billion CNY, The Knack of Wuhan-Guangzhou HSL for Doing Business", The Economic Report in 21st Century

Table 2 shows that the financial loss of Wuhan-Guangzhou HSL mainly comes from high capital investment (15.69 m. Euros/km), high financial costs and a lower traffic density (19.71 m. passenger trips per annum) although it exhibit a very high annual traffic increase rate at 44.34%. It seems that the commercial viability of this kind of project will be achieved if the traffic can keep increasing at 20%.

Table 3 shows that the heavy financial loss of the Zhengzhou Xian HSL project mainly comes from a very low traffic density (5.75 million passenger trips per annum), rather than high financial costs, although its capital investment (12.07 m. Euros/km) is relatively low. This kind of project, i.e. a HSR project in the middle and west part of China, is unlikely to break-even financially in the foreseeable future.

Table 3. **Estimation on the financial performance of Zhengzhou-Xi'an HSL**

Item	2010	2011	2012
Total traffic volume（m pass-km）	929.00	1 858.00	2 903.12
Interest payment(m. CNY)	1 254.76	1 254.76	1 254.76
Depreciation(m. CNY)	1 140.69	1 140.69	1 140.69
O & M cost except energy (m. CNY）	170.94	341.87	534.17
Energy for Train(m. CNY)	53.88	107.76	168.38
Total cost (m. CNY）	2 620.26	2 845.08	3 098.00
Rate（CNY/Pass-km)	0.46	0.46	0.46
Total ticket sale (m. CNY）	427.34	854.68	1 335.43
Financial result (m CNY)	-2 192.92	-1990.40	-1 762.56
Annual average repay of the principal (m. CNY)	2 100	2 100	2 100

Table 4. **Estimation on the financial performance of Jian-Qingdao HSL**

Item	2010	2011	2012
Traffic volume（ m pass-km）	8 434.57	9 914.92	1 1016.58
Interest payment(m. CNY)	561.76	561.76	561.76
Depreciation(m. CNY)	510.69	510.69	510.69
O & M cost except energy (m. CNY）	489.32	575.20	639.11
Energy for Train(m. CNY)	221.31	260.15	289.05
Total cost (m. CNY）	1 783.07	1 907.79	2 000.60
Average rate（CNY/Pass-km)	0.21	0.21	0.21
Total ticket sale (m. CNY）	1 786.99	2 100.62	2 334.02
Financial result(m CNY)	3.92	192.83	333.42
Annual average repay of the principal（m. CNY)	850	850	850

Table 4 shows that, unlike the previous three 350km/h HSL, the financial result of Jian-Qingdao HSL is positive, which is very unique among the operating HSLs. This is simply because of the very low capital investment (6.27 m. Euros/km) from lower technical standard (with 250 km/h), a rather high traffic density (28.03 m. passenger trips per annum) and a middle annual traffic increase rate at 14.29%.

4.2. The estimation of commercial break-even traffic density of HSRs in China via international comparison and their initial financial performance

Given the level of unit construction costs, the high level of debt funding structure (up to 60% of the total investment), the current tariff level and the operating and maintenance costs of the of HSRs, the breakeven traffic density in China for the HSRs with 350 km/h is estimated to be about 40-50 million passenger trips per annum, while that for the HSRs with 250 km/h is estimated about 25-30 million passenger trips per annum (Appendix 4). For HSRs with traffic density less than 10 million passenger trips per annum, if other trains could not run on them, their operating incomes will have difficulty to cover operating costs and interest repayment. If so, these lines will become long-term loss making assets.

5. ECONOMIC ASSESSMENT OF CHINA'S HSR INVESTMENTS

In China, the establishment of an economic assessment system for a HSR project is still underway and there is almost no published ex post cost-benefit analyses of specific HSR projects. In this section, we discuss some key issues related to the economic assessment of China's HSR investments and then introduce some trial studies for the appraisal of several HSR projects.

5.1. Mode split, generated traffic and the competition between HSR and air

The official data on the HSR impact on mode split is not yet available in China, not only due to the short period of time of HSR operation, but also due to the lack of a sense of importance for those data from the Chinese Railway authority. However, several case studies have been made to estimate the HSR impact on modal split.

As has happened in other countries where HSR services have been introduced, China's HSR investments lead to shorter travel times, somewhat cheaper price and much higher frequency compared to air transport, and improved travelling conditions, which have resulted in different levels of modal shift and generation of new demand on different routes (Givoni, 2006). Most of the demand shifted to the HSR services from other modes is either from aircraft for long distance travel, which was the case on the Wuhan-Guangzhou route and Beijing-Shanghai route (Tables 10 & 11), or from bus for shorter distance travel, which was the case on the Beijing-Tianjin route (Table 7). However, it is also true that at least half of the demand for new HSR services is demand shifted from the conventional railway, leading to reductions in passenger services on the conventional rail network (Vickerman, 1997). For example, on the Jinan-Qingdao HSR, over 90% of the traffic on the new line was diverted from other rail lines (Table 7), while the numbers are over 50% for both routes on Wuhan-Guangzhou and Beijing-Tianjin (Table 5 & 6).

In some cases, the traffic generation effect of new HSR services is substantial. On the Wuhan-Guangzhou route, total rail traffic within this transport OD pairs increased by 38% one year after the opening of the HSR services, of which a total of 4% is related to the trend of growth and 34% is considered as induced and shifted traffic from other modes. Also on the Beijing-Tianjin route, total rail traffic within this rail transport OD pair increased by 71.52% one year after the opening of the HSR services. A total of 5% is related to the trend of growth and 66% is considered as induced and shifted traffic from road. Some informal investigations show that quite a large part of the new generated traffic for Wuhan-Guangzhou HSR is from tourism, induced by shorter travel time and better quality of service. Further, at the beginning when the Beijing-Tianjin HSR started in service, part of the generated traffic was related to passengers who were just curious about the experience of riding the new HSR train service.

Table 5. **Estimate of the composition of Wuhan-Guangzhou HS traffic in 2010**

Diverted from conventional lines	52%
Diverted from aircraft	6%
Generated or shifted from road	42%

The air traffic in the Wuhan and Guangzhou corridor was reduced by about 50%, of which the air traffic between Wuhan and Guangzhou OD was reduced about 40% while that between Changsha and Guangzhou OD was reduced 60% (Wu, Cui, etc., 2011).

