High Speed Railway (HSR): India And The World

Comparison of existing systems

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Abstract: **India has one of the largest rail networks in the world but has no line which can be classified as HSR allowing operational speed of 125mph. The current fastest train runs at 100 mph over a distance of only around 100 miles. However, supported by a robust political willingness, a new HSR corporation has been set up to kick-start the HSR projects from ideation to reality. Four major corridors have been identified and pre-feasibility studies have been commissioned.**

***The first in this ambitious program is the HSR between Mumbai and Ahmedabad,* two major population and commercial centers in the west of India. The success or failure of this project could show the way for future road map of HSR in India.**

This paper identifies and analyses the countries where HSR systems are in operation – their political, economic and social conditions relevant to HSR systems and then the features of HSR systems themselves to understand the commonalities between the nations that have opted for HSR. The objective is to identify if there is a common character or a baseline characteristic in terms of geographical, economic, political and social conditions which are essential to be a member of this exclusive club? Is there a standard financial and business model that has been adopted by these countries?Theattempt is also to compare these baseline benchmarks with those in India, to assess its strengths and weaknesses and reaffirm the chances of its success in taking up this project, one of the biggestever in its history.

The results would be relevant not only for India but for all countries who aspire to be HSR countries in near future.

BACKGROUND

Since 1964, HSR, which was opened in Japan, has had a huge impact on the world. Historically, HSR has characteristics similar to the Roman Road, which promoted rapid movement and had a great influence on international society as a transport infrastructure. Recently the development of HSR has become more rapid because of economic, environmental and external cost concern, emphasizing Environmentally Sustainable Transport(EST). In particular, the external cost has become a more important factor for justifying HSR which has seen a rapid growth in passenger traffic and the share in transport pie all over the HSR countries. The growth of HSR has come from the competitive speed, safety and social effects.

This has been possible because of technological advancements like distributed traction, in cab signaling, tilting technology for coaches, computerized train control systems, reduction in running weight by hollow axles and al alloy box, smaller diameter wheelsetc., supported by national policies and bulwarked by international organizations like the European Union, the WB, ADB and institutional financing.

Since the nineteenth-century, railways have had as great an influence on society by changing the concept of distance, spread culture and made travel generally available. Railway stations were viewed as a symbol of modernization. Standard time was created and life styles were totally changed by railways. However, cars, which were made in the twentieth-century, had a huge influence on the railway. The development of cars caused a decrease in the demand for travel by rail. Cars have some advantages over the train. They are convenient, with diverse designs and competitive prices. In 1960, oil prices were very low, and the car was an adequate means of establishing rapid economic growth. Therefore, car use increased quickly. This phenomenon was repeated all over the world.

Meanwhile, the transport system, which focused on the car, has changed gradually since 1980, because of road congestion, air pollution and high fuel prices. Transport policy has also changed from a supply policy to a demand policy which limits car use, and has in some cases adopted congestion pricing, and high road taxes. Hence, railways are being revived and have made a comeback after the economic stagnation of the 1980s, because many countries are seeking the environmentally-friendly, energy-saving, mass transport systems for economic and social reasons. This is called the **Rail Renaissance**.

The reasons for the cross board support to HSR are many, the biggest being it being most economical and energy efficient in comparison to all other modes of transport in the medium distance bracket (100-600 miles), as has been established by

numerous studies. HSR has been an unadulterated success in various exploitationand financial models in a variety of contexts and countries. Criticism by thedetractors is basically on thegrounds of charges of elitism, unaffordability, lack of popular support, worthiness for taxpayers' subsidy,overstated benefits etc. Financial crisis is often cited as the biggest reason, be it the wealthiest nation like the USA or a developing emerging economy like India. It would not be out of place to mention that "High Speed" has always been associated (and has yet survived) with "High Cost" since the concept has come into being.

Interestingly, the criticism is not on the railway sector and support thereof, **but on the speed**. How much is the criticism valid in the sense that in either case, the cost of creation of the infrastructure has to be borne by the state, is a matter of discussion.

Considering that generally an HSR system is based upon separation of ownership of infrastructure and operations and that the operations in itselfareself-sustaining, the state is actually richer by the opportunity cost of the not bearing the responsibility of operations, which in a conventional railway, would have been there. Also of significance is the fact that the cost of building a 6 lane express way is almost the same as the cost of a high speed railway while the latter has much smaller land and carbon footprint and is three times more energy efficient.

According to the UIC, whose definition of the HSR has the highest international consensus, it is a broad system where trains regularly operate at 200kmph (125mph). The second narrower definition covers new systems where trains regularly operate at 250kmph (155 mph). **The second definition** is the one used by UIC in monitoring new and future HSR projects and is applied in a typically international setting. Under this definition, 14 countries in Europe and Asia have resorted to HSR in a big way and the USA too with the Acela (from Washington to Boston) has joined the bandwagon, though it technically runs at the highest speed of 241kmph. The USA has now launched the very ambitious CHSR, a part of President Obama's initiative to revitalize rail passenger transport all over the country with a vision of the HSR playing a big role in the future of American transportation.

INDIAN SCENARIO

India has one of the largest rail networks in the world but has no line which can be classified as HSR allowing operational speed of 155mph. The current fastest train runs at 100 mph over a distance of only around 100 miles. However, supported by a robust political willingness, a new HSR corporation has been set up to kick start the HSR projects from ideation to reality. Four major corridors have been identified and pre-feasibility studies have been commissioned.

The first in this ambitious program is the HSR between Mumbai and Ahmedabad, two major population and commercial centers in the west of India. The success or failure of this project could show the way for future road map of HSR in India.

