Introducing High Speed Rail (HSR) System in Developing Asia: Issues and Prospects

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Abstract: Higher economic growth and rapid urbanization in developing Asia is likely to result in an unprecedented level of travel demand. This paper focuses on the intercity transport issues and explores the role of High Speed Rail (HSR) system to meet the emerging demand. The characteristics of HSR, when compared with other competing modes, fit well into the context of Asian developing countries. The paper also computes both conceptually and empirically the competitive market niche of HSR in term of origin-destination (OD) distance. Issues and prospects for introducing HSR in developing Asia is discussed outlining key elements of ongoing policy debates. In the process, focus is mentioned to draw policy insights from international experience. Finally policy recommendations are made to address the critical issues. The core argument advanced in the paper is that the HSR is technical necessity for developing countries rather than political choice for sustainability objective (as was the case in European countries), which would anyway accrue as a co-benefit.

Keywords: High Speed Rail (HSR), Asia Developing Countries, Intercity Transport

1. INTRODUCTION

High economic growth rate and rapid urbanization is likely to generate huge travel demand in developing Asian megacities. Policy makers and researchers are normally focusing their attention on the case of urban transport as the problems are more visible on a day-to-day basis in major developing cities. However, the intercity transport problems are also equally pressing and deserve due policy attention. In this regards, this paper first review travel patterns in selected developed countries and build a scenario for developing Asian countries for building an efficient and sustainable transport system for intercity passenger travel. This will be followed by a discussion on the role of high speed rail (HSR), which is defined as a rail system with design speed more than 250 km/h for a new system (UIC 2011). Key issues and prospects for HSR development in developing Asia are outlined and policy recommendations are drawn.

2. TRAVEL PATTERNS INTERNATIONAL COMPARISION

Developed countries have passed through a longer course of transport evolution and have now achieved the most matured state of transport system. Since the evolutionary path followed by the transport system in a country is shaped by multiple elements and some of the elements are country-specific, it is natural that the resulting patterns of passenger transport are greatly varied across the countries. The patterns of passenger transport in selected developed countries are examined below.

Table 1. Trend of annual distance (km) travelled per person in selected countries

		1960	1970	1980	1990	2000	2005	2010[1]
US	Road	10,933	15,550	18,537	22,380	24,778	26,199	22,080
		(95.9)	*(94.1)*	*(91.7)*	*(90.3)*	*(88.7)*	*(88.9)*	*(87.2)*
	Rail	183	82	154	159	170	166	307
		(1.6)	*(0.5)*	*(0.8)*	*(0.6)*	*(0.6)*	*(0.6)*	*(1.2)*
	Air	287	895	1,518	2,242	2,984	3,115	2,938
		(2.5)	*(5.4)*	*(7.5)*	*(9.0)*	*(10.7)*	*(10.6)*	*(11.6)*
	Total	11,403	16,527	20,208	24,781	27,932	29,480	25,325
Great Britain	Road	4,602	6,557	8,044	11,270	11,811	12,163	11,389
		(85.5)	*(90.6)*	*(92.3)*	*(93.5)*	*(92.8)*	*(92.2)*	*(90.8)*
	Rail	764	647	622	694	790	861	1,032
		(14.2)	*(8.9)*	*(7.1)*	*(5.8)*	*(6.2)*	*(6.5)*	*(8.2)*
	Air	15	36	53	91	129	164	125
		(0.3)	*(0.5)*	*(0.6)*	*(0.8)*	*(1.0)*	*(1.2)*	*(1.0)*
	Total	5,381	7,240	8,719	12,054	12,730	13,188	12,546
France	Road	1,948	3,837	8,333	11,034	12,586	12,646	13,225
		(72.2)	*(81.7)*	*(87.7)*	*(88.6)*	*(86.3)*	*(88.2)*	*(88.3)*
	Rail	700	808	1,012	1,123	1,363	1,254	1,546
		(26.0)	*(17.2)*	*(10.7)*	*(9.0)*	*(9.3)*	*(8.7)*	*(10.3)*
	Air	50	51	152	300	642	443	207
		(1.9)	*(1.1)*	*(1.6)*	*(2.4)*	*(4.4)*	*(3.1)*	*(1.4)*
	Total	2,699	4,696	9,497	12,456	14,591	14,343	14,978
Japan	Road	590	2,724	3,696	5,553	6,518	6,458	7,052
		(23.1)	*(48.8)*	*(55.6)*	*(61.0)*	*(64.1)*	*(63.5)*	*(65.7)*
	Rail	1,955	2,770	2,697	3,133	3,023	3,057	3,090
		(76.6)	*(49.6)*	*(40.6)*	*(34.4)*	*(29.7)*	*(30.1)*	*(28.8)*
	Air	7	90	257	421	630	649	590
		(0.3)	*(1.6)*	*(3.9)*	*(4.6)*	*(6.2)*	*(6.4)*	*(5.5)*
	Total	2,553	5,584	6,649	9,107	10,171	10,164	10,731

1. for Japan, 2009

Data sources: US: The Bureau of Transportation Statistics (2012), Great Britain: Department for Transport (2012), France: Ministère du développement durable (2012); Japan: MLIT (2012)

2.1 Excessive travel demand

Table 1 shows trend of annual passenger-km per person (include both urban and intercity transport) by different transport modes in selected developed countries. As is usually expected, demand for passenger transport increased across the countries over the time. This trend is mainly driven by economic growth and development along with infrastructure and technological development which generated new trips or increased trip distance for passenger travel. However, the pattern of travel demand varies widely across the countries. Even among OECD countries, significant differences can be observed in overall travel demand, and choice of travel modes, and as result in the efficiency of transport system in terms of economic, social and environmental aspects. In 2010, the distance travelled per capita per year was 25,325 km in US, whereas the figures for France, UK and Japan were 14978, 12546 and 10731km respectively. The striking differences in travel demand can partly be attributed to the size of a country. Moreover, some other factors such as spatial development pattern or structure of transport system itself might be in play.