Table 6. **Composition of Beijing-Tianjin HS traffic from 2009 to 2011**

	2009	**2010**	**2011**
Diverted from conventional lines	55.39%	49.76%	47.73%
Generated or shifted from road	44.61%	50.24%	52.27%
inc. road	11.09%	9.50%	8.68%
inc. generated	33.53%	40.74%	43.59%

Table 7. **Composition of Jinan-Qingdao HS traffic in 2012**

Diverted from conventional lines	93.61%
Generated or shifted from road	6.39%

The competition between HSR and air

In the EU, one of the two desires for building a new high speed line is to compete with air in the major railway corridors, which has been proved very successful. Table 8 indicates the market shares of plane and train before and after the introduction of high speed rail. The impact on rail market share is very substantial (Nash, 2009). Moreover, the figures in table X demonstrate that when journey times are within 4 hours (or with a distance less than 800 km), HSR tends to have a rail/air market share of at least 60%, and sometimes effectively drives air out of the market when rail journey times are below three hours. This is also the case in Japan.

Table 8. **Before and after rail/air market share comparison in France and Spain**

	TGV Sud-Est		AVE Madrid-Seville	
	Before	**After**	**Before**	**After**
Plane	44%	9%	71%	20%
Train	56%	91%	29%	80%

Source: COST318 (1998)

Table 9. **Travel time (distance) and rail/air market share in EU and Japan**

OD pair	Travel time on board(h)	Rail/air share %	Distance (km)
Paris-Bruxelles	1.4	95	310
Paris-Lyon	2	90	430
Madrid-Seville	2.25	82	471
Paris-London	2.65	70	494
Stockholm-Goteborg	3	60	455
Tokyo-Osaka	2.5	85	515
Tokyo-Hiroshima	3.85	56	894
Rome-Bologne	2.55	74	358
Paris-Amsterdam	4	45	450
Rome-Milan	4.5	38	560

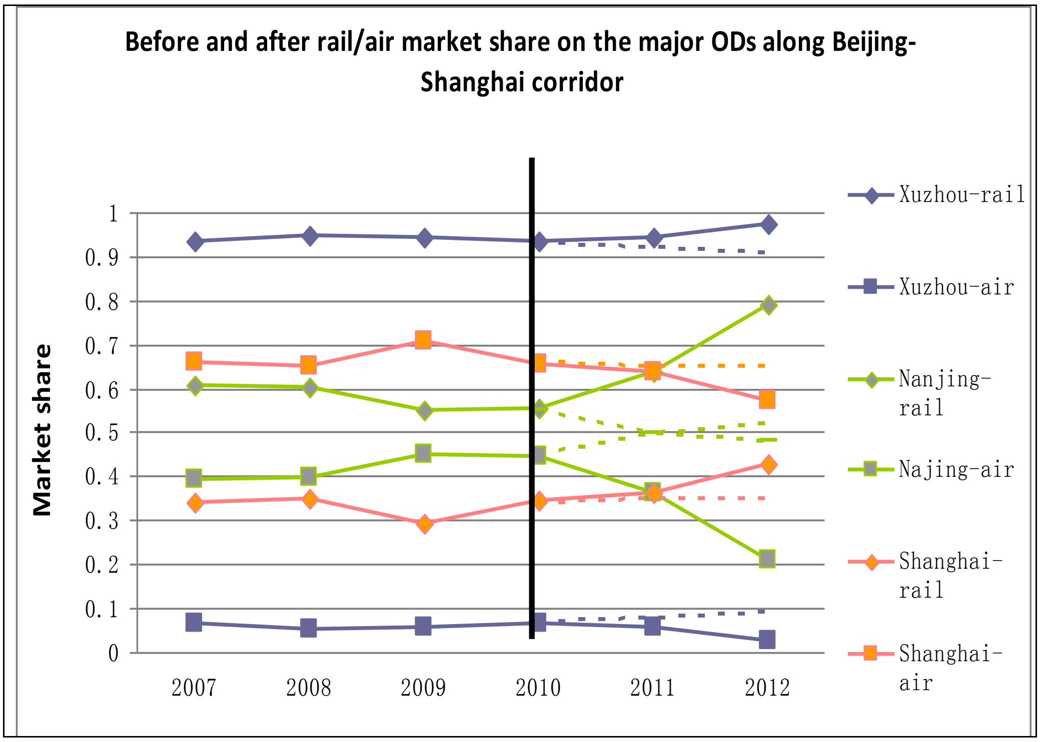
In China, the rail share increases very impressively after the introduction of HSR on the main truck lines, such as Wuhan-Guangzhou transport corridor since 2009 and Beijing-Shanghai transport corridor since 2011. As indicated in Table 5,the air traffic share in the Wuhan-Guangzhou corridor was reduced from 7.01% to 2.86%, of which the air traffic between Wuhan - Guangzhou OD (1 000km) was reduced about 40% while that between Changsha - Guangzhou OD (700km) was reduced 60% (Wu, Cui, etc., 2011).

Table 10. **Before and after rail/air share in Wuhan-Guangzhou transport OD pairs**

	Before (2009)	After (2010)	Change
Aircraft	7.01%	2.86%	-4.16%
Conventional Train	92.99%	55.92%	-37.06%
HS Train	0.00%	41.22%	41.22%
Total	100.00%	100.00%	

For the Beijing-Shanghai transport corridor, Figure 10 shows that the rail shares of 3 ODs, namely Beijing-Xuzhou, Beijing-Nanjing and Beijing-Shanghai, were in the trend of declining at different extent until 2011 when the HSRs were put into operation.

Figure 10. **Before and after rail/air market share on the major ODs of Beijing-Shanghai corridor**



Main sources: 1. The Civil Aviation Publishing House in China, 2010-2013,The Annual Statistics of Civil Aviation in China. 2. Authors'estimation based on the data collected from various websites, including JPSKB.

Further, the data in table 11 illustrate that the actual impact of HSR to air traffic along the Beijing-Shanghai transport corridor is much stronger than forecasted by some experts (Peng and Hu, 2009; Ding, etc., 2013,). It seems clear that in China HSR tends to have a market share of about 80% when rail journey times are within 4 hours or travel distance around 1 000km, which is significantly higher or longer than those of the EU and Japan. This can be explained by the HSR's rather cheaper price[7] and higher frequency when compared with the air (Appendix 5) and also the heavy airport delay that happened so frequently in recent years.

7. Further deregulation both in air tariff and in air market by the introduction of low cost carriers to compete with HSR on the main transport corridors has been proposed by some experts from air industry.