The Japan International Cooperation Agency (Jica), which hadrecently submitted its final feasibility report of the project, has estimated a cost of $US 14.7bn (Rs 988.05bn) inclusive of price escalation and interest during construction, and a seven-year construction phase from 2017 to 2023 for what will be India's first high-speed project. A corresponding Japanese loan, with the precondition that 30% of equipment is purchased from Japanese firms, is available with an interest rate as low as 1%.

It is a matter of history that H Neuvon, who was a member of the Japanese delegation (1960) visiting France to study the 25kV overhead traction system and played an important role in the first Shinkansen, was closely associated with the Indian Railways in introducing the Rajdhani Express trains in 1964. While IR is still stuck at the same determined 130 kmph speed, the Japanese have migrated to double the speed already.

This intransigence probably stemmed from the continuing dilemma within the Indian establishment concerning the project's scope, technicalities and popular acceptability. For one, **a huge decision had to be taken over the business/ operation exploitation model** (dedicated or mixed traffic with conventional railway or freight) **which has a direct bearing over the gauge selection** and thus its operating environment and revenue streams. One viewpoint referred to Russia's plan to build its first high-speed line with broad-gauge tracks and arguing that India should follow suit and build its high-speed line at 1600mm-gauge to ensure interoperability with the rest of the network. In contrast there is an argument to follow the example of Japan and Spain, where 300km/h lines use 1435mm-gauge tracks, which have dedicated HSR networks. For its part, Jica has recommended building a standard-gauge network which would make it isolated from the conventional rail network, with attended benefits and consequences.

Jica foresees that the line will require construction of 318km of embankments, 162km of viaduct, and 11 tunnels with a total length of 27.01km, including a 2.16km tunnel underneath Thane Creek to link Mumbai with Navi-Mumbai. This is equivalent to nearly 35 % over viaduct and the rest

on conventional track. This proposal has an apparent inclination towards the viaduct option which is akin to Japanese style were viaducts are often in excess of 75% of the track. India may want to have a closer examination of the length of the proposed viaduct in order to reduce capex.

Given its present challenges of saturated routes and inadequate capacity in crucial sectors like mine and port connectivity, some have argued that it might be more prudent for India to focus on ramping up the speed of existing trains and enhancing capacity of the existing system rather than taking to the fanciful idea of running a high-speed network. However, the enthusiasm for high speed is equally strong. "India cannot remain blind to the technological advancements made across the world," one IR official said. "It is high time that the country took to the high-speed route." The successful development of the telecom and the air transport sectors in India has shown that supported by political will, technology and entrepreneurship, new models of organization and business have a low risk and high gain future in a high growth economy like India.

Objectives of the study:

Considering the crossroads of decision making that India is on at the moment, the objective of this paper is as follows:

1. Identify and study the countries where HSR systems are in operation – their political, economic and social conditions relevant to HSR systems
2. Features of HSR system itself, including the type of the system and how it is managed, financed etc.
3. Lessons for India- whether to go ahead or to drop the dream, albeit temporarily.

The study of the political, economic and other conditions on countries with HSR systems is based on aggregate quantitative data measuring GDP, population, land mass etc. Comparison will also be attempted for the existing transportation system and the geographic, demographic, economic and political factors that are of relevance to HSR. After studying the countries and the context, the governing features of the HSR systems covering who owns and operates the HSR shall be attempted. After having examined the features and conditions of HSR systems and the countries in which they exist, preliminary conclusions will be drawn, **based on features that seem common to most countries with HSR.**

The results derived from the exercises above shall be used to appreciate the threats and opportunities and create a road map for the HSR dream of Indian Railways.

Identification of countries where HSR is in operation:

Following are the countries where HSR systems are in operation at present:

Country	Line in operation	Line under construction	Total
China	3529	6696	10225
Spain	1604	2219	3823
Japan	2452	590	3042
France	1872	234	2106
Germany	1285	378	1663
Italy	923	0	923
Turkey	235	510	745
South Korea	330	82	412
U.S.	362	0	362
Taiwan	345	0	345
Belgium	209	0	209
Netherlands	120	0	120
UK	113	0	113
Switzerland	35	72	107

The first 5 countries can be called the HSR superpowers having nearly 21000km (86%) out of the total 24000km (existing and under construction) of HSR of the world. All thesecountries are major players in HSR construction and technology transfer in other aspiring HSR nations.

China, by far, has the largest existing HSR network, followed by Japan, France, Spain and Germany. China also has the most ambitious expansion plans, with the most kilometers of lines currently under construction and the most planned. Spain is also undergoing an HSR construction and planning boom, with France and Turkey also notably having ambitious HSR expansion plans. Overall, Japan has the most developed and integrated HSR system, being the first country to develop the technology and make it commercially available in 1964. Europe also has an extensive and internationally integrated HSR system.

Concerning HSR speed, China has the fastest scheduled trains, which, along with trains in France, are the only scheduled HSR trains currently operating above 300 km/h. Most HSR countries have trains operating at maximum speeds of 300 km/h, with the United States and a couple of other countries being exceptions to this rule. This could be, in part, because trains reaching 300 km/h require dedicated HSR track.While China is the only country to operate a "magnetic levitation" (maglev) train on a commercial basis, with speeds reaching 431 km/h, Germany and Japan have tested maglev trains at speeds of 550 km/h and 581 km/h, respectively.

France has the fastest tested time for a non-maglev, steel-wheeled train, at 574 km/h.

The United States also joins the handful of HSR countries whose fastest trains run at average speeds of less than 200 km/h and who have not tested trains at speeds higher than 300 km/h. It has now embarked on an ambitious HSR program with the vision of connecting 85% of Americans by HSR by 2030 with the endorsement and backing of President Obama, and insuring guaranteed funding.

