High Speed Rail in Asia and Europe: Lesson Learned for Indonesia

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***Abstract*— China's offer to build the Jakarta-Bandung high speed rail line (HSR) without requiring loan neither guarantee nor funding. This paper examines the prospects for HSR in Indonesia, since building HSR has its proponents and its critics. How HSR operates around the world and to determine whether a HSR system could actually succeed are explored.**

***Keywords*— HSR, Indonesia, factor, density, disperse**

I. Introduction

Plans and studies have been in the works for high-speed rail (HSR) in Indonesia since before 2010. A new plan to build a HSR was announced by Indonesian Government in July 2015. Indonesia's first — and possibly also Southeast Asia's first high-speed rail project — was expected to connect the national capital Jakarta with Bandung in neighboring West Java province, covering a distance of around 140 kilometers. Plans were also mentioned for a possible later extension of the HSR to Indonesia's second largest city, Surabaya in East Java. Both Japan and China had expressed their interest in the project. Previously, both countries had carried out comprehensive studies for a project for the Jakarta-Bandung section (150 km). Only the Japanese agency, JICA, had issued a study for a project extending to Surabaya (730 km). The Indonesian HSR bid marked rivalry between Japan and China in their competition for Asian infrastructure projects. On late September 2015, Indonesia awarded the rail project to China, much to Japan's disappointment. It was said that China's offer to build the Jakarta-Bandung line without requiring an official loan guarantee nor funding from Indonesia was the tipping point of Jakarta's decision. In January 2016, Transportation Minister released a route permit for a high speed railway between Jakarta-Bandung (142.3 kilometers) with stations located at Halim (Jakarta end), Karawang, Walini, and Tegalluar (Bandung end) and also Tegalluar depo. The better departure point at the Jakarta end would be the inner city railway station of Gambir but because construction of the Gambir-Halim leg was seen as adding complications, the link will only be from Halim (Jakarta) to Tegalluar (Bandung) with a cost of $5.135 million. Concession period is 50 years from May 31, 2019 and cannot be prolonged, except in force-majeur situation. Groundbreaking has been done on January 21, 2016. The HSR is project of 60 percent of Indonesian consortium and 40 percent of China Railway International. The Jakarta-Bandung high-speed rail is planned to begin its operations to public in 2019. The Japanese proposal can start operation only by 2023. The section Bandung-Surabaya, though a priority section due to heavy congestion, has been officially shelved for budget reasons since early 2015 [1], as shown in figure 1.

Fig. 1. Proposed Java high speed rail.

While building HSR in Indonesia has its proponents and its critics, little research has been conducted to examine how HSR operates around the world and to determine whether a HSR system could actually succeed in Indonesia. This research examines the prospects for HSR in Indonesia. It studies how this country differs from, Japan, China and Europe in travel patterns, spatial structure, car ownership and other factors. It uses these results to determine whether HSR is a realistic prospect for Indonesia. This study addresses the following parts: definition and history of high speed rail; fiscal evaluation of worldwide HSR systems; variables determining HSR success; government travel policy; and analysis of Indonesian prospects for HSR and conclusion.

II. The Definition and History of HSR

High speed rail has different definitions in different countries. Based on the International Union of Railways [2], the European Union defines HSR as lines specially built for speeds greater than or equal to 250 km/h or lines that are specially upgraded with speeds greater than 200 km/h. There are four major types of HSR:

A. *Fully Dedicated*

Japan's Shinkansen is an example of dedicated service with separate high speed tracks that exclusively serve high speed

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trains. The system was developed because the existing rail network was heavily congested with conventional passenger and freight trains and the track gauge did not support the new high speed trains.

B. Mixed High Speed

Exemplified by France's TGV (Train a Grande Vitesse), this type includes both dedicated, high speed tracks that serve only high speed trains and upgraded, conventional tracks that serve both high speed and conventional trains.

C. Mixed Conventional

Spain's AVE (Alta Velocidad Espanola) has dedicated, high speed, standard gauge tracks that serve both high speed and conventional trains equipped with a gauge-changing system, and conventional, non-standard gauge tracks that serve only conventional trains.

D. Fully Mixed

In this type exemplified by Germany's ICE (Inter-City Express), most of the tracks a compatible with all high speed, conventional passenger and freight trains. Table I listed the countries with HSR according to the European Union definition.