Table 11. **Change of rail/air market share and airport's impact caused by Beijing-Shanghai HSR**

Airport	Rail distance to Beijing	Rail journey time to Beijing	Expected Impact to air before	Market Share %				Actual impact to air after
				Before (2010)		After (2012)		
				Rail	Air	Rail	Air	
Jinan	406 km	1.63h	-36%	91%	9%	98%	2%	-78%
Xuzhou	692km	2.85h	-67%	93%	7%	98%	2%	-64%
Nanjing	1023km	4.10h	-4%	55%	45%	79%	21%	-53%
Wuxi	1210km	4.90h	-2%	57%	43%	70%	30%	-31%
Shanghai	1318km	5.53h	-2%	34%	66%	43%	57%	-13%

Source: 1. Ding, etc., 2013.
2. The Civil Aviation Publishing House in China, 2010-2013,The Annual Statistics of Civil Aviation in China;
3. Authors' estimation based on the data collected from JPSKB.

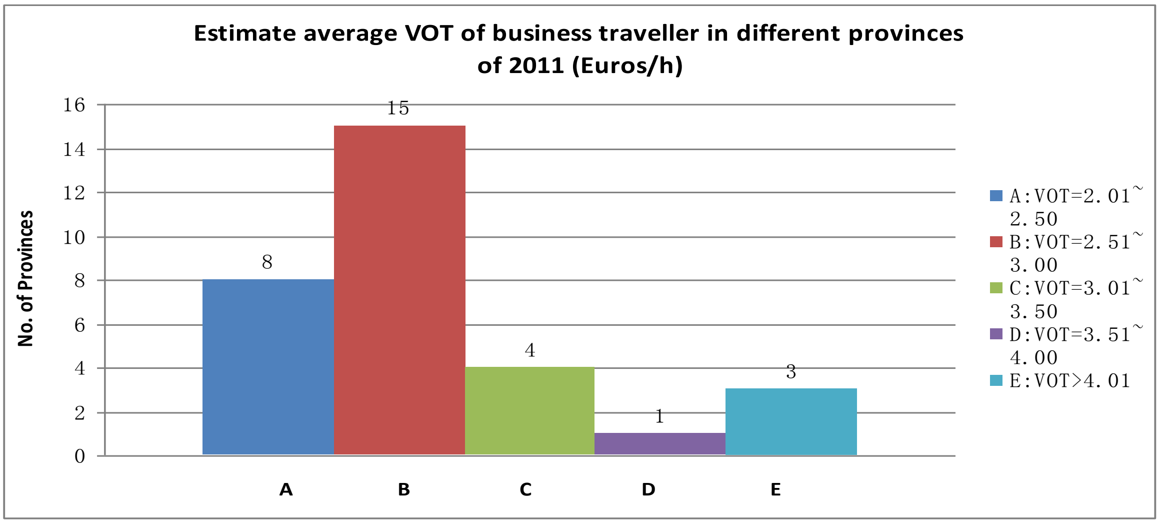
5.2 Time savings[8]

5.2.1 Estimation of VOT in China

In European countries, numerous studies have been undertaken into the value passengers place on time savings (VOT). For travel in working time, it is usually assumed that the value is what the employer pays for the time in question (i.e. the wage rate plus the overhead cost of employing labour). In China, there is neither an official parameter for VOT nor a reliable specific study in this field. However, the willingness to pay principle for estimating VOT was written in the government document for railway project evaluation (MOHURC, NDRC and MOR, 2012) and the common practice is to use the average hourly wage plus welfare payment of employee in urban units for business travellers and 30%-50% for non-business travellers, as an estimate of VOT. Accordingly, we estimate the average VOT of business traveller in different provinces in Euros/h and divided them into 5 groups (Figure 11).

8. Based on (Wu, Nash, and Wang, 2013)

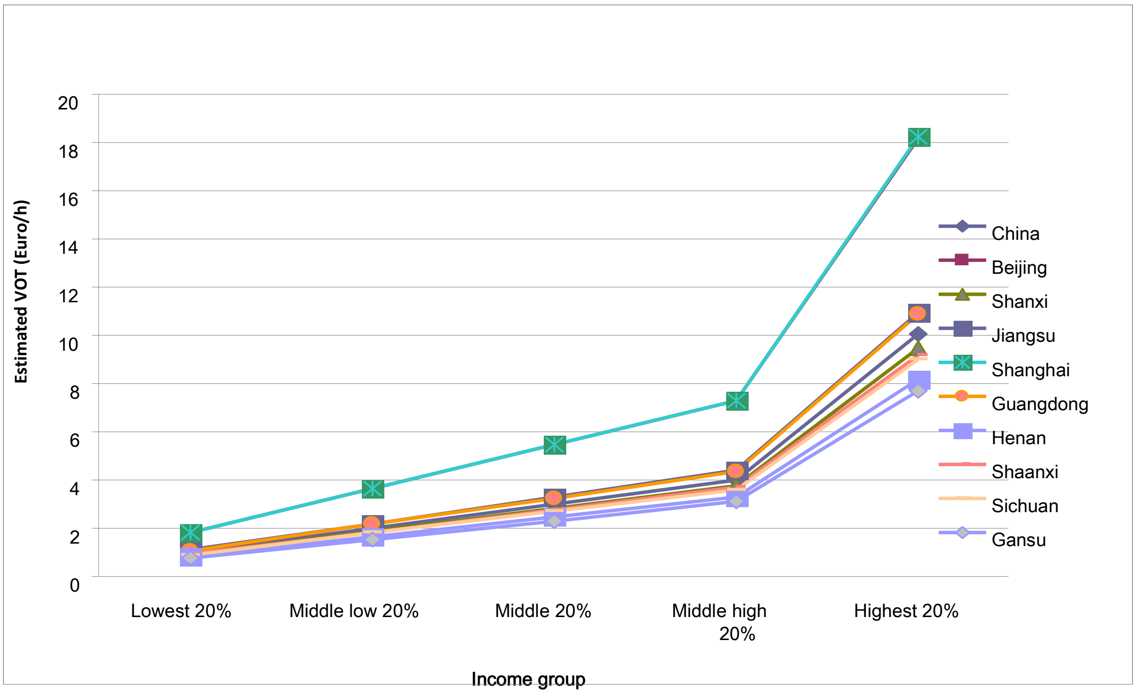
Figure 11. **Estimate average VOT of business traveler in different provinces**



Source: China Statistics Year Book, 2011

Figure 11 shows that China, despite its astonishing economic growth in recent decades, remains a relatively poor country and values of time remain low by European standards; moreover they differ enormously between regions. Further, there could be also large income gaps within the same province. As it is indicated in Figure 12, the VOT of the highest income group in Shanghai could be as high as 18.21 Euros/h, while the VOT of the lowest group could be lower than 1 Euros/h in provinces like Gansu, Henan and Sichuan, which will be about one twentieth of that in Shanghai.