There are two successful HSR models, the Japanese and the French. The former operates based on high demand oriented and the latter focuses on its minimizing costs. The demand orientated model means HSR carries over 100,000 passengers per day as in Japan and Far East Asian countries. The cost minimized model focuses on lower operation and construction costs as in France. In particular, Germany carries both passengers and freight on HSR. The construction costs in Germany are in between those of Japan and France. The successful factors of HSR are high demand and cost minimal construction costs. France was able to recover its investments in 12 years.In future, Korea, Taiwan and China HSR will follow Japan's successful model because of high population density and concentration of economic activity along railway lines. (Yong Sang LEE 1)

Vickerman has argued that HSR is justified where there is a demand of between 12 million and 15 million railway passenger a year (about 40thousand persons/day) between two urban centers. He also concludes that the development of HSR as a new of transport has accelerated in many European countries and become a key element in the priority TENs. The rationale for this has, however, been somewhat confused so it is not clear whether HSR is simply an updating of the rail system to deal with problems of capacity and thus help maintain rail's market share, whether it is a means of competing with the rapid growth of air travel for medium distance journeys in the 400 to 600 km range, or whether it is a morefundamental agent of economic change with impacts on both competitiveness and cohesion. It also important that nations with high GDP's and high growth rates need an infrastructure which can sustain and promote the level of economic and concomitant social development that such countries experience. (Roger Vickerman)

Review of country conditions where HSR is in operation:

In order to assess the feasibility of HSR in a developing nation like India, we need to analyze the economic, political and social conditions in the countries with HSR systems. The aggregate quantitative and qualitative data for their geographical, demographical and economic indicators shall be enumerated and compared along with several political and cultural factors which are relevant to projects which are enormous in terms of cost and time like HSR.

Economic Conditions

Country	TotalHSR	GDP(PPP)Billion $	GDP/capita$
China	10225	8789	6600
Spain	3823	1368	33700
Japan	3042	4137	32600
France	2106	2110	32800
Germany	1663	2811	34100
Italy	923	1760	30300
Turkey	745	863	11200
South Korea	412	1356	28000
U.S.	362	14260	46400
Taiwan	345	718	29800
Belgium	209	381	36600
Netherlands	120	655	39200
UK	113	2149	35200
Switzerland	107	317	41700
India	0	5300	5100

These statistics for mega regions comprising of the states of Gujarat and Maharashtra (together) are:

GDP (PPP) Billion $	GDP / Capita $
128	5725

The above figure displays the size of the economy of the country as measured by Gross Domestic Product (GDP), as well as the GDP per capita, which captures the portion of the economy per person within the country. GDP is important to consider as a factor in HSR systems because it represents the size of the economy as a whole. *The bigger and more advanced an economy is, the more complex transportation infrastructure is necessary, such as air, road and rail transit options, to move people and goods.*

GDP also represents an indirect measure of how large a base a national government has to tax and therefore how much government revenue can be raised and resources directed towards HSR. Since HSR development is almost always dependent on government support, GDP is an important measure of the ability of government to marshal resources. Similar to GDP, per capita GDP is a measure of the wealth of a country. Countries with higher per capita GDPs are more likely to be advanced and have citizens who consume more products and services. Therefore, countries with high per capita GDPs will likely be more amenable to investment in and development of transit options that facilitate their work and lifestyles.

India has displaced Japan to become the world's third biggest economy in terms of purchasing power parity (PPP), according to a World Bank. The 2014 round of the bank's International Comparison Program (ICP) ranked India after the US and China. PPP is used to compare economies and incomes of people by adjusting for differences in prices in different countries to make a meaningful comparison.

The survey covered 199 economies. India was now the world's third largest economy, moving ahead of Japan.

The above information places India at a favourable position as far as the GDP is concerned but when converted to per capita GDP, all the HSR nations are far ahead except China. Having said this, per capita GDP is an imperfect measure of the wealth of individuals in a country because it is an average and does not represent the dispersion of incomes and income disparities. For instance, some countries have a very high concentration of wealth among relatively few individuals, with the remainder of the population having significantly less income at their disposal; this could yield per capita GDP numbers that do not reflect individual wealth.

The fact that China has leapfrogged into the HSR world and has now begun to export the technology proves that this could not only be an economy driver within the region and the country but also a sound earning potential from export of technology within a decade.

Another factor in increasing HSR passengers are the price competition of fare between HSR and aircraft. India has a huge population which can sustain the High Speed Railway network, but ticket prices have to be affordable and competitive to other modes of transport. Currently, domestic airfares are higher than HSR in France and in Korea, whereas in Japan it is the almost the same.

Fare comparison between HSR and aircraft in a few HSR countries:

Country	Cities	HSR	Aircraft
Japan	Tokyo-Osaka	100	100
France	Paris-Lyon	100	130
Korea	Seoul-Busan	100	130
India	Mumbai-Ahmedabad	100	100

On the other hand, when capital costs are compared, the TGV of France is much cheaper than HSRs in other countries. France has devised no special structure and makes light trains by adapting the articulated bogie. It lessens the lading tonnage of train on track. In contrast, Japan has more tunnels and bridge because of the topography. It can be said that one of the essential points of HSRs is an economical system based on advanced technology like the TGV.