China, France, Germany, Italy, Japan and Spain have six of the most extensive high speed rail system in the world (see table I). The world's first HSR line, known as the Tokaido Shinkansen, was built in 1964 between Tokyo and Shin-Osaka, Japan. This line was built in a corridor well suited to rail travel, and the train was built to expand capacity on an overcrowded route. Construction was financed with loans from the World Bank and the Japanese government. The railway repaid the loans in seven years. After that, operating profits on the line were used to cross subsidize local trains. The success of this line encouraged expansion, and the Japanese government continued to build high speed lines throughout the country.

TABLE I
HSR-KM BY COUNTRY IN OPERATION AND UNDER CONSTRUCTION

Country	HSR-km	Country	HSR-km
Austria	502	Poland	407
Belgium	209	Russia	1,496
China	37,155	South Korea	1,404
Denmark	65	Spain	4,900
France	2,793	Switzerland	137
Germany	1,762	Taiwan	348
Italy	1,084	Turkey	2,926
Japan	3,446	United Kingdom	1,377
Netherland	120	U.S.	845
Norway	18	Uzbekistan	344

The Sanyo Shinkansen, the second line, came close to breaking even, but none of the other lines generated enough passenger revenue to cover their operating costs, not to mention their capital costs. This expansion of the Japanese HSR network included new lines that were not economically efficient, and were built in response to political pressure to extend the benefits of high speed service to other parts of the nation. Partly as a result of large operating losses, Japan National Railways was privatized in 1987. Since 1987, extension of high speed lines has continued, supported by the notion that infrastructure spending stimulates economy [3]. The current network features almost 2,700 km of tracks with top speed of 240-295 km/h, and more lines under construction.

The world's second HSR line opened in Italy between Rome and Florence in 1977. Italy now has two lines: one connecting Turin and Venice and the second linking Milan to Salermo. Parts of the Milan to Salermo line remain under construction. Italy has slowly expanded its track to connect most major cities by HSR. However, it has not expanded rapidly over the past twenty years.

France built the world's third HSR system. Referred to as TGV the first line opened in 1981, between Paris and Lyon. As of 2014, the French system had approximately 1,895 km of HSR lines. Unlike the Japanese system, which features a linear design where some lines do not connect with Tokyo, the French system has spokes radiating outward from the hub of Paris. France's system has been expanded to Belgium, Germany, Italy and Switzerland and is the longest in Europe and operates at top speeds around 322 km/h.

Encouraged by HSR in France and Italy, German leaders made HSR a national priority. As a result, Article 87 of the German Constitution makes rail transport a government responsibility. Construction on Germany's ICE high speed rail system began two years after French construction. However, lawsuits slowed construction and the first HSR line connecting Hamburg and Munich did not open until 1991. As of 2014, Germany had eight lines at a total length of more than 1,620 km.

Spain opened its first HSR line in 1992. Spain has four separate HSR network. As of 2014, Spain's HSR system was 1,768 km in length, making it the second longest system in Europe after France. Since 2003 Spain has been spending more money on rail than on roads. However, the recent election of the conservative government, coupled with spiralling materials costs, and the underperformance of other HSR lines have put most of new construction on hold.

China is planning to develop the largest HSR network in the world. China's rationale is that HSR will, (1) relieve the pressure both passenger and freight demand on its overcrowded existing rail system; (2) improve transportation connections between the country's different regions; (3) promote the economies of less developed regions. China is upgrading existing lines and building new dedicated electrified lines. In 2008, China's government announced plans to have approximately 16,000 km of high speed lines (including both upgraded existing lines and new dedicated electrified lines) in operation by 2020. As of 2014, China's HSR system was 9,500 km in length, making it the longest system in the world.

In Indonesia, months of debate and a media circus have stalled the construction of a 142 kilometer Jakarta-Bandung high speed railway, with various policymakers, business stakeholders and representatives from NGOs trading jabs in newswires over the project's feasibility. The multi-billion-dollar question now is whether the economic cooperation between Indonesia and China, which are two countries with strikingly different political systems, can prosper. If the economic cost was the only concern, the Indonesian government's decision to grant China, not Japan, the responsibility of building the Jakarta-Bandung bullet train project is justifiable.