Figure 12. **The unbalanced distribution of estimated VOT within the same province**



5.2. 2. Estimation of the time savings per passenger

Before the introduction of the HST, the Chinese Ministry of Railways has carried out 7 rounds of raising train speed in the existing lines. The maximum technical speed of conventional train (CT) could reached to 200 km/h or even 250 km/h for EMU in some part of the main truck lines, such as Beijing-Shanghai, Beijing-Wuhan. Accordingly, the average operational speed of CT was 120 km/h on the main truck lines, while those of CT on Beijing-Shanghai and Beijing-Guangzhou were 138 km/h, 136 km/h respectively.

Table 12 lists the estimate result of average value of time saving per passenger for a 500 km journey in Euro when we compare the HSR train with the fast CT[9].

9. We assume that the business/leisure traveller split is 50/50, and value of leisure travel is 50% of business travel shown in Figure 11.

Table 12. **Estimation of average value of time saving per passenger for a 500 km journey** (Euros)

	Time savings per trip	Average VOT	Value of time saved per trip
The operational speed of HS train with a max design speed of 250km/h at national average level	0.88	2.27	1.99
The operational speed of HS train with a max design speed of 350km/h at national average level	1.79	2.27	4.05
Beijing-Shanghai HS Line	1.58	2.84	4.49
Wuhan-Guangzhou HS Line	1.68	2.09	3.51
Zhengzhou-Xian HS Line	1.69	1.97	3.34

Source: 1. He, H., (2007) ;
2. Authors' study based on the data collected from JPSKB

5.3. Estimation of the break even traffic required to justify the investment of a high speed line only in terms of time savings (Wu, Nash and Wang. 2013)

Based on the methodology developed by de Rus and Nombela (2007), we built the following formula:

$$B = \sum_{i=1}^{T} \frac{Q_i * \Delta t * VOT_i}{(1+\gamma)^{i-1}} - I_C \qquad (1)$$

B : Total net benefits of a HSR project in its project evaluation period;

T : Project evaluation period, T = 50 year;

Q_i : Demand in i year and $Q_{i+1} = Q_i * (1+\alpha_i)$

α_i : Annual growth rate of traffic; assumption of 5.4% for next 50 years

Δt : Average travel time saving per passenger;

VOT_i : Average value of travel time in year i and $VOT_{i+1} = VOT_i * (1+\theta_i)$;

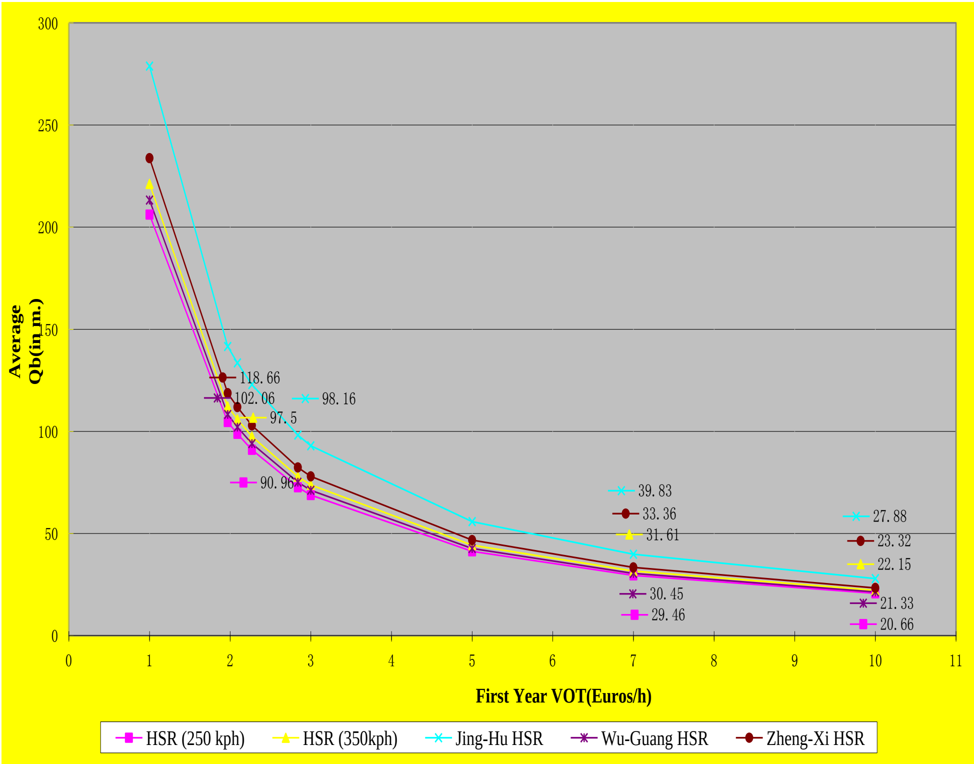
θ_i : Average growth rate of personal income; assumption of 4.45% for next 50 years

I_C : Total investment cost of a HSR line;

γ : Social discount rate, 8% in China

If we assume that an average passenger trip is 500km, we can compare the infrastructure construction cost with the benefits of time savings. Based on formula (1) and the assumptions we have made above, if B=0, or NPV≥0, then we can draw a set of curves illustrating the relationship between an average demand thresholds (Q_b) and VOT for a positive NPV during the project evaluation period, ignoring any increase in operating costs. (Figure 13)

Figure 13. **Estimation of breakeven traffic level for different HSR lines in China**



From Figure 13, solely in terms of time savings, we can conclude that it would require of the order of 90-100m passengers per annum to justify HSR even at 250km/h given typical Chinese values of time. Even if we assumed that on average rail passengers had twice the income of the population in general, at least 50m trips per annum would be needed. Only in the richest parts of the country, such as Beijing, Shanghai and Jiangsu province, are values of time high enough that HSR may be justified on the basis of time savings at the traffic densities currently found.

5.4. Additional capacity and its benefits

One of the advantages of building HSR is to transfer conventional passenger trains from existing lines to release capacity for freight trains, but in the Chinese case many passengers of conventional trains refused to change to the passengers of the HSR with 350 km/h, mainly due to the high level of tariff (Figure 9) and because the lower axle load limitation of HSL with 350 km/h prohibits the conventional passenger trains to run on it. Accordingly, a large number of conventional trains have to be kept running on the existing lines (Table 13). So it is difficult to free up substantial capacity for freight trains on most of the existing lines. For the HSRs in operation, the additional revenue cargo volume that can be actually achieved in recent years is quite low, between one third and one tenth of that expected (Wu and Wang, 2010). One of the problems is that high speed lines have only been built on some sections, and bottlenecks remain elsewhere on the main freight routes. Obviously, when a more complete network is open, and if there were not such a pronounced difference in fares, HSR might provide more relief to existing lines. However, it also means that more investment is needed to complete the rest of the HSR network and that maybe more financial loss has to be expected when the whole HSR network would be put into operation.