Country	HSR line	Distance (km)	Construction period in years	Cost (km/m euros)
Tofuku Shinkansen	Tokyo-Morioka	465	20	35
Choetsu Shinkansen	Omiya-Nikata	270	11	41
Country	HSR line	Distance (km)	Construction period in years	Cost (km/m euros)
TGV Atlantic	Paris- Lemans	290	5	10
ICE 2002	Frankfurt-Cologne	180	4	32
KTX	Seoul-Busan	410	13	42
Taiwan	Taipae-Kaoshung	345	6	48

Political conditions- Comparison of governments:

Country	TotalHSR	Type of government
China	10225	Communist, centralized, heavy command and control, policies easy to implement
Spain	3823	Parliament, 17 regional autonomous governments
Japan	3042	Parliament with 47 prefectures, heavily centralized, dependent on center
France	2106	Small country, power centralized in national govt, little powers to local govt
Germany	1663	Parliament with 16 small states, limited powers to states
Italy	923	Parliament, 94 small provinces, heavily centralized and answerable to center
Turkey	745	Parliament with 81 provinces, less autonomy to provices
South Korea	412	Parliament, 9 provinces, 7 cities, semi-autonomous provincial govt
U.S.	362	Parliament with high federal character
Taiwan	345	Parliament, 18 counties, centralized
Belgium	209	Parliament
Netherlands	120	Small country, Parliament, 12 provinces, heavily centrally inclined
UK	113	Parliament with strong states
Switzerland	107	Parliament, 26 cantons, highly autonomous
India	0	Parliament, 26 states, highly autonomous

The type of national government is important to consider with regard to HSR systems for a number of reasons. If a country has a strong, centralized national government, policies, laws and regulations concerning HSR will likely be more consistent and easier to implement and enforce. Federal systems, such as that in the United States are more decentralized, with sub-national governments with significant authorities to regulate and implement policies and local objectives generally. However, the nature of federal systems can vary greatly. The United States is rather unique in having a federal system where the sub-national governments enjoy relatively great autonomy and ability to legislate and enact policy and regulations. Sub-national governments in other countries with federal national governments, by virtue of the size and close proximity of their sub-national governments (and therefore, their greater interdependence) have much less independence.

Another aspect of government type to consider is the relative strength of democratic institutions within the countries in question. While all

ostensibly have some form of representative government, China has a very centralized government with significant top-down structures of authority. This stands in contrast to more democratic systems with democratic representation, a variety of political parties and ideologies, and a separation of powers. In such systems, authority is more diffuse and opposing views more influential. Therefore, under such systems, it can be more difficult for political leaders to channel resources and coalesce around common objectives.

Since HSR systems are large in terms of cost and time, investors, particularly foreign look for a stable and peaceful environment over the long term horizon. Other than the first BOT in HSR, Taiwan was a leader in providing this enabling environment by creating a constitutional body to govern HSR which will not be affected by change in the government.

India stands at a vantage point in this factor considering that it has a stable democracy which is devoid of any major political and social turbulence. But following the footsteps of Taiwan by creating an authority which is insulated from possible political fracas will be a step in the right direction.

Geographic and Demographic Features

The tables above give an overview of the geographic and demographic size of countries with HSR systems, as well as the population density within the countries and the portion of the population that lives in urban areas. The geographic size of a country is an important consideration with regard to HSR because of the potential land area that must be crossed, or served, by HSR.

Country	Land area sq km	Population million	Population density	Urban Population %
China	9569901	1340	140	43
Spain	498980	40	81	77
Japan	364485	127	350	66
France	549970	62	113	77
Germany	348672	82	236	74
Italy	294140	58	200	68
Turkey	769632	76	100	69
South Korea	96920	48	500	81
U.S.	9161966	308	34	82
Taiwan	32260	23	712	-
Belgium	30278	10	344	97
Netherlands	33893	17	493	82
UK	241930	61	252	90
Switzerland	39997	8	190	73
India	3287570	1189	361	34

This demonstrates that one feature of rail development, where densely populated countries show a high possibility of developing railways. This possibility of development of railways has a close relation to population density, where Korea has 500 persons/㎢, Japan 350 persons/㎢, German 236 persons/㎢, France 113 persons/㎢. This confirms that Japan's rail passenger traffic shows 26.8% of the modal share in transport. Korea has a higher population density than Japan. Therefore, in future, if the rail network of Korea is expanded, the passenger traffic is likely to increase substantially. This postulation can be adapted similarly to China and Taiwan. In transport economics, the railways are superior to road and aircraft between 200km and 500km considering the speed and comfort.

The data gathered, especially for large and populous countries, will not necessarily reflect differences within the countries, such as between regions; for instance, differences between the western and eastern United States. Countries are usually much more complex than country-level data can suggest.With the context of the Mumbai-Ahmedabad HSR corridor in mind, the aforementioned data for the **mega regions comprising of the states of Gujarat and Maharashtra (together)** which will be the primary catchment area for the HSR corridor are:

Land area sqkm	Population million	Population density per sqkm	Urban Population
503737	176	334	45%

Population density and urbanization are important considerations in that, in order for HSR to have economies of scale, enough people must be willing to regularly commute or travel from one place to another. This means that HSR works best when connecting large, densely populated cities or population centers with a high GDP contribution. Research has suggested that, given the current state of technology, HSR works best when connecting population centers less than 600 and more than 100 miles apart. Beyond 600 miles, airplanes tend to be faster and more efficient and getting their passengers to their destinations and for distances less than 100 miles, cars tend to be quicker because they are more quickly accessible than the stations from which trains depart.

As can be observed from the chart, the large majority of countries with existing HSR systems are less than 550,000 sq. km in size. Only China and the United States are exceptions to this trend, with the latter having very limited HSR systems. Europe, in contrast, has less than half of the land mass of either the U.S. or China.When we compare the average moving distance per person of HSR, France is 456km, Germany 308 km, Japan 258 km and Korea 240 km. In addition, the distance between stations, in France it is 142 km, on the contrary, in Japan it is 34.5km because of many major cities location like as Nagoya, Kyoto along HSR in Japan. Thus, Japan has a diverse operation system like direct long train and short-stop train.

Although the trend is not quite as strong as with land area, countries with HSR appear to have high

population densities, with the large majority having densities over 200 people/sq. km. Compared to most other countries with HSR, the United States has considerably less population density. Having said that, urbanization rates in the U.S. are not significantly different from those in other countries with HSR, implying that U.S. population centers are likely as dense as in other countries, just more spread out. China, which also has large land area, has population centers clustered in certain regions of the country. In China, population is very dense, but most large cities are located in the east of the country and along the east coast. This allows HSR to be focused where it is most efficient and effective within those countries, without having to bridge vast distances between cities. The United States also has population centers on both coasts and in the middle. Concentrating on HSR within specific corridors and regions would likely prove more workable.