2.2 Unbalanced mode share

Since different transport modes exhibit inherent advantages in efficiently serving particular market niche of intercity passenger transport, achieving optimal balance of mode share is the most important goal of transport policies. The mounting concern for reducing transport emission has further raised the importance of balanced modal share as the emission load varies greatly among different transport modes. Normally, railway and bus, if operated with reasonable load factor, can transport passenger with minimum cost and emission load per passenger kilometer, while automobile and air mode are more burdensome particularly for environment. Table 1 shows diverse pattern of mode share across the selected developed countries. The share of railway in total passenger travel (includes both urban and intercity) is relatively much higher in Japan, which accounts for 28.8% of total, while railway share in US is only 1.2 %. Even in EU countries, which have traditionally maintained sustained policy priority for railways, the rail share is not anywhere closer to that of Japan. For example, rail share in UK and France account for only 8.2 % and 10.3 % respectively. Table 1 also shows that in US and UK, railway passenger volume was on declining path since 1960, which reversed the trend somehow in recent years. In both France and Japan, the volume of railway passenger demand in absolute term (pass-km) continuously followed an upward trend although the mode share figures were on downward path mainly because of a huge surge in road passenger. Early development of HSR in Japan and France might have played important role to attract passengers to railway services.

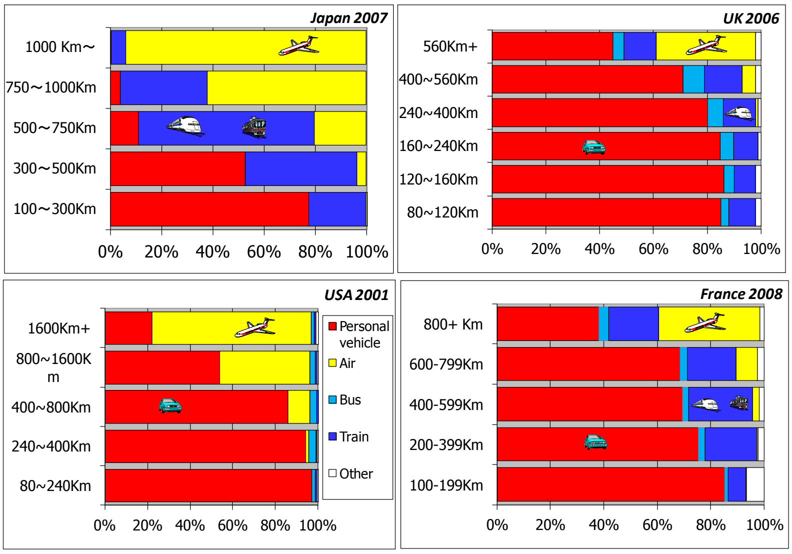

Figure 1. Mode share by travel distance
Data sources: MLIT (2009), Department for Transport (2006), BTS (2007)

While discussing mode share for intercity travel, it is important to examine the mode share by travel distance since the efficient market niche for each mode is primary determined by travel distance especially in intercity passenger market. Figure 1 shows modal share (national average) of intercity transport by distance for selected developed countries. There are contrasting patterns for modal share by trip distance particularly in terms of role of railways. For this USA and Japan stand at opposite ends and EU countries fall in between.

3. SPECIALTIES OF DEVELOPING ASIA AND IMPLICATIONS FOR INTERCITY

TRANSPORT

Developing Asian countries have some special characteristics with significant policy implications for intercity transport development calling for a different approach. The key defining feature of developing Asian includes, among others, higher economic growth, rapid economic structuring, rapid urbanization, growth of megacities, higher population density, widening income disparity, inadequate transport infrastructure, and lack of funding and financing resources. Under such context, policy makers are facing the challenge of meeting huge transport demand in a more sustainable way. The question therefore is not only about meeting the emerging demand but also about doing so through efficient and sustainable transport system with a balanced share of different modes. The diverse international patterns discussed above may offer an important strategic direction for developing Asia.

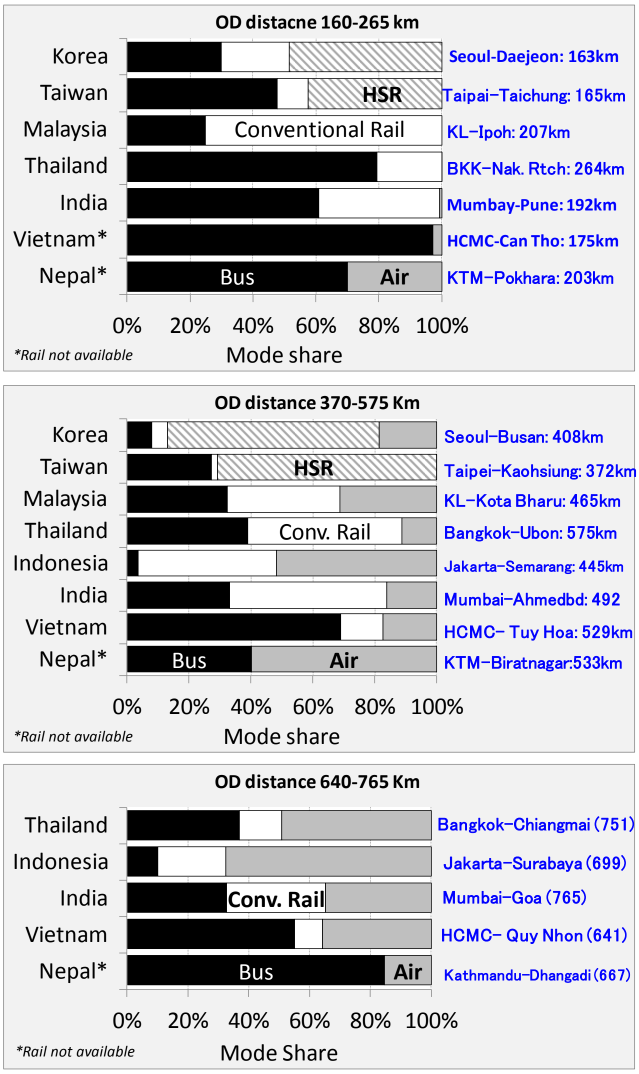

Figure 2: Mode share for different OD pairs in selected Asian countries
Data source: Original survey (by members of international research team)

Figure 2 shows mode shares (in intercity passenger market of only collective modes viz bus, conventional rail, high speed rail and air) for selected origin-destination pairs from selected Asian countries. In developing countries, bus and conventional rail is still dominant for all

OD distance ranges possibly because of lack of affordability for air fare. Some OD pairs even with medium distance for which rail service is not available shows domination of air modes. In countries like Malaysia and Indonesia, where Low Cost Carriers (LCC) have recently entered the market aggressively, air mode is dominant for OD distance otherwise suitable for rail travel. On the other hand, patterns in Korea and Taiwan with HSR show domination of HSR.