Table 13. **Before and after CT numbers on the selected existing conventional lines**

Conventional line	Before (no. of CT)	After (no. of CT)	Change
Wuhan-Guangzhou	32	28	-12.5%
Zhengzhou-Xi'an	48	43	-10.4%
Beijing-Shanghai	6	2	-66.6%
Total	**86**	**73**	**-15.1%**

5.5. Reduced externalities from other modes (Nash, 2009)

In the EU, it is frequently argued that HSR has substantial environmental advantages since it diverts traffic from road and particularly air, where greenhouse gas emissions are much greater, however, a part of the traffic is diverted from conventional rail whose energy consumption could be lower because of lower running. As Table 14 indicates, in Germany HSR accounts for 30%-40% of energy consumption as air transport, and 150%-200% energy consumption as conventional rail. At the same time, these figures are about 11% and 60% respectively in France (SNCF, ADEME, 1997), mainly due to higher loader factor and better infrastructure layout of the TGV system. So, whilst HSR can reduce externalities from other modes, the degree of benefit varies from case to case.

Table 14. **Energy consumption by mode 2010**

	Intercity train	HST	Air (500km)	Diesel car on motorway
Seating capacity	434	377	99	5
Load factor	44%	49%	70%	36%
Primary energy (MJ per seat km)	0.22	0.53	1.8	0.34
MJ per passenger km	0.5	1.08(0.76*)	2.57	0.94

*At 70% load factor
Source: CE Delft (2003)

In China, an unofficial study made in a specific transport corridor shows that the unit energy consumption of a HST, where given rather lower load factor and much higher speeds, is more than 2.4 times higher than that of a conventional intercity train, although it still has substantial environmental advantages when compared to air (Table 15).

Given the composition of the HS traffic from mode shifting and generation listed in Table 5, 6 and 7, the energy savings seem to be very limited. The introduction of HSR cannot lead to a substantial environmental advantage and where there is only limited diversion from air, it will undoubtedly lead to an increase in energy consumption. So the objective to reduce negative externalities will not happen unless HST can raise its load factor substantially and shift huge traffic from the other modes, especially from potential future car traffic, given the fact that about 70%-80% of electricity generation in China still rested on coal in 2011.

Table 15. **Energy consumption by train and air on a specific transport corridor in 2010**

	Intercity train	High speed train	Air (900km)
Maximum speed	160	350	700
Seating capacity	1200	600	180
Load factor	90%	50%	81%
KWH per gross ton km	0.016	0.043	n.a
KWH per 100 passenger km	1.63	5.59	n.a
MJ per passenger km		0.61	1.28

Source: Wu, Cui and etc., 2011

5.6. Wider economic impact

The wider economic impact of HSR in China could be greater than in the EU. This can be partially illustrated by the much higher generated traffic along the more economic advanced HSR corridors, such as Beijing-Tianjin, Wuhan-Guangzhou and Beijing-Shanghai. However, it is still difficult to quantify it at this moment not only due to their short time operation, but also because of the difficulty in separating the agglomeration economies induced by HSR from other reasons, such as the additional large investment to other sectors. Officials from Dezhou city and Xuzhou city claimed that the land price around their stations of Beijing-Shanghai HSR rose more than 20 times after the operation of HSR. Further, as it has happened in the EU, there is also a negative impact of HSR on regional economic development, e.g. a decrease of the total tourism income from Mountain Tai in Taian city was reported because of a dramatically reduction in the number of one night stay tourists as the opening of HSR now makes the one day return trip possible. Most importantly, we doubt whether the wider economic impact, even if it is rather substantial, can compensate the heavy financial and economic loss that the large scale construction of HSRs has brought to China.

5.7. Some trial ex-post cost-benefit analysis of HSR projects

Up to now, there are no published ex post analyses on specific HSR projects in China and the establishment of a system for cost benefit analyses of the HSR projects is still underway. However, some trial studies in this field have been carried out on several HSR projects when the 1st round of HSR projects were put into operation since 2008 (Wu and Wang, 2010).

During the research process, we divided the HSR projects into 3 types (A, B, C) according to their values of FIRR and EIRR. A summary of the appraisal is given in Table 16.

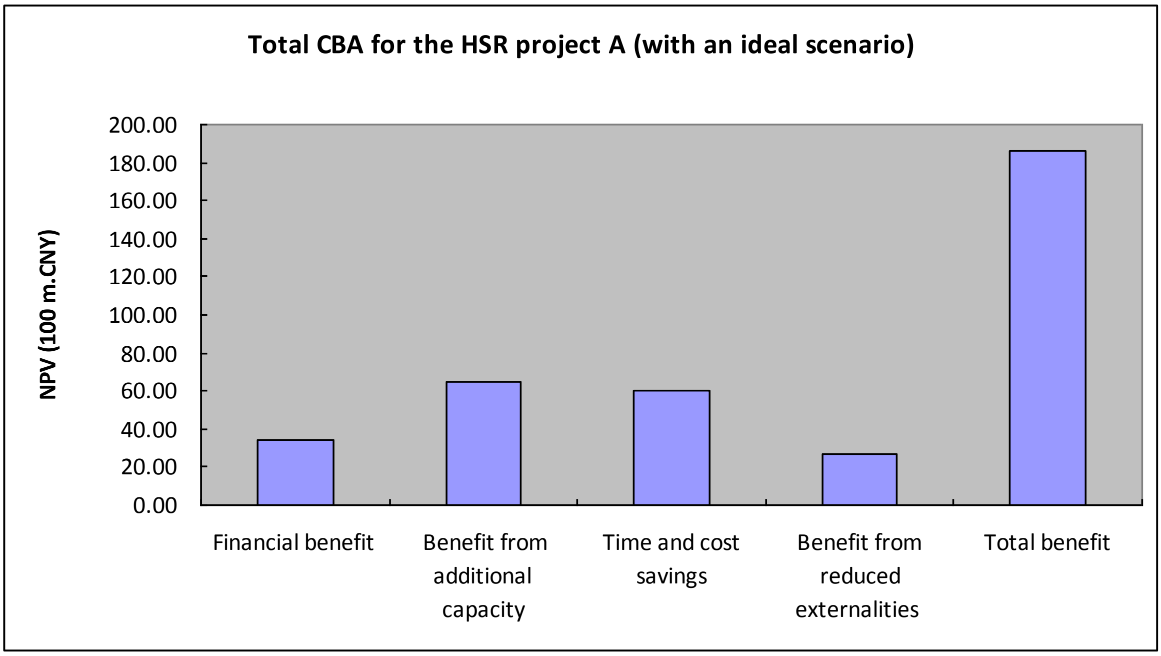
Table 16. **Ex post appraisal of HSR project in China**

<table>
<tr><th></th><th></th><th>Project A</th><th>Project B</th><th>Project C</th><td rowspan="5">In China, the official discount rate for financial evaluation is 3% and was 6% before 2006, while that for economic evaluation is 8% and was 12% before 2006. The rail project evaluation period has been 25 years since 2006</td></tr>
<tr><td rowspan="2">FIRR</td><td>Ex ante</td><td>≥6%</td><td>≥6%</td><td>≥6%</td></tr>
<tr><td>Ex post</td><td>6.00%</td><td>positive, but less than 3%</td><td>negative</td></tr>
<tr><td rowspan="2">EIRR</td><td>Ex ante</td><td>≥20%</td><td>≥20%</td><td>≥20%</td></tr>
<tr><td>Ex post</td><td>10.90%</td><td>10.00%</td><td>8.50%</td></tr>
</table>

Source: 1.NDRC and MOHURD (2006). 2. Wu and Wang, 2010.