III. Fiscal Evaluation of Worldwide HSR Systems

There are many different costs to plan, construct, operate and maintain a HSR line. Capital costs include the construction of track including the siding and terminal stations, and the train control system and the purchasing of the train vehicles. The operating costs include expenditures needed to run the trains every day. These include costs such as employees and the power source. Maintenance costs are the funds expended to keep the train operating correctly. Planning costs are the buffer costs that need to be included to counter against inflation, minor changes in scope and unexpected occurrences such as discovery of historical artefacts. All HSR has each of these four costs. The following tables detail each of these costs. But due to the limited number of pages, this paper displays only two tables. Table 2 explores HSR capital costs for the most popular lines with available data.

TABLE II
Capital Cost of High Speed Rail

HSR line	Construction Cost (billion)	Length (km)	Cost per km (million)
Tokyo–Shin Osaka	0,92	515	1.8
Hakata–Shin Osaka	2,95	554	5.3
Tokyo–Shin Aomori	11,02	675	16.3
Tokyo–Niigata	6,69	301	22.2
Paris-Lyon (Southeast)	3.85	409	9.4
EAST Strasbourg	2.75	106	25.9
BPL Brittainy	4.51	182	24.8
CNM Nimes–Montpellier	2.46	80	30.8
Sud Europe Atlantique	10.67	303	35.2
Cordoba–Malaga	4.18	155	27
Madrid–Barcelona–Figueras	21.72	749	29
LGV East	9.30	300	31
Madrid–Valladolid	6.90	177	39
Shijiazhuang–Zhengzhou	7.47	355	21.0
Guiyang–Guangzhou	16.09	857	18.8
Jilin–Hunchun	6.74	360	18.7
Zhangjiakou–Hohhot	5.88	286	20.5

As shown in Table 2, capital costs vary significantly among different lines. The line constructed before 1990 such as Tokyo–Shin Osaka, Hakata–Shin Osaka and Paris–Lyon, built when land prices were lower, had lower construction costs. Generally, Asian's construction costs are lower than European. China's HSR with a maximum speed of 350 km/h has a typical capital cost of about US$19–21 million per km with a high ratio of viaducts and tunnels. The cost HSR construction in Europe, having design speed of 300 km/h or above is estimated to be of the order of US$25–39 million per km. Aside from the lower cost of manpower, several other factors are likely to have led to lower HSR unit cost in China. At a program level, the declaration of a credible medium term plan for construction of 10,000 km of HSR in China over a period of 6-7 years energized the construction and equipment supply community to build capacity rapidly and adopt innovative techniques to take advantage of very high volumes of work related to HSR construction. This has led to lower unit costs as a result of the development of competitive multiple local sources for construction (earthworks, bridges, tunnels, EMU trains etc.) that adopted mechanization in construction and manufacturing. Further, large volumes and the ability to amortize capital investment in high-cost construction equipment over a number of projects contributed to the lowering of unit costs [4].

It is not a coincidence that the two most fiscally successful lines have the two lowest construction costs per km. Typically the first HSR line a country builds makes the most economic sense. Politicians then place pressure on builders to construct additional lines that make less financial sense. However, due to the high capital costs and the technically challenging, all but three HSR lines require significant subsidies. Even when revenue covers capital costs or operating and maintenance costs, it rarely covers both. Table 3 examines a summary of the total costs for a theoretical line in Europe.

TABLE III
Estimated Cost of 500-Km HSR Line in Europe

	Cost per unit (000)	Units	Total costs (US million)**
Capital costs			
Infrastructure construction (km)	13,200 – 44,000	500	6,600 – 22,000
Rolling stock (Trains)	16,500	40	660
Running costs (p.a.)			
Infrastructure maintenance (km)	137	500	33.75
Rolling stock maintenance (Trains)	1,178	40	39.60
Energy (Trains)	1,168	40	39.27
Labour (Employees)	47	550	21.78

** Total cost assumes two tracks

In general, the maintenance of infrastructure and tracks represents 40-67% of total maintenance costs, whereas the signalling costs comprise between 10-35% of the costs in HSR. The relative weight of the electrification costs makes up the third major cost component. These estimated costs are quite far from the China's proposal. However, the theoretical line as displays in Table 3 has much higher distances than are proposed by the China and Indonesian's consortium.