Despite the observed patterns of respectable mode share of bus and conventional rail in intercity passenger transport of developing Asia, the question is about how the mode share pattern is going to evolve in the future in the face of increasing income and resulting changes in travel behavior. As income increases, it is quite intuitive that travelers prefer faster and comfortable modes, which would result in modal shift from bus and conventional rail to cars and air. Figure 3 hypothesize a scenario in which developing Asia has to make a choice between a path closer to that of USA (with domination of car for shorter distance and air for medium and longer distance) or that of Japan (with respectable mode share of railways for medium distance OD pairs). The challenge here is how to achieve such a desirable mode share patterns.

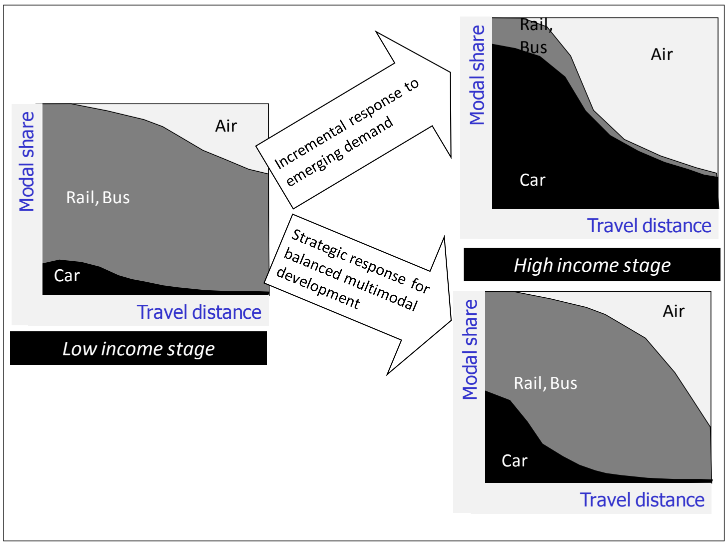

Figure 3: Scenarios for modal split by travel distance and possible patterns

The specialties of developing Asian countries discussed above have clear policy implications. These countries need simultaneous investment for different modes to meeting burgeoning travel demand. HSR option therefore comes more for providing capacity and higher service and the contribution of HSR for sustainability is just a co-benefits. Likewise, need of simultaneous investment for different modes also provide an opportunity for better integration of different modes right from the planning stages. The high population density in Asian countries also offers many transport corridors with higher demand density making operation of HSR commercially viable. The policy imperatives imposed by special context of developing Asia and the strategic path as distilled from international experience therefore converge, and HSR features as one of the key element of intercity transport strategy.

4. ROLE OF HIGH SPEED RAIL (HSR)

In the context of developing Asia, HSR plays multiples roles, such as providing high capacity system to cater increasing intercity travel demand, offering faster, reliable and comfortable mode of transport to better compete with car and air and contribute to make transport system economically efficiency and environmentally sustainable. However, the key question is under what circumstances HSR can be better placed to effectively fulfilled such roles. For this, we need to understand characteristics of different transport modes along with market niche in terms of ranges of OD distance over which a particular mode would have an advantage.

4.1 Characteristics of different Intercity transport Modes

Table 2 compares basic characteristics- which are normally of interest to policy makers- of different intercity transport modes. General highways offer flexible mobility and thus higher accessibility to wider area while the speed and capacity (say passengers per lane per hour) is the lowest. Expressways have better speed (80-120 km per hour) and capacity (1500-1800 cars per lane per hour) than general highway but a little less flexibility because of access control. Conventional intercity rail, on the other hand can transport much bigger passenger volume with large capacity rail vehicle and the average speed in the range of 60-120 km per hour (or even higher with speed upgrading). High speed rail (HSR) overcomes the speed limitation which may go up to 300-350 km per hour offering a very high capacity for passenger transport. For example, a double track HSR needs only 12 m width of right-of way which can run 13 trains per hour with 1,323 passenger capacity per train (the case of Japan's Tokaido line). A six-lane divided expressway (3 lanes each direction) with right-of-way normally requires a 40 m wide right-of-way and, with average lane capacity of 1500 cars per hours, can transport 4,500 cars per hours per direction. If vehicle occupancy is 1.7 persons per car, the expressway can transport 6,750 passengers per hour, while HSR can transport 12,038 passengers per direction with 70 % load factor. If right-of-way width is taken into account, HSR's capacity is more than five times the capacity of expressways. But in order to achieve higher average speed, HSR stations needs to be located in longer interval (around 50 km) and some trains may need to skip smaller stations. As a result, flexibility and accessibility of high-speed rail may be lower than expressway and conventional rail but still higher than aviation. Aviation offers fastest speed and moderate capacity but very low flexibility.

Table 2. Characteristics of different intercity transport modes

	Speed	Capacity	Flexibility, accessibility	Environmental sustainability	Impact on spatial development
General highways	△	△	◎	△	Low density dispersion
Conventional rail	○	◎	○	◎	Higher density corridor development
Expressways	○	○	○	△	Moderate density wider corridor development
High-speed rail	◎	◎	○	○	Development of corridors with poles
Aviation	◎	○	△	△	Concentration at big cities

◎ High ○ Moderate △ Low

Different intercity transport modes also have different impacts for spatial development at regional and national level mainly because of varying degree of accessibility and flexibility they may offer. General highway, being most flexible, promotes dispersion of economic activities, while expressways, conventional railways, and HSR all delivers higher benefits to areas closer to the expressway interchanges and entry/exit points or around railway stations resulting in high density corridor development of varying degree. Air transport on the other hand reinforces the concentration in the big cities, while HSR can compete with air over a wide range of travel distance (in terms of travel time) but can serve several destinations along the corridor offering so called network externalities. In particular, HSR may contribute growth of secondary and tertiary cities along the corridors (Levinson 2012, Gutierrezez, 2001). Table 3 shows the environmental performance different modes, which has recently been a most important issue for policy makers in recent years. Railway outperforms other modes for lower emission burden. There are several other mode-specific features, such as service quality including reliability. Since the characteristics of intercity travel demand for different kind of trips are also in great variation, the challenge for policy makers is to develop a well coordinated multimodal transport system which makes it possible to best utilize the inherent advantages of each mode.