Table 16 shows that all the 3 projects were justified during the feasibility study stage, while our ex post study indicates that only project A can be justified both financially and socially (Figure 14).

Figure 14. **Total CBA for the HSR project A (with an ideal scenario)**



Project B represents the case where both FIRR and EIRR are positive, but FIRR is less than the official rate. As Figure 15 shows project B's financial net present value (NPV) is negative, while its economic NPV, mainly composed of time and cost savings, is quite substantial and can cover its financial loss. Therefore, this is a good social project although it implies a financial loss.

Figure 15. **Total CBA for the HSR project B**

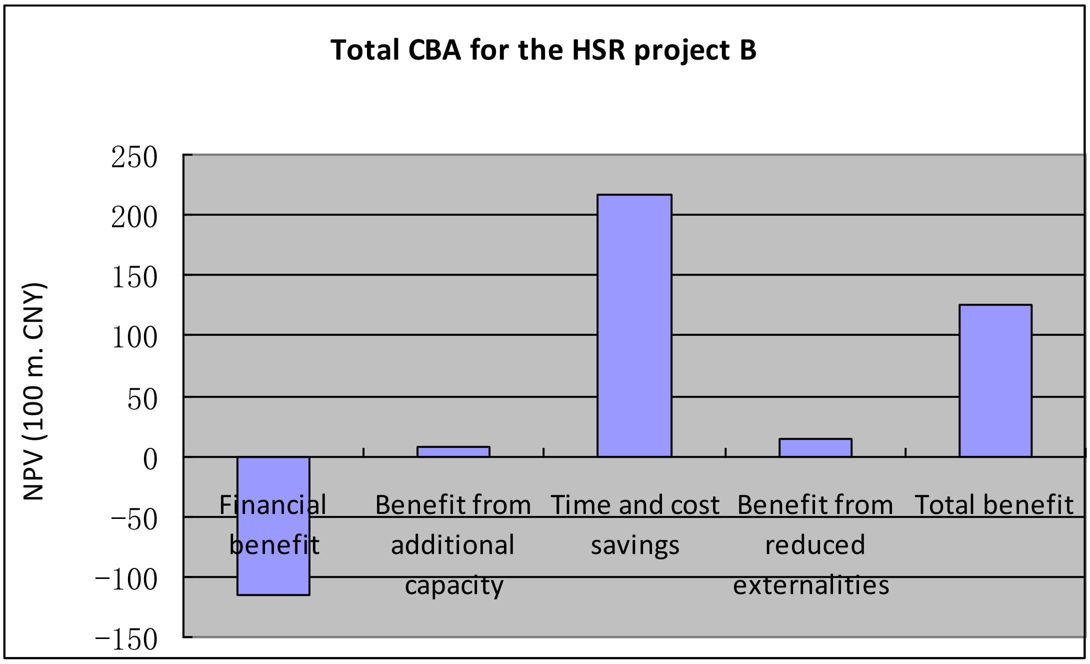
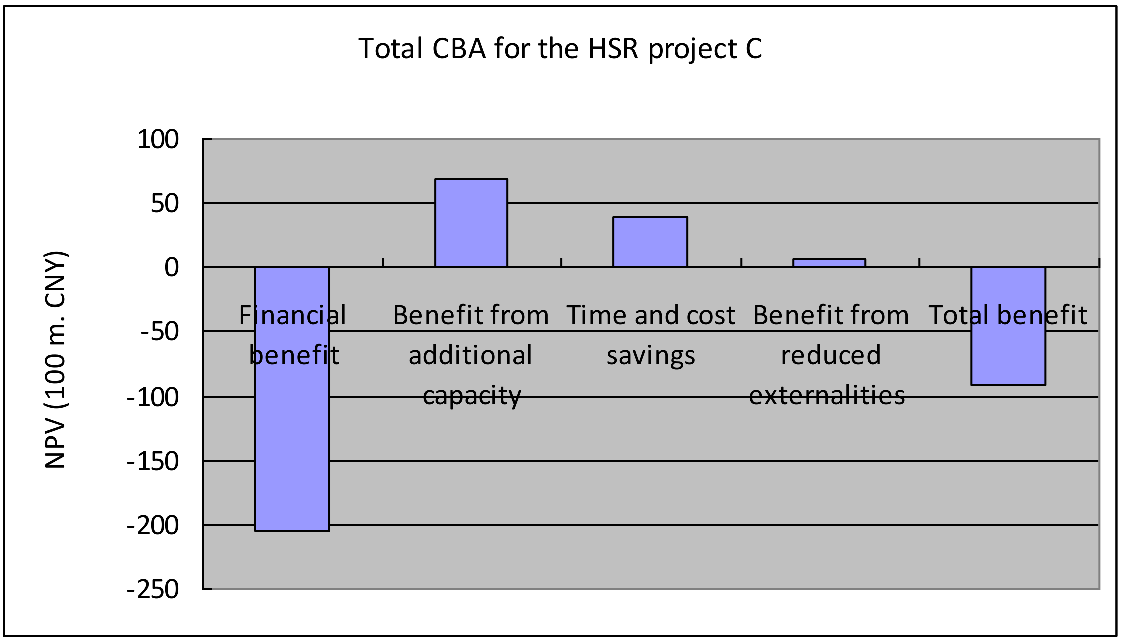


Figure 16. **Total CBA for the HSR project C**



Project C represents the case where FIRR is negative, while EIRR is marginally larger than the official rate. As Figure 16 shows project C's financial NPV is negative, while the economic NPV is positive. Its economic benefits mainly come from additional capacity on conventional rail for freight, while the environmental benefits are very limited. Here again this is a social project, but the economic benefits cannot cover the financial loss.