India, on the other hand is much smaller than China and US but much larger than other HSR countries. The population density of over 300 in the country and 350 in the HSR corridor augers well for the proposed HSR corridors.

Existing Non HSR transport infrastructure in HSR countries:

In Absolute numbers

Country	Land Area sq km	Airports		Railways route km	Standard Gauge	Paved roads	Express ways
China	9,569,901	195		77,834	77,084	3,583,715**	53,913
Japan	364,485	49		26,435	3,978	961,366	7,560
South Korea	96,920	25		3,381	3,381	80,642	3,367
Turkey	769,632	49		8,697	8,697	426,951**	1,987
Taiwan	32,260	16		1,582	345	40,843	976
Germany	348,672	65		41,896	41,641	644,480	12,600
U.K.	241,930	41		16,454	16,151	398,366	3,520
Belgium	30278	14		3233	3,233	119,079	1,763
Italy	294,140	39		19,729	18,317	487,700	6,700
France	549,970	41		29,213	29,046	1,027,183**	10,950
Netherlands	33,893	11		2,896	2,896	136,827**	2,582
Spain	498,980	30		15,288	1,392	681,224	13,872
Switzerland	39,997	7		4888	3397	71,384	1,793
E.U.	4,324,782	456		229,450	NA	5,454,446**	NA
U.S.	9,161,966	419		226,427	226,427	6586610	75,040
INDIA	3287570	132		65348	-	4865000	1324

Non HSR transport infrastructure- Relative numbers in terms of per 1000 sq km of land area

Country	Airports per 100k sq km	Railways route km per 100k sq km	Paved roads km per 100k sq km
Asia			
China	2.04	8.13	374.47
Japan	13.44	72.53	2637.6
South Korea	25.79	34.88	832.04
Turkey	6.37	11.3	554.74
Taiwan	49.60	49.03	1266.05
Europe			
Germany	18.64	120.15	1848.38
U.K.	16.95	68.01	1646.6
Belgium	46.24	106.77	3932.8
Italy	13.26	67.07	1658.05
France	7.45	53.11	1867.7
Netherlands	32.46	85.44	4037.02
Spain	6.01	30.63	1365.23
Switzerland	17.50	178.47	1784.7
North America			
U.S.	4.57	24.71	718.9

Concerning air travel infrastructure, it is interesting that most HSR countries have a relatively high concentration of airports for their land size. This is particularly true in Europe. This could be indicative of what transportation experts have suggested, that, while HSR is viewed as a competitor to air travel for travel distances under 600 miles, HSR complements air travel infrastructure designed around longer-distance trips. In contrast, the United States and China, which are both geographically much larger than Europe, have significantly fewer airports. This could be a reflection of the fact that population centers are more spread out in these countries than in Europe.

The kilometers of rail in HSR countries is an indicator of the amount of rail-based infrastructure in a country. This is not high-speed rail, but rather rail of any type, for freight or non-high-speed rail passenger trains. Perhaps ironically, the United States, which has very little HSR, has by far the most extensive rail infrastructure of any country in the world, although it comes a close second to the existing rail in all EU countries combined. China has less than a third of the rail infrastructure the United States has, despite its size.

The kilometers of paved roadways and expressways gives an indication of the availability of road-based travel options in a country. The United States has, by a significant margin, the most roadways and freeways of any HSR country and is second only to the EU as a whole. China and France also have notably large roadway infrastructures, with the latter being particularly noteworthy considering its small land area compared to the U.S. and China.

Looking over HSR countries generally, it appears that there is little relationship between the amount of paved road infrastructure and HSR. This could

be attributable to what research on HSR has suggested, that, while cars are more convenient and accessible in some ways and for some shorter trips, the speed of HSR makes it a more likely choice for trips where the slow speed of cars becomes a significant disadvantage. In this way, as with air travel, roads and HSR can complement each other as transportation alternatives within their respective areas of competitive advantage, cars for shorter trips and trains for longer ones.

India stands at the middle of the infrastructure spectrum in terms of airports, railways and roads in HSR nations meaning thereby that it has adequate supporting infrastructure to create efficient synergy in the overall transport environment.

Cultural Conditions:

One perhaps less obvious condition to consider in relation to countries with HSR systems is the culture of the given country. Culture can play an important role in how people view collective efforts and policies, such as those required to develop HSR systems, as well as how people view, trust, interact and defer to government and others authorities. In this latter sense, culture provides the context within which political conditions and governments exist. In this way, some cultures can be more amenable to certain government policies and collective actions than others.

While it is difficult to generalize culture for countries and to definitively determine whether culture actually has a significant impact on something such as HSR, some commonalities and trends do exist. Business consultant and social psychologist Geert Hofstede has mapped several dimensions of culture that have been used to assists businesses that have relations with foreign governments and business partners to better understand the cultural environments they operate in.