Table 3: CO_2 emission per passenger-km by travel modes in selected countries

Country, (data year)	System and modes	CO2 per pass-km, (grams)
US[2] (2008)	*Urban transport*	
	Heavy rail	94
	Urban buses	191
	Intercity transport	
	Intercity bus	31
	Intercity rail (AMTRAK)	116
	Domestic air	145
	Car average trip (urban/ intercity)	145
	Car, one passenger (urban/intercity)	235
UK (2010)	Cars (urban/intercity)	129
	Urban transport	
	London Underground	73
	London Buses	86
	Intercity transport	
	National rail	53
	Intercity bus	30
	Domestic air	163
France (2008)	Car (intercity trip)	105
	Intercity rail	10
	Domestic air	128
Japan	Average of urban and intercity (2010)	
	Taxi	396
	Car	169
	Rail	18
	Buses	49
	Domestic air	102

Data sources: For US: M.J. Bradley & Associates LLC (2008); For UK: DEFRA (2011); For France Commissariat général au Développement durable (2010); For Japan, MLIT (2012)

4.2 Competitive niche of different intercity modes by trip distance

Different levels of average speed and access/egress distance (or time) for different intercity transport modes result in distinct competitive niche for each mode by travel distance. Normally, intercity rail station or bus terminal can be located at the city center while airport has to be located outside the city. That is why intercity bus and rail have advantage of shorter access and egress time and can off-set the effect of higher speed of air for certain range of travel distance. Even though travelers make mode choice decision based on multiple variables, such as fare, comfort, reliability and so forth, the required travel time is perhaps the most influential variable to determine market niche for each mode (see TRB 1991). It is important to examine such a competitive niche for HSR while discussing its role as an intercity transport mode. In the following paragraphs, simple equations are first derived conceptually to compute the boundary of competitive niches between private car and HSR and HSR and air. This will be followed by estimation of models using Origin-Destination data of Tokyo-Fukuoka corridor of Japan.

4.2.1 Computing competitive niche distance conceptually

Let us consider three intercity transport modes, Car (C), Railways (R) and Air (A).

E_i: Total access and egress time for mode *i*
M_i: Terminal time for mode *i* (if applicable)
V_i: Average speed of mode *i*
D: Distance between origin and destination

Now for a given origin-destination (OD) pair, door-to-door travel time (T_i) for mode *i* can be given as

$$T_C = E_C + M_C + \frac{D}{V_C} \quad (1)$$
$$T_R = E_R + M_R + \frac{D}{V_R} \quad (2)$$
$$T_A = E_A + M_A + \frac{D}{V_A} \quad (3)$$

Because of unique characteristics of different modes in terms of access, egress and terminal times, and average speeds, each mode has its own competitive niche of OD distance based on door-to-door travel time. Here, other factors that determine modal competitiveness such as travel cost, comfort or reliability have not been considered, since the purpose is to examine the competitive niche based on technical characteristics and travel time. The air transport normally involves longer access, egress and terminal time but with fastest cursing speed. This makes air mode most competitive for longer OD distance. At the opposite end stands the car transport with minimum access and egress and zero terminal time, which make car most competitive for short OD distance. Rail transport falls in between the car and air. Using above equations, we can find competitive niche of OD distance for each mode. For this, we can make reasonable assumptions that,

$$(E_R + M_R) > (E_C + M_C); V_R > V_C; \;\; (E_A + M_A) > (E_R + M_R); V_A > V_R$$

The OD distance at which the travel time for car and rail is equal can be considered as the boundary between the competitive distances niches of car and rail. Let's call it critical OD distance, D_{CR}, up to which car is competitive and beyond which rail is competitive. From Eq. (1) and Eq. (2),

$$E_C + M_C + \frac{D_{CR}}{V_C} = E_R + M_R + \frac{D_{CR}}{V_R} \quad (4)$$

By rearrangement,

$$D_{CR} = \{(E_R + M_R) - (E_C + M_C)\}\frac{V_C V_R}{V_R - V_C} \quad (5)$$

Similarly, critical OD distance that lies at the boundary of competitive niche of rail and air can be given as,

$$D_{RA} = \{(E_A + M_A) - (E_R + M_R)\}\frac{V_R V_A}{V_A - V_R} \quad (6)$$

Reasonable values for access, access and terminal time and average speed for each mode are assigned and critical OD distances that lie at the boundary of competitive niches of different travel modes are computed as shown in Table 1.

Table 4. Assumed parameter values and competitive OD distance for each modes

	Car	Rail	Air
Access/Egress time (Ei), min	15	60	120
Terminal time (Mi), min	0	10	70
Average speed (Vi), km/h	90	240	840
Competitive OD distance niche, km	<132	132-672	> 672

For the given value of parameters, car is dominant up to 132 km of OD distance, beyond which high speed rail starts dominating and continues up to 672 km. For over 672 km air transport dominates. The computed values for OD range for each mode look reasonable though they are sensitive to the value of parameters chosen. For example, if the speed or access/egress time of rail is changed, the distance range also changes. Since the parameters value and other variables relevant for mode choice decision various greatly by countries or travel corridors, the real world pattern can be much different. Nonetheless, Eq (5) and (6) may provide simple yet useful formula for policy makers for computing competitive OD distance of different modes for intercity travel.

4.2.2 Estimating models to determine competitive niche distance

As shown in Figure 1, the mode share by trip distance varies substantially across the countries. Railway commands much wider range of trip distance in Japan than in European countries (intercity railway share is negligible in USA). In developing countries, the high speed rail (HSR) investment is now an emerging policy agenda and the information on possible range of OD distance that an HSR system can command is much relevant. When making decision about a particular HSR route, the patterns shown in Figure 1 present just a rough picture and may not be of much help since the data are for national average which is aggregated over some distance intervals. For practical purpose more relevant information would be the distance niches in a particular travel corridor. For this purpose, from the Interregional Travel Survey of Japan (MLIT 2005) database, modal data only for OD pairs along Tokyo-Osaka-Fukuoka corridor (Tokaido-Sanyo HSR route) are extracted and utilized to calibrate models for mode share by OD distance.

Here, the share of each mode is modeled as a non-liner function of OD distance (D) as given below (a_i represent parameters). The model chosen for railway share is Weibull distribution curve, for air share is logistic curve and for car share is inverse logistic curve in order to obtain better fit considering the mode characteristics in terms of respective competitive niches for OD distance.

Model for rail share (RS)

$$RS = \frac{a_1}{a_2}\left(\frac{a_3 D}{a_2}\right)^{(a_1-1)} \frac{1}{e^{\left(\frac{a_3 D}{a_2}\right)^{a_1}}} \quad (7)$$

Model for air share (AS)

$$AS = \frac{1}{1 + a_4 e^{-a_5 D}} \quad (8)$$

Model for car share (CS)

$$CS = \frac{e^{a_6 - a_7 D}}{1 + e^{a_6 - a_7 D}} \quad (9)$$

Result of parameter estimation using non-liner lest square regression is shown in Table 2. All models have reasonably good fit and all parameters are also statistically significant 95 % confidence level).