A study from the World Bank office in Beijing shows that the construction of China's high speed railway has a typically infrastructure unit cost of about US$17-21 million per kilometre, excluding land, rolling stock and interest during construction. In European countries such as France and Spain, similar infrastructure is estimated by the World Bank to cost US$25-39 million for every kilometre, while in California, the United States, the price tag stands at US$51 million.

In reality, China currently possesses the technical know-how for building railway networks in the fastest and cheapest way possible and a successful localization of manufacturing of its goods and components. The predicament faced by China's firms, however, is that building a railway network on their own turf and in Indonesia might be totally different ball games.

IV. Factor Determining HSR Success

There are a number of factors that help determine the success of high speed rail. The first is population density near the rail station. Since HSR requires high urban densities, particularly those concentrated close to major stations, extending HSR to places without the ability or desire to encourage high densities is unlikely to be successful. Table 4 compares the population density of selected major Asian cities. Both Indonesian cities are substantially less dense than their counterparts. Further, the urban area became more dispersed where metropolitan areas tend to consume more land for urbanization. The greater dispersion of population makes it difficult to concentrate as needed to operate HSR efficiently [5].

To compete with conventional trains and intercity buses, HSRs must depart frequently but they must also fill or nearly fill their seats to generate enough ticket revenue to cover their operating costs.

TABLE IV
DENSITY OF SELECTED ASIAN CITY

Asian city	People/km^2
Mumbai	32,400
Manila	15,300
Bandung	12,200
Delhi	12,100
Seoul	10,400
Jakarta	9,500

Connectivity of rapid public transport is the second major factor. In Tokyo and Seoul, passenger can arrive at station and travel by metro or commuter rail to nearly all the destinations in the urban area. Bus ride may be necessary to reach one's final destination. Otherwise, both Jakarta and Bandung have not extensive public transport systems that could make seamless travel possible. And since public transport usage is one of the greatest indicators for rail success, ridership is important. However, in two of the metro areas, it is less than 30%. Contrast this with Tokyo where it is 60% and Seoul where it is 65%. Hence, this does not bode well for the success of high speed rail in Indonesian cities.

Moreover, most European countries and Japan have substantially more rail network density than Indonesia as shown in table V. China itself has an 8.11 of rail network density, that is almost nine times lower than Japan. However, it still has almost ten times more rail network density than Indonesia. Further, passenger train service in Europe and Japan and even China is substantially more integrated into modern life. Railways are more popular in those countries than in Indonesia. Many countries implemented high speed rail to relieve over-crowded conventional trains [6].

In addition, the research at neighbourhood and station-area scale indicates that significant transit trip generation rates from residential development proximate to rail stations, especially for systems and regions in which both housing and employment are found adjacent to transit. Empirically, the distance to transit varies case by case. Generally, current planning practice recommends a 400 to 800 meters' radius as the pedestrian catchment area for transit service, representing a 5-minute walking distance [7]. In Indonesia, including Jakarta and Bandung, however, very rare metropolitan areas are sufficiently dense or have the extensive transit or urban bus systems to make transfer between different modes possible.

TABLE V
RAIL NETWORK DENSITY OF SELECTED COUNTRY

Country	Rail network density (in m per km^2)	Length of the rail network (in km)	Size of the country (in km^2)
Germany	117.35	41,896	357,022
Poland	71.36	22,314	312,685
Japan	69.95	26,435	377,915
United Kingdom	67.54	16,454	243,610
Italy	65.47	19,729	301,340
EU	53.10	229,450	4,324,782
China	8.11	77,834	9,596,981
Indonesia	0.90	4,684	5,193,250

V. CONCLUSION

It must be recognized that Indonesia lacks some of variables that make high speed rail successful in other countries. For starters, Indonesia has neither the population density nor the land use regulations necessary to support the development of high speed rail. It lacks a pre-existing, successful passenger rail system, and far less on urban public transport usage than Tokyo and Seoul. Further, high speed rail cannot work in the absence of large urban populations clustered around city centre's rail terminals and extensive public transport systems that allow passengers to easily complete their journeys. If those variables do not exist, high speed rail will never be an appealing transportation choice to most travellers.

However, if the economic cost was the only concern, the Indonesian government's decision to grant China, not Japan, the responsibility of building the Jakarta-Bandung bullet train project is justifiable.

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