6. SOME TENTATIVE CONCLUSIONS

From the preliminary studies undertaken and the four years of experience of HSR operation in China, it is possible to reach some tentative conclusions that could be useful for a developing country that is planning HSR projects.

Firstly, a comprehensive appraisal should be undertaken before investing in a HSR project. Both demand for a large increase in rail capacity and a commercial need for higher speeds are important for successful investment in HSR (Nash, 2009). These factors are especially important in the case of a developing country.

The initial financial and economic performance of HSR in China indicates that deployment of HSR throughout the country to high technical standards is unlikely to be justified[10]. This allies to most HSR lines built and to be built in the middle and west part of China, where most people are not rich enough to afford HSR tariffs that are much higher than for travel by conventional train.

Secondly, the commercial breakeven traffic density in China for the 350 km/h HSR lines is about 40-50 million passenger trips per annum, while that for 250 km/h HSR lines is about 25-30 million passenger trips per annum. The unit construction cost and the level of debt funding are the most important variables in determining the breakeven volume.

Thirdly, for a positive social cost-benefit ratio in China, solely in terms of time savings, it would require of the order of 100 million passengers per annum to justify HSR. For a new advanced conventional line (electrified double tracks for mixed traffic and a maximum speed of 160 km/h for passenger trains) the figure is 28 million passengers per annum.[11]

Fourthly, HSR in China seems to be more successful at competing with air than in the rest of the world. In China HSR tends to have a market share of about 80% when rail journey times are within 4 hours or travel distance around 1 000 km. This can be explained by the cheaper price and higher frequency of HSR in China when compared with air and also severe delays at airports that are increasingly frequent.

Fifthly, the introduction of HSR in China is unlikely to have significant environmental benefits unless load factors can be raised substantially and large volumes of traffic can be shifted from other modes in the future.

Sixthly, there is an urgent need to design and adopt a package of new HSR policies in China, both for improving the operational, financial and economic efficiencies of the existing HSR lines and for re-evaluating the HSR projects that are under construction or still in the planning stage. For HSR lines in the western part of China additional significant subsidy

10. "HSR's Great Leap Froward" has led to the former Ministry of Railways, now the Chinese Railways Corporation, becoming very heavily in debt.

11. The unit construction cost of advanced conventional lines is estimated at 5.5 m Euros per route km in China

from central and regional governments will be needed not only for construction of infrastructure but also for high speed train operations.

Finally, network effects and evaluation of the wider economic benefits of HSR are important issues to be addressed for the future planning of HSR in China.

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Appendix 1.

HSR construction, design speed and HSR scale in China by 2012

	HSR Line	Time for starting construction	Design speed (kmph)	Length (km)	Time for opening into traffic
1	Hefei-Nanjing	2005.07	250	156	2008.04
2	Beijing-Tianjin	2005.07	350	120	2008.08
3	Qingdao-Jinan	2006	250	393	2008.12
4	Shijiazhuang-Taiyuan	2005.06	250	190	2009.04
5	Hefei-Wuhan	2005.10	250	333	2009.04
6	Coastal HSL	2004.12	250	650	2009.09
7	Wuhan-Guangzhou	2005.06	350	980	2009.12
8	Zhengzhou-Xi'an	2005.09	350	456	2010.01
9	Fuzhou-Xiamen	2005.09	250	275	2010.04
10	Chengdu-Dujiangyan	2008.11	250	67	2010.05
11	Shanghai-Nanjing	2008.07	350	300	2010.07
12	Nanchang-Jiujiang	2007.06	250	131	2010.09
13	Shanghai-Hangzhou	2009.02	350	154	2010.10
14	Changchun-Jilin	2007	250	96	2010.11
15	Hainan East Circle	2007.09	250	308	2010.12
16	Beijing-Shanghai	2008.04	≥350	1318	2011.07
17	Guangzhou-Shenzhen	2005.12	350	104	2011.12
18	Wuhan-Yichang	2008.09	250	293	2012.07
19	Hefei-Bengbu	2009.01	250	131	2012.10
20	Zhengzhou-Wuhan	2008.09	350	536	2012.09
21	Harbin-Dalian	2007.08	350	921	2012.12
22	Beijing-Zhengzhou	2008.09	350	684	2012.12

Major sources: 1. MOR's documents on issuing railway bonds;
2. Study data by author

Appendix 2.

HSR infrastructure construction cost in China by 2012

	HS Line	Design speed (kmph)	Length (km)	Estimated unit construction cost (m euro /km)*
1	Hefei-Nanjing	250	156	6.03
2	Qingdao-Jinan	250	393	6.27
3	Shijiazhuang-Taiyuan	250	190	14.48
4	Hefei-Wuhan	250	333	7.00
5	Coastal HSL	250	650	7.24
6	Fuzhou-Xiamen	250	275	7.24
7	Chengdu-Dujiangyan	250	67	18.10
8	Nanchang-Jiujiang	250	131	7.24
9	Changchun-Jilin	250	96	10.81
10	Hainan East Circle	250	308	8.69
11	Wuhan-Yichang	250	293	9.78
12	Hefei-Bengbu	250	131	12.53
Average construction cost of the HSL with 250kph				8.84
1	Beijing-Tianjin	350	120	20.51
2	Wuhan-Guangzhou	350	1068	15.69
3	Zhengzhou-Xi'an	350	456	12.07
4	Shanghai-Nanjing	350	300	18.10
5	Shanghai-Hangzhou	350	154	22.93
6	Guangzhou-Shenzhen	350	104	27.57
7	Zhengzhou-Wuhan	350	536	15.66
8	Harbin-Dalian	350	921	13.30
9	Beijing-Zhengzhou	350	684	15.66
10	Beijing-Shanghai	≥350	1318	19.31
Average construction cost of the HSL with 350kph				16.50
*Euro exchange rate to CNY was about 8.28788 on 2010-06-30 Major sources: 1. MOR's documents on issuing railway bonds; 2. Study data by author				

Appendix 3.