Table 5. Result of parameter estimation by non-linear least square regression

Car share (no of obs 95)			Rail share (no of obs 95)			Air share (no of obs 95)		
Para.	value	t-stat	Para.	value	t-stat	Para.	value	t-stat
a_6	2.0351	9.7	a_1	0.0015	24.0	a_4	424.8	2.7
a_7	0.0105	12.3	a_2	2.2411	28.0	a_5	0.0062	15.1
			a_3	1.1351	39.2			
Adj R^2 = *0.81*			*Adj* R^2 = *0.73*			*Adj* R^2 = *0.87*		

Figure 4 plots share of different modes by OD distance over which estimated curves are overlaid. The fitted models yield the value of competitive distance ranges as car <270, 270<rail<960 and air>960. This range for HSR is significantly wider than the range indicated by national average aggregated over wider distance interval (Figure 1). Also the competitive distance niche for HSR against air is longer than the one shown in Table 1. It may be because that the Tokyo-Fukuoka corridor in Japan enjoys the highest passenger density in the world, and thereby frequent services. On the other hand, the competitive niche of car against HSR is longer than the conceptually derived in Table 1, which may be because of other service attributes of car such as flexibility and privacy.

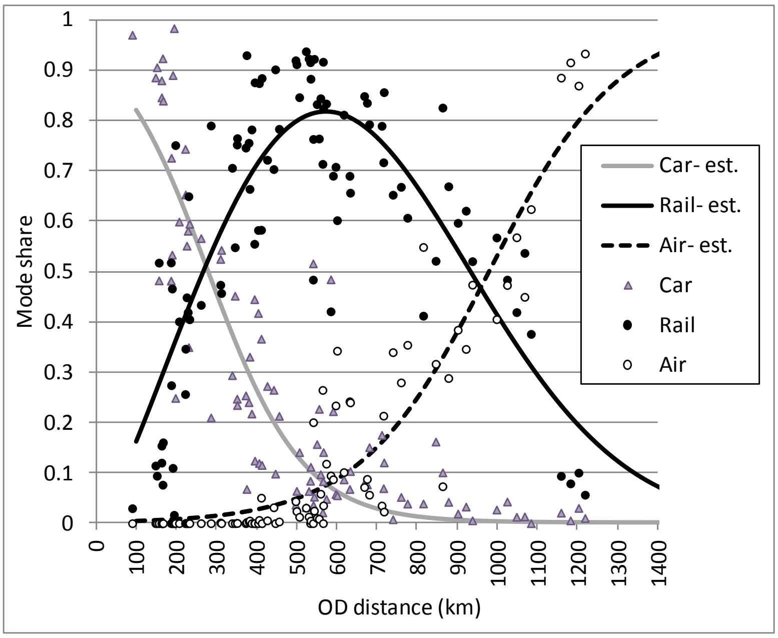

Figure 4 Competitive range of Origin-Destination (O-D) distance for different modes based on travel time (based on Tokyo-Fukuoka corridor OD data)

4. ISSUES AND PROSPECTS

4.1 Long-run prospect of conventional rail

Despite the imperative of HSR system in Asian developing countries, policy makers are now weighing the options of upgrading conventional rail with higher speed versus full-fledged HSR, mainly because of huge capital investment HSR investment requires. The conventional rails in developing Asian countries are now providing valuable services for both passenger and freight movement. There is good possibility that significant improvement in system capacity and the service level can be achieved though institutional reform and system modernization. The rail transport has received renewed emphasis mainly for its ability to serve large demand and lower carbon load. Most developing countries have already formulated plans to improve their conventional rail system. There is no doubt that any of such improvement would contribute to enhance the competitiveness of rail transport in the intercity passenger market. In this context, the key question is that how long such effect of enhanced competitiveness last? Some technological factors along with the dynamics of model competition may act as critical constraints for the long-run competitiveness of conventional rail system

4.1.1 Technical constraint for higher speed

The mode choice behavior of intercity travelers would be mainly driven by the travel speed offered by alternative modes. This is because of increase in value-of-time as income grows. In fact, policy makers in developing countries have already realized people’s preference for faster travel and therefore taken initiatives to reduce travel time by trains. The common measures for this include the introduction of express trains with fewer stoppages or upgrading rail infrastructure to increase maximum speed. The option of speeding up conventional rails to achieve maximum speed of 160 or even 200 km per hour has been quite appealing for policy makers in developing countries since this measure may reduce travel time significantly, and can even be considered closer to high speed rail at least in terms of maximum speed with much smaller cost. However, few cautionary notes are warranted here. Given the basic technical features of conventional rails namely route alignment, signaling and switches, maximum speed can be achieved only over a small section of route. Based on data from real operation, Figure 5 compares portion of rail routes for conventional rail and high speed rail (HSR) where train can be operated with max speed or face constraints. For HSR, train can run with max speed over almost 90 % of the route, while for conventional rail, max speed is possible only much smaller portion of the route. This indicates biding technical limitation for conventional rail to gain higher average speed for a given trip. And without improving speed significantly, railway cannot compete effectively against the car and air travels.

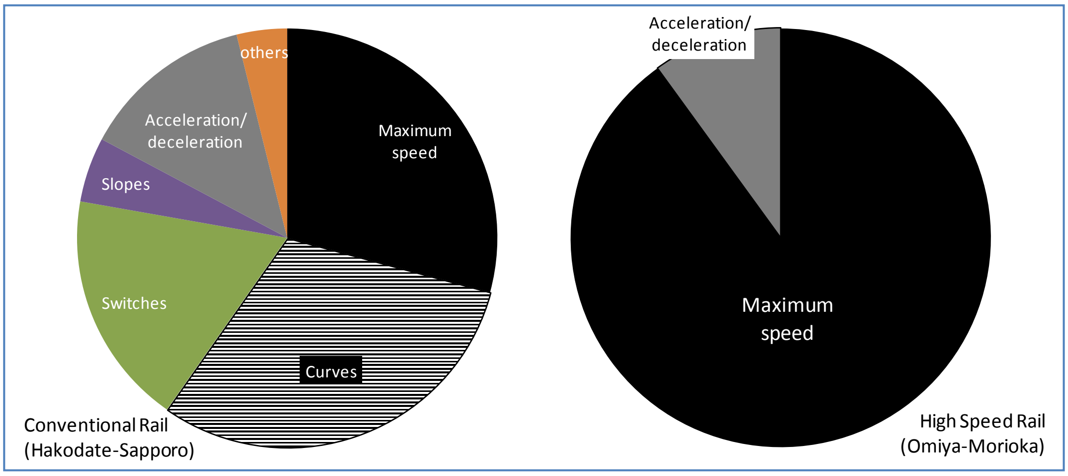

Figure 5. Proportion of railway section over which maximum design speed is possible (proportion and factors responsible for reduced speed)

Source: Morichi, Shigeru: High Speed Railway in Japan-The Shinkansen Experience (undated paper)

4.1.2 Unfavorable dynamic of operation cost

Conventional rail operation is relatively more labor intensive (over 50% in total operating cost) as compared with other competing modes, such as private car and air. For private car there is no labor cost and for air labor cost is about only 15-25 % of total operation cost. As economy grows, so does the wage and the cost side of conventional rail operation is hit much harder than its competitors. Further, the technological progress in automobile industry has brought the real price of cars down which can be clearly seen by comparing car price index against consumer price index (CPI). These trends imply that the dynamics of operation cost and resulting modal competition would be much unfavorable for the conventional rail. Garcia (2010) shows that, in the operating environment of a typical developed economy, the operating cost (per seat-km basis) of conventional rail is same or even higher than HSR.