The dimensions listed here include*: Power Distance Index (PDI), Individualism IDV), Uncertainty Avoidance Index (UAI), and Long-Term Outlook*

Country	PDI	IDV	UAI	LTO
China	80	20	30	118
Japan	54	46	92	80
S. Korea	60	18	85	75
Turkey	66	37	85	0
Taiwan	58	17	69	87
Germany	35	67	65	31
Country	PDI	IDV	UAI	LTO
U.K.	35	89	35	25
Belgium	65	75	94	0
Italy	50	76	75	0
France	68	71	86	0
Netherlands	38	80	53	44
Spain	57	51	86	86
Switzerland	34	68	58	0
U.S.	40	91	46	29

Cultural dimensions score in India:

Source: Going Local in India: Carol Barnum, Anant Patil, Dec 2010

Index	India	World Average	HSR Average	Range	Consequence for India
Power Distance	77	56.5	52.85	34-80	Very positive
Individualism	48	40	57.57	18-91	Positive
Uncertainity Avoidance	40	65	68.5	35-94	Not positive
Long Term Orientation	61	48	61.125	29-118	Positive

The Power DistanceIndexis basically a measure of deference to authority, or how much distance there is between people of various authority status in a given culture. Countries with a high PDIare ones where individuals defer to and respect authorities in government, business and society. This has bearing on the development of HSR in that countries where there is a high PDI are more likely to defer to decisions by government and other authorities to implement projects, such as HSR.On the other hand, countries where there is a lower PDI are more likely to have a tradition of not simply accepting decisions by authority and could therefore be more likely to challenge government and other actions that run counter to their interests. Notably, China, which has recently embarked on a massive expansion of HSR, has a high PDI score, whereas the United States has a lower one. While there are few clear trends in PDI scores, most countries with well-developed HSR systems have scores above 50.

India has Power Distance (PDI) as the highest Hofstede dimension for the culture, with a score of 77 compared to a world average of 56.5. This PDI score for India indicates a high level of inequality of power and wealth within the society. In high PDI cultures, the inequality of power, wealth, physical strength, and intellectual capacity is accepted by the population as a cultural norm (Hofstede et al., 2010, p. 54). From the HSR pint of view, it reflects that once the government takes a decision, it is likely to be accepted and supported by the population in general.

The Individualism score is a measure of the degree to which people in the given culture are individualistically oriented or not. A high IDV score would indicate the presence of a culture of strong individualism, whereas a low score would indicate a culture with strong collectivist sensibilities, or cultures that value a sense of unity within communities. Countries with low IDV scores are more likely to engage in collective efforts to solve community-wide problems. Here again, China distinguished itself as having a low IDV score, surpassed only by South Korea and

Taiwan among countries with existing HSR systems. In contrast, the United States has a very high IDV score, having not just the highest score among HSR countries, but also the highest among all countries measured. This could be an indicator of increased difficulty in rallying public support for a large HSR development endeavor, if the public in the United States view such an endeavor as either contrary to or not benefiting their interests. Generally speaking, however, there is no strong pattern of IDV scores among HSR countries.

India's low individualism score (IDV) suggests that its culture stresses the interdependence and long-term mutual obligations between individuals and organizations. This interdependence influences an individual to want to be in an environment where he feels belonged and integrated. Hence, collective cultures enjoy group work and derive their identity from being part of a collectivity

The **Uncertainty Avoidance Index** is a measure of how much a culture is risk-averse when confronted with uncertain and unstructured situations. A high UAI score indicates a culture that is likely to favor strict laws and rules regulating situations where uncertainty is present. This could have bearing on HSR development in that HSR could be viewed as a way of regulating the uncertainty of growing populations or global warming. Alternatively, HSR could be viewed as a new and uncertain technology for those not already familiar with it and therefore could be shunned.

Among HSR countries, there is an apparent trend of high UAI scores, indicating that most countries with HSR prefer structure and rules for dealing with uncertainty. However, most of these countries are in Europe, in contrast with China, which has the second-lowest UAI among HSR countries. This could indicate that Europe, which is already comfortable with HSR, sees its expansion as a "known" variable for mitigating climate change, for example. China, with its low UAI, on the other hand, might be willing to embrace what, for them, is a new technology, for dealing with rapid growth, urbanization and economic expansion. On this measure, the United States has an average score, indicating neither a strong predilection for dealing with uncertainty through rules and regulations, nor a particular disposition for "winging it."

India's lowest ranking dimension is Uncertainty Avoidance (UAI) at 40, compared to the world average of 65. This suggests that the India's culture is more used to unstructured ideas and situations. The population has fewer rules and regulations with which to attempt control of every unknown and unexpected event or situation

Long-Term Outlook is a measure of cultures' orientation towards the future. A high LTO score indicates a culture that values long-run results, even in the face of short-term set-backs. A low LTO score indicates a greater focus on tactical decisions, even at the expense of the long-term. LTO scores having a bearing on projects, such as HSR, which take a considerable amount of time to decide on, plan for, build and then, finally, start operating. Countries with high LTO scores might be more likely to be willing to undertake long-term projects that will not bear fruit for years.

Notably, China has a very high LTO score, as do the other Asian HSR countries Japan, South Korea and Taiwan. On the other hand, while there is more limited data available, western countries, including the United States, tend to have lower scores. This could indicate that, while Europe has a well-developed HSR system, its development might have come as an immediate response to pressing needs, rather than as part of a larger transportation infrastructure strategy. This could possibly have implications for the development of HSR in the United States, where such development might not be politically or popularly feasible until there is a perceived need to address an immediate problem or issue. **India's high LTO score** indicates the country prescribes to the values of long-term commitments and respect for tradition. This is thought to support a strong work ethic where long-term rewards are expected as a result of today's hard work.

Finally, concerning culture, it should be noted that the dimensions measured here do not represent a comprehensive picture of culture in any given country. Furthermore, culture can also vary across and even within regions within a country, making generalizations difficult.

There are many cultural factors than may play a significant role in the development of HSR in a country, or even within a given region, for example, the preference of people in some countries or regions of countries for cars over public transportation. Such cultural factors should also be given due consideration. **However, from an Indian perspective, it can be said that from these social psychological indicators, HSR can be a long term project which would be acceptable to the population in general.**

HSR and Passenger Rail System Features

The following table depict the size, ownership structures and financing of HSR in these countries. Privatizations and the breaking apart of monolithic state companies are usually done because of the losses incurred by the state-run companies and because of perceived gains in efficiency and profits from making public HSR companies more

competitive or from privatization. This latter consideration has driven EU laws **mandating the breaking apart of monolithic state railway companies and the separation of those companies into independent operations and infrastructure companies.**

Almost all HSR systems, particularly with regard to infrastructure, have been implemented by, or with the help of, national governments. While there is a move towards market liberalization and privatization, the up-front capital costs associated with building HSR are enormous and almost always require the financial support of the national government to begin with. In some countries, HSR service has been either privatized or turned over to independent public companies or is run by international consortia comprising state companies.