Estimation of traffic density on selected HS lines from 2010 to 2012

HS lines	Design speed (kmph)	Year 2010 Daily number of trains Total (pairs)	Year 2010 HST*	Year 2010 CT*	Year 2010 Estimated traffic density m. pass per annum	Year 2011 Daily number of trains Total (pairs)	Year 2011 HST	Year 2011 CT	Year 2011 Estimated traffic density m. pass per annum	Year 2012 Daily number of trains Total (pairs)	Year 2012 HST	Year 2012 CT	Year 2012 Estimated traffic density m. pass per annum	Average annual increase rate
Hefei-Nanjing	250	19	11	8	11.93	36	26	10	16.99	55	42	13	21.29	33.59%
Beijing-Tianjin	350	68	68	0	19.80	85	85		20.22	96	96		21.02	3.05%
Qingdao-Jinan	250	37	17	20	21.46	45	27	18	25.23	48	30	18	28.03	14.29%
Shi-Tai	250	24	13	11	13.67	35	13	22	21.22	38	14	24	22.60	28.60%
Hefei-Wuhan	250	12	10	2	6.45	26	20	6	9.81	27	18	9	11.04	30.78%
Coastal HSL	250	20	20		14.45	32	32		15.13	37	37		15.13	2.30%
Wuhan-Guangzhou	350	48	48		9.46	50	50		13.14	75	75		19.71	44.34%
Zhengzhou-Xi'an	350	7	7		1.84	12	12		3.68	18.75	18.75		5.75	76.78%
Chengdu-Dujiangyan	250	14	14		3.68	17	17		4.47	18	18		4.73	13.39%
Shanghai-Nanjing	350	82	82		25.40	92	92		26.86	100	100		29.20	7.21%
Shanghai-Hangzhou	350	33	33		12.53	89	89		28.59	88	88		28.27	50.21%
Nanchang-Jiujiang	250	43	0	43	30.13	49	11	38	32.85	47	13	34	30.22	0.15%
Changchun-Jilin	250					31	31		8.15	32	32		8.41	3.23%
Hainan East Circle	250					35	32	3	6.66	28	27	1	6.44	-3.29%
Beijing-Shanghai	≥350					74	74		22.17	86	86		24.81	20.52%

ST* for high speed train, CT* for conventional Train.

ain source: Authors' estimation based on the data collected from various Websites, including JPSKB (极品时刻表), an electric train time table in China.

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Appendix 4.

The Estimation of break-even traffic density of HSR in China via international comparison

	Tokaido Shinkansen*	**Paris-Lyon TGV***	**Beijing-Shanghai HSL**	**Wuhan-Guangzhou HSL**	**Qingdao-Jinan HSL**	**Beijing-Tianjin HSL**	**Zhengzhou-Xi'an HSL**	**China HSL (with 350 kph) in average**
Tariff (Euro/pkm) in 2010	0.195	0.121	0.051	0.056	0.037	0.058	0.058	0.056
Traffic density (m pass per annum) in 2010	80	20	25	14	25	20	4	
Annual revenues per Km (m Euro/Km)	15.6	2.42	1.275	0.784	0.925	1.16	0.232	
Unit construction cost (m Euros /km)	34.00	15.20	19.31	15.69	6.27	20.51	12.07	15.68
Debt / Asset ratio	55%	n.a	n.a	50%	50%	50%-60%	50%	50%-60%
Input/Output ratio per Km **	0.4589	**0.1592**	0.0660	0.0500	**0.1475**	0.0566	0.0192	
(Initial) financial performance	Full recovery of investment within 8 years	FIRR=15%	Loss	Loss	Break-even	Loss	Loss	Break-even
Break-even traffic density corresponding to I/O ratio=0.145 (m pkm/km)	25.28	18.22	54.90	**40.63**	**24.57**	51.28	30.18	**40.60**

*: revaluation value in 2003
**: refers to traffic revenue per line km of HS lines /construction cost per line km of HS lines

Appendix 5.

The Air and HSR Comparison between China (Beijing-Shanghai) and Japan (Tokaido and Sanyo Shinkansen)

	O-D Pairs	Rail Distance (km)	Market Share %		Travel time （h）		Daily frequency （pairs）		Tariff （JPY or CNY trip ）	
			Air	HSR	Air	HSR	Air	HSR	Air*	HSR
Tokaido， Sanyo Shinkansen	Tokyo-Nagoya	366	0%	100%			0	120		
	Tokyo-Osaka	553	14%	86%	1	2.5	57	120	18800	13750
	Tokyo-Okayama	733	18%	82%	1.25	3.27	18	61	23800	16360
	Tokyo-Hiroshima	894	44%	56%	1.28	3.85	30	32	26300	18050
	Tokyo-Fukuoka	1 180	88%	12%	1.58	4.97	47	17	31300	21720
Beijing--Shanghai HSR	Beijing-Jinan	406	2.08%	97.92%	1.1	1.63	2	58	317	125**-185***
	Beijing-Xuzhou	692	2.42%	97.58%	1.60	2.85	1	31	615	215-310
	Beijing-Nanjing	1 023	21.13%	78.87%	2	4.1	13	60	676	315-445
	Beijing-Wuxi	1 210	29.61%	70.39%	2.1	4.90	5	21	761	375-515
	Beijing-Shanghai	1 318	57.29%	42.71%	2.17	5.53	48	54	789	410-555

*: The air tariff in China=air distance*0.75CNY/pkm*0.75+fuel surcharge+airport tax;
**: For the fare of HST with max speed of 250 kmph;
***:For the fare of HST with max speed of 350 kmph.

Main source: 1.WANG Meijia,2009, Taking the Challenge of Rail Speeding, Airbus China;
2. The Civil Aviation Publishing House in China, 2010-2013, The Annual Statistics of Civil Aviation in China;
3. Authors' estimation based on the data collected from various websites, including JPSKB.

Appendix 6.

The tariff level and estimated load factors of selected HSR lines in China in 2012

HS Lines	Design speed (kmph)	Tariff for 1st class in HST* (euro/pkm)	Tariff for 2nd class in HST(euro/pkm)	Tariff for 2nd class in fast CT** (euro/pkm)	Tariff for 2nd class in slow CT (euro/pkm)	Estimated load factor (%)	
						HST	CT
Hefei-Nanjing	250	0.057	0.047		0.010	60	90
Qingdao-Jinan	250	0.044	0.037	0.017		70	100
Shijiazhuang-Taiyuan	250	0.042	0.035	0.020	0.008	60	90
Coastal HSL	250	0.042	0.036			70	
Chengdu-Dujiangyan	250		0.032			60	
Nanchang-Jiujiang	250	0.042	0.035	0.019	0.009	60	90
Changchun-Jilin	250	0.042	0.034	0.018	0.008	60	
Average level of the HST and CT running on 250kph lines		0.045	0.037	0.019	0.009	65	93
Beijing-Tianjin	350	0.066	0.055			50	
Wuhan-Guangzhou	350	0.083	0.052			60	
Zhengzhou-Xi'an	350	0.088	0.055			70	
Shanghai-Nanjing	350	0.088	0.056			50	
Beijing-Shanghai	≥350	0.085	0.051			70	
Average level of the HST running on 350kph or over lines		0.082	0.054			55	

* HST for high speed train, **CT for conventional train

Main source: Authors' calculation based on the data collected from JPSKB （极品时刻表），an electric train time table in China

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