Despite the likely unfavorable scenario for conventional rail in future, the system can yet command some range of competitive niche. Urban services and freight transport are technically suited for conventional rail. Conventional rail can also continue to serve as a viable alternative for many intercity and regional routes, which would be justified mainly on the basis of economic, social and environmental criteria. Higher income disparity and sizable section of low income users in developing countries would demand continuation of conventional rail service even in parallel with HSR routes (such as in Korea, Taiwan and China) as an affordable option.

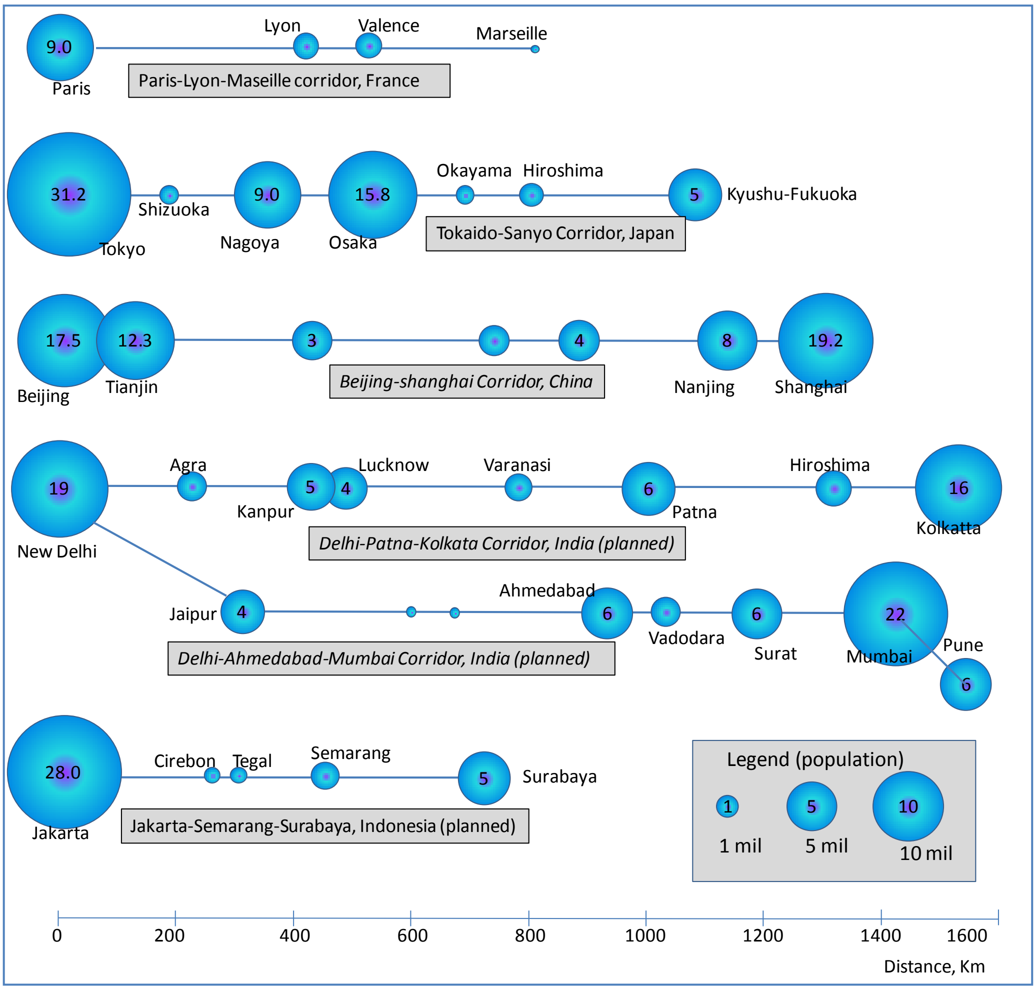

Figure 6: Population and location of major cities along the HSR corridors (existing and planned)
Source: Authors' sketch
Note: For metropolitan areas, metropolitan level population is taken; for others city population is taken; smaller cities and towns along the corridors are not shown

4.2 Adequacy of demand for HSR in developing Asia

The single most important criteria for judging the relevance of HSR is perhaps the demand size. If passenger demand for the HSR is low, all perceived benefits of HSR cannot be realized, and at worst, the system could be a financial disaster. There is a great deal of skepticism on the desirability of some HSR projects currently under consideration, such as in US, UK and Spain (Albalate and Bel 2012, De Rus 2011, De Rus and Inglada 1997, Julian 2010, Mendoza 2009). In fact, European HSR systems were introduced mainly for service improvement (to enhance railway competitiveness), promoting regional cohesion and environmental sustainability. Even after significant modal shift from air and car in favor of HSR, European systems are running under capacity.

On the other hand, Japan introduced HSR to address the problem of severe capacity constraint in the conventional rail and at the same time to have quantum jump in service improvement. The Tokaio-Sanyo corridor now command annual passenger of 140 million making Paris-Lyon as a distant second with annual passenger volume of just 14 millions. Figure 6 shows location and population of cities along some selected HSR routes (existing and planned). If we examine the specific characteristics of some planned HSR, such as in India and Indonesia, the planned corridors stand out and resemble very closely the pattern of Tokaido-Sanyo corridor in Japan or Beijing-Shanghai corridor in China, which has recently been opened for service and is performing well in terms of passenger demand. Higher population density and growth of megacities, which are among key defining features of developing Asia, would indeed guarantee much higher passenger demand for HSR. If the dynamic impacts of HSR for spatial development including formation of intermediate cities are also factored, an unprecedented level of passenger demand can be expected. Therefore, the risk of inadequate passenger demand for HSR in future is much lower for developing Asia.