Country	Infrastructure ownership	Operations ownership	FINANCING
China	State owned corporation CRC	State owned corporation CRC	50% national government, 40% bonds by MoR, 10% states
Japan	State owned JRCTTA	Private companies	Infrastructure on lease to private companies
South Korea	State owned Construction & Transportation ministry	State owned corporation KTX	National government, loans
Turkey	State owned company TCDD	State owned company YHT/TCDD	State funding
Taiwan	Privately owned THRSC	Privately owned THRSC	Privately owned THRSC for 35 years, then transfer to government
Germany	State owned DB Netz	State owned DB	Both owned by BEV (federal rail property agency)
U.K.	Privately owned Network rail	Private Rail operators	Government grants subsidies
Belgium	state owned infrabel	State managed by NMBS/SNCB; Operated by 4 private JV's	
Italy	**state owned RFI**	**state owned Trainitalia**	**Both owned by FS holdings (State Railways)**
France	**State owned company (RFF)**	**State owned company (SNCF)**	**Both owned by French Ministry of Transport**
Netherlands	**State owned company Prorail**	**2 international JV's (Thalys and Intercity Express)**	
Spain	**State owned company**	**State owned company RENFE & 2 PRIVATE COMPANIES**	**National Funding**
Switzerland	**Private company BLS**	**Private company BLS**	**Fully Privately owned**

The conclusions can be enumerated as follows:

1. There is no single formulae for constitution of the structure for an HSR company. Simplistically speaking, the organization model is as follows:

Infrastructure	Operations	Examples
Private	Private	Taiwan,Switzerland,UK,Japan
Private	State	USA
State	Private	Belgium, Netherland, Spain
State	State	Turkey, China, S. Korea, Italy, Germany, France

   Most of the European HSR systems have separated ownership of infrastructure and operations under mandate by the EU. However, either both or one are being owned by the government or by private companies.

2. However, these companies have usually either been relieved of the debt associated with initial capital costs, or receive government assistance, in the form of subsidies or low-interest loans, which help them to pay off the debt.

3. While recognizing the need for state-backing in the initial capital outlays required for HSR, EU law mandates the separation of operations and infrastructure companies in order to encourage private competition to public operators and to encourage more transparent pricing and bidding for access to track owned by public infrastructure companies.

4. In several cases where privatization or the breaking apart of public companies has happened, such companies become profitable in terms of operations.

High Speed Railways worldwide generate surpluses from their operations because they attract more passengers and generate more revenues at lower unit costs of production (for ex. crew can make two round of trips instead of one). In most of the countries, HSR systems generate enough revenue to cover 'Operational Costs' and most of the HSR lines cover some of their 'Construction Costs'. Tokyo-Osaka generated enough operation surpluses in its first decade to completely match capital costs.

Analyzing the business exploitation model and the infra structure creation model adopted by all the HSR countries, it is seen that, as in the case of ownership study earlier, there is no pattern which runs through the HSR system suggesting a straight jacketed structure regarding exploitation model. Every country has adopted different models for different projects within the same country. One philosophy which probably runs common to all is

that the track gauge adopted by them for HSR lines is the same as that of the mainline railway system.Since choosing a particular exploitation model is a decision affected by the comparison of the costs of building new infrastructure versus the costs of upgrading (and maintaining) the conventional network, or a combination of both, the definition and decision of HSR model immediately becomes not only a technical question but also a (very relevant) economic one.

SUMMARY OF RESULTS AND CONCLUSIONS

Political Environment:

Since HSR systems usually span sub-national jurisdictions, national involvement in the implementation of HSR is often required. National, or federal, involvement often requires the creation of regulations and conditions to which sub-national governments must submit. States' autonomy and states' rights issues make such coordination more difficult, due to variances in states' goals and their willingness to cooperate with the federal government and with each other.

In terms of the political environment, most of the HSR countries are democracies with a stable and string central government. In India, the structure of the government has a strong federal tilt with states having a large portfolio of subjectsto legislate upon, much like that in the USA. However, a lot depends upon the political lines the ruling parties in the states are affiliated to. The project in question in India (Mumbai- Ahmedabad) serves the states which have the same ruling partyas that in the center and both have long tenures ahead. This would allowdecisions to be made in more of a top-down manner, where national directives are implemented without much resistance from regional or local government. What would be necessary is to create an arrangement of coalition of states and the centerthat facilitates (including funding) and provides a stake and ownership in the system.

It is notable that the only HSR country close and bigger than the size of India is the U.S. which has similar strong federal character of the government with states having greater autonomy. China, on the other hand, has a very centralized government, with top-down decisions being the norm. In all other HSR countries, the national governments are much stronger have a much larger say in the course of policies than the state and local governments do.

While some HSR systems are able to cover the cost of operations and maintenance from the revenue received from fares alone, the upfront capital costs, in the form of track and other physical infrastructure, are usually prohibitively expensive, without the financial assistance of government. Even the most successful private companies in Japan were initially government-owned entities that benefited from government investment in capital. Successful independent companies in Europe usually own and operate their own trains, but run those trains on track that was initially paid for by the state.

All large infrastructure projects including HSR (save a few nations like Japan) have been built by borrowing money. It is only the financial leverage that a country can expect to possess by which the repayment of loan is possible. Also of note is that in a conventional railway system, the infrastructure and the trainsets and the operations, including staff has to be provided by the state whereas in an HSR, the state provides for only the infrastructure and leaves the rest to the private parties. Thus, the financial burden on the state and in turn the common taxpayer through tax on GDP is not much higher than the conventional railway system where as the quality of service is much superior.