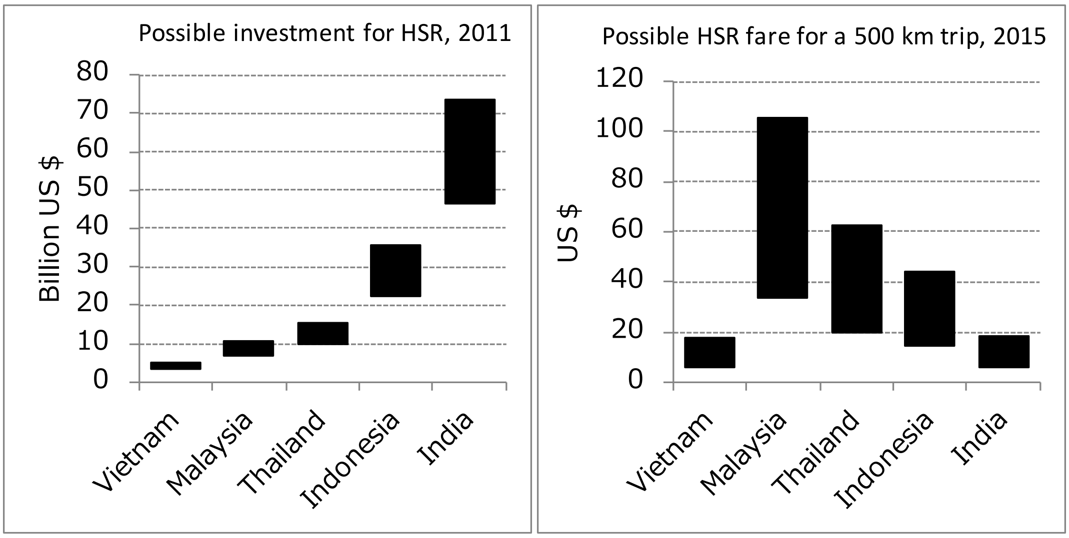

Figure 7: Possible investment for the first high-speed rail project in developing countries

Note: Investment range is based on 4.6 % GDP (case of Taiwan) and 2.9 % of GDP (case of Japan). Fare range is based on 1 % GDP per capita (case of Japan) and 0.32 % of GDP (case of Korea). Data source for GDP and GDP per capita, IMF (2012)

4.3 Timing of investment

Despite the indispensible role of HSR as the core element of intercity passenger transports system in Asian countries, the question that when developing countries should make HSR investment cannot be easily answered. The timing of HSR investment should be analyzed mainly from two angles. First, the ability of the economy to mobilize significantly high investment should be carefully assessed. Next issue is if the level of economic development is high enough to charge fare level that is affordable and can also generate adequate revenue for profitable operation. As a possible reference, the cases of Japan, Korea and Taiwan are taken.

The project cost for Tokyo-Osaka HSR in Japan was 2.9 % of GDP, while that for Taipei-Zuoying in Taiwan was 4.6 % of GDP. Likewise, the HSR fare for a representative journey of 500 km came as 1 % GDP per capita while both Korea and Taiwan kept lower fare which is 0.32 % and 0.38 % of GDP per capita. Utilizing these figures as benchmarks, Figure 7 shows ranges for possible HSR investment (for 2011) and fare level (for 2015). The per km construction cost of HSR depends upon local condition and varies. Taking a reasonable figure of 30 million per km, for a 500 km route, the investment need is 15 billion dollars. By this measure, for 2011, Vietnam cannot mobilize enough investment resource while it is possible for Thailand, Indonesia and India. On the other hand, India and Indonesia may face a problem of charging financially sustainable fare since income is still lower. Countries with smaller investment resources and low affordability may go for a shorter section along the planned corridor and operate the service with public subsidy in the early years, since the experience of such project can immensely contribute to capacity building. On the other hand, country like Malaysia, where affordability is not a problem but investment might be too high as percentage of GDP, can go for public-private-partnership (PPP) to mobilize additional financing.

4.4 Route alignment, location of stations and access/egress time

HSR command a distinct niche of intercity passenger transport manly defined by origin-destination (OD) distance. The advantage of HSR against air mode is mainly due to shorter access, egress and terminal time. Despite this fact, while planning for route alignment, there is a real risk of ignoring the importance of minimizing access and egress time because of some other priority such as achieving higher speed with straight route alignment, which often require locating stations away from the city center because of technical constraint imposed by higher value of minimum radius of curvature. Japan's Tokaido Shinkansen with max speed of 270 km per hour has minimum radius of curvature just 2,500 m,, which offer good flexibility for route alignment. Korea's HSR (KTX) and China's HSR adopted max speed of 350 km with minimum radius of curvature as 7,000 km that requires almost straight line alignment and can have adverse impact on access/egress time. It is quite appealing for policy makers to go for higher speed since the travel time is directly dependent on the speed and it also serves as a symbol of superior technology.

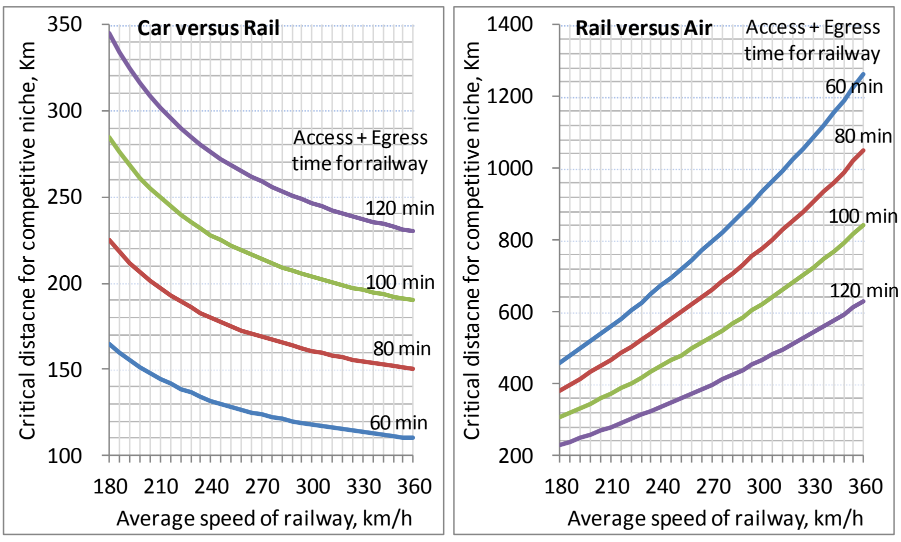

Figure 8: Impact of railway speed and access/egress time on the competitive niche distance for different modes

In order to see how the boundaries of competitive niche for different intercity transport modes change with respect to the speed and access/egress time of HSR, Figure 8 plots the simulation results using equation (5) and (6). Value of other parameters is same as given in table 4. There are few distinct patterns offering important insights. First, as HSR speed increases, HSR make more gain against the air than against the car as reflected by the steeper slope of rail versus air. But minimizing access/egress time contributes expanding HSR market niche at both ends. For example, let us consider a base case of HSR speed of 240 km per hour and access/agrees time of 80 minutes, for which HSR commands the market over 180 -560 km OD distance. If speed is increased to 300 km per hour, the distance range changes to 161-778 km. On the other hand, if access/egress time of HSR is reduced to 60 min, the competitive distance range for HSR would be 132-672 km. In the later case, though the gain against air is smaller, the gain against car is bigger, which may be more important since the absolute travel volume toward the lower end of OD distance is much higher and improve competitiveness against car may deliver multiple benefits with respect to road congestion and safety and emissions.

Other important insights that can be drawn from the Figure 8 is that if adoption of higher speed for HSR causes longer access/egress distance, the perceived benefits in terms of expanding competitive niche of HSR might be completely wiped out. For example, from the base case if HSR speed is adopted to 300 km per hour but access/egress time is increased just by 20 minutes to 100 min, then resulting competitive OD range for HSR would be 204-622 km. Here we can see there is marginal gain against the air (from 560 km to 622 km) but significant loss of market against car (161 km versus 204 km). The key message from the simulated result is that while adopting high speed for HSR, it is important to maintain minimum access/egress time for HSR. For this, it is important to locate HSR station at the city center and also provision of efficient public transport system for easy access to the city center.

4.5 Station location and urban development

As mentioned above, HSR station should be located at the center of existing cities with sizable population. For other stations there would be alternative option for locating stations, such as existing station of conventional rail line, new station on the conventional rail line or HSR station at the green-field site (new site). Former two cases are helpful to provide access to HSR station while the latter case provides flexibility in planning new urban areas. In all cases, HSR station contributes to the development of local city. However, it depends on multiple factors, such population of surrounding area, network of urban rails, coordination with land-use plan and stage of development (Nakamura and Ueda 1989). For example, in Japan Shin-Yokohama station at a green field location brought about visible impact on city development while Gifu, another new station could not brings expected impacts.

4.6 Coordination between conventional and High-speed railways

Network and instructional level coordination between HSR and conventional rail system is another important issue. For seamless operation, it is desirable to run HSR vehicles over the conventional track. In case, gauge for HSR and conventional rail is different (such as in Japan), so-called mini-Shinkansen line can be introduced with standard track gauge (same as HSR by laying a third rail) but smaller loading gauge (vehicle size) so as to fit in the conventional rail infrastructure such as tunnel. For operation, both HSR and conventional rail can be operated under the same entity, such as in Japan and Korea or under separate entity such as in Taiwan. Whatever the institutional setting, it is important to redefine the role of conventional rail, such as dedicating to local and regional services with involvement of local authority.

4.7 Capacity building for HSR

HSR system involves technology and operational management entirely different from that of conventional rail system. Therefore, developing countries should start capacity building efforts in much earlier. For this, some HSR line in a shorter route can provide useful learning experience.

5. POLICY RECOMMENDATIONS

- With the proven technology and distinct competitive niche for intercity market, the question on the necessity of HSR in developing countries is only about ‘when” rather than “if”. The timing of introduction should however be considered taking multiple factors into account, such as ability of the economy to mobilize huge capital investment necessary for HSR, fare level to ensure commercial operation (if not recovery of capital investment) and affordability of users, and possible impacts on regional development.

- The competitive OD distance for HSR should be understood in a dynamic context. Over time, because of technological advantage (in terms of costs and speed) and user’s behavior, car and air modes gain at the expense of railways including HSR.

- Unlike in some European countries, where HSR is for both passenger and freight mainly to make full use of capacity, Asian developing countries should opt the system only for passenger transport since passenger demand is large enough (in the long-run) to utilize the capacity. Though having both freight and passenger traffic may appear tempting when demand is low, it creates serious safety and noise problems.

- Minimizing access and egress distance is most important to make HSR more competitive than car and air modes. Higher speed of HSR to be achieved mainly by straight alignment, which might require to locate stations away from city centers, may not reduce OD travel time (or may even risk to increase) because of increased access and egress time.

- HSR is often discussed in the context of competition with air. But large volume of intercity trips is within the range for which HSR has to compete with car. Policy makers therefore should also consider this aspect by making HSR service competitive for relatively short-distance trips. Minimizing aggresses and egress distance plays key role here again. Also HSR service with frequent stoppage (such as Kodama in Tokaido route in Japan) may help for the purpose.

- After introduction of HSR, parallel service by conventional railway should be stopped or discouraged unless or otherwise necessary to serve excessive demand. The fare sensitive users’ group can be served with market segmentation through fare discrimination.

- In order to have seamless operation between HSR and conventional rail tracks (with smaller gauge), different types of HSR options should be considered, such as full HSR, mini-HSR (small vehicles running on meter gauges) and combination of full and mini-HSR.

- HSR technology should not be understood as a simple extension of conventional rail technology. The track and signal infrastructure, vehicles, control system and other features of HSR are entirely different, which demands significant level of capacity building to manage and operate the system. For this, a shorter HSR route at an early stage may offer important capacity building experience for developing countries.

- The nature of HSR entity should be decided based on commercial viability and operational efficiency. An independent entity under PPP scheme (with public sector domination) may be an option but coordination with conventional railway operator should be carefully worked out to avoid possible conflict.

6. CONCLUSION

Higher economic growth and rapid urbanization in developing Asia is likely to result in an unprecedented level of travel demand. This paper focuses on the intercity transport issues and explores the role of High Speed Rail (HSR) system to meet the emerging demand. The characteristics of HSR, when compared with other competing modes, fit well into the context of Asian developing countries. The paper also computes both conceptually and empirically the competitive market niche of HSR in term of origin-destination (OD) distance. Issues and prospects for introducing HSR in developing Asia is discussed outlining key elements of ongoing policy debates. In the process, focus is mentioned to draw policy insights from international experience. Finally policy recommendations are made to address the critical issues. The core argument advanced in the paper is that the HSR is technical necessity for developing countries rather than political choice for sustainability objective (as was the case in European countries), which would anyway accrue as a co-benefit.

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