Cultural Environment:

This study attempts to generalize the cultural ethos of a society and there are obvious pitfalls. However it does give a broad conceptualization about how mature and ready a population is for accepting a decision of such large consequences.

On the **PDI**, India ranks high indicating a large deference to authority than other countries. The implications are that the idea of imposing HSR through a government decision (particularly with a favorable political environment) may not find much resistance.

In terms of **individualism**, India ranks low and that means that collectivism often masks individuality in India and the population is more amenable to collective national decisions. This could be a favorable turn in the decision making towards HSR. However, the HSR should be presented to the public as the American Highway effort was placed in the 1960s. Though it was a collective effort, it was presented as a quintessential American endeavor because of the independence it would provide to people.

In terms of**UAI**, India ranks pretty low meaning that Indians are normally highly risk averse than other HSR countries with theexception of China. Which means that the people of has embarked upon its HSR expansion as a result of the tolerance for such an uncertainty that this project may entail. Her India will have to more careful than China **and will have to ensure that support for HSR policy comes from the bottom up, as the result of successful grass-roots and public education**

efforts, then the political feasibility of passing and implementing HSR policy would increase.

The LTO is favorable to HSR in India where this index is fairly high suggesting that the Indians have a more "long-term" thinking compared to others in the HSR group. If HSR is presented as a long term solution to a long term need, support in India is likely to be much higher.

Overall, it can be concluded that as a society, in India, HSR can expect to be greeted with cautious optimism but the government will have to present it to the public tactically with a bottom up approach.

Economic And Geographic Conditions:

In terms of their economies, countries with HSR tend to be well developed, with large GDPs overall and on a per person basis. This is likely because of the financial leverage required to fund HSR projects. Even small projects cost in the billions of dollars. However, some economies that are relatively poorer, on a per person basis, such as China and Turkey, nonetheless have the financial heft, from the overall size of their economies, to afford HSR.

Whatever the governance arrangement may be, funding for HSR systems almost always depends on external capital contributions. This is because HSR almost always requires significant financial resources, as well as the financial leverage to be able to borrow such resources. Whatever form HSR governance and ownership might take in India, it is likely that it will require an infusion of capital from the public sector. Now that the JICA has come forward with a proposal of a soft loan, the National government in India has fewer troubles as far as funding of the project is concerned.

In terms of geography, most HSR countries are relatively small, with tight clusters of urbanization and population. As mentioned above, China and the USA are the only countries larger in size to India that have HSR, and in China's case, HSR is concentrated on its populous, wealthier east coast only. Even the USA is not planning an East West high speed connection relying on the rule of thumb of 100 – 600 mile range for HSR to be cost effective. India HSR program qualifies well on this account.

HSR And Passenger Rail System Features:

The most common structure for providing HSR services generally includes the following:

1. A state-backed, independent, public company and/or private companies, which have responsibility for rolling stock and operations.

2. A state-backed, independent rail infrastructure company that owns and manages track and allows both the state-backed operator, as well as other private operators (which tend to be much smaller than the state company), to purchase access to infrastructure.

3. A division of the debt incurred by the previously unified (operations and infrastructure) state railway company among the operator and infrastructure manager, perhaps with government assistance in paying debt service.

Having highlighted this commonality, it is observed that there is a wide difference in the structure of almost all HSR systems, particularly in regard to ownership of the system and the business exploitation models they have opted for. Some HSR's have privately owned infrastructure with publicly owned operators (USA) and others have the opposite ( ). Some have completely dedicated new lines for HSR and some share their lines with conventional railway systems, either passenger or freight. The models adopted are based upon operational exigencies and economic/ financial considerations.

While there is a move towards market liberalization and privatization, the up-front capital costs associated with building HSR are enormous and almost always require the financial support of the national government to begin with. In some countries, HSR service has been either privatized or turned over to independent public companies or is run by international consortia comprising state companies.

Privatizations and the breaking apart of monolithic state companies are usually done because of the losses incurred by the state-run companies and because of perceived gains in efficiency and profits from making public HSR companies more competitive or from privatization. *This step will be a major obstacle to crack in terms of Indian conditions where the railway is owned and operated by the national government. Being the largest employer in the country, it has forceful unions which have a strong influence over long term decisions like breaking up organizational structures.*

The common features among those companies that do not receive government assistance include serving to connect areas that are densely populated and close to each other (no more than 600 miles), and they are usually either privatized or independent government companies, with operations and infrastructure independent of each other. Companies that require subsidies are usually state-owned railways that either do not separate operations from infrastructure, or which serve areas less dense and close together, and are viewed as serving areas that private enterprise would not view as profitable. However, it is notable, again, that,

with the exception of Taiwan (where a private company has used a BOT agreement and may perhaps need government assistance in the future) almost no HSR starts as a private enterprise, without subsidies or help from the government.

FINAL OBSERVATIONS

Since HSR is undeniably a transport trend of the future, India will have to show confident pragmatism and create the right conditions for a positive attractive alternative.

1. From the point of view of political stability, social maturity and economic tenacity (in terms of GDP and supporting infrastructure), it appears that India is reasonable well placed to take a confident step towards going ahead with the HSR dream. The corridor chosen is among the highest in India in terms of industrialization, urbanization and per capita GDP, all primary ingredients of a success HSR scenario.
2. However, it has to bite the proverbial bullet now, particularly in the context of Japan making an offer of a very soft loan to finance the whole project. Important decisions have to be take about business exploitation model followed by the track gauge.
3. Formation of a state–nation high powered authority will go a long way forward to regulate and facilitate the policy, finances and construction monitoring.

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