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**Working Paper**

# The economics of investment in high speed rail: Summary and conclusions

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International Transport Forum

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## Summary and Conclusions

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**December 2013**

OECD

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## Table of contents

## Executive summary

From its origin with the Tokaido Shinkansen in 1964, High Speed Rail (HSR), defined here as new rail lines capable of operating speeds of 250 kilometres per hour or more, has grown relatively slowly over the last 50 years, with the World HSR network as of late 2013 standing at under 22 000 km. However, the network has been growing rapidly in recent years. With the first opening as recently as 2007, China has already an HSR network of almost 10,000 km. with a further 9 000 km under construction (out of a worldwide total of 14,000 km of line under construction).

Given the backdrop of an HSR investment boom, a roundtable was held in New Delhi in November 2013 with aim of achieving a better understanding of the economics of HSR given the evidence that is emerging from both well established (e.g. France and Japan) and from new HSR (e.g. China) schemes.

At the outset it needs to be recognised that there is a range of HSR systems. It is important to distinguish between largely freestanding systems (such as the Shinkansen in Japan) and systems integrated with conventional rail networks. Integrated options may come in a number of forms, for example, HSR passenger services using classic rail tracks (such as the TGV in France), classic rail passenger services using HSR tracks (such as the AVE in Spain) or a complete mixing of classic and HSR services, including freight on HSR tracks (such as the ICE network in Germany). HSR may penetrate (or at least run close to) city centres using conventional tracks (as in France) or new tracks (as in Japan) or may instead predominantly serve edge of city locations (such as the mainly freestanding systems in China, Chinese Taipei and Korea).

The earliest HSR schemes, in Japan and France, principally tackled the inter-related issues of capacity (as separating fast trains from slow trains can enhance the capacity of rail infrastructure) and speed (with the requirement for rail to compete with air for the day return market on journeys of around 500 km), although promoting national champions in the rail supply industry was also an important factor. More recently factors such as journey time reliability (UK), economic development (China, Chinese Taipei), political integration/centralisation (Spain) and the environment (UK) have emerged as being important. The chosen HSR objectives will affect service design. Where the focus is on speed then the emphasis will be on non-stop services between major business centres around 500 km apart, although in exceptional circumstances there could be scope for night services at much greater distances. Where the emphasis is on other factors, there may be scope for more intermediate stops and for the development of long distance commuting markets.

In both the ex-ante appraisal and ex-post evaluation of HSR, cost-benefit analysis is the dominant methodological tool. Impact tables need to be carefully compiled to identify the relevant incidence groups (which is complicated where the rail industry is both vertically and horizontally separated) and the extent of fiscal and other transfers (particularly relating to changes in revenue, costs, land values and indirect taxation). If distributional issues are important (which they usually are for HSR given concerns that these are 'elitist' investments that might be something of 'a rich man's toy') then the results should be presented in terms of market prices rather than resource costs, and the impacts on users segmented by income (or some proxy such as journey purpose).

Evidence from the UK on proposed HSR services, where analysis is based on market prices, suggests revenue may form 30% of gross benefits and rail user time savings (including from improved reliability) may be around 50% of gross benefits. Other important sources of benefit (around 10% each) can be related to reductions in rail overcrowding and wider economic benefits. Benefits from reduced road congestion and environmental betterment are relatively minor. These results are not inconsistent with the resource cost based analysis of HSR investments in Spain. Business travellers appear to be the main beneficiaries of HSR. As a result, key issues include the use of travel time by business users, their income levels and values of travel time savings, and the extent to which business travel will grow over time.

Sources of HSR traffic vary from scheme to scheme and according to the definition of what constitutes generated travel, but evidence from five existing HSR schemes in Europe suggests around 30% of HSR demand is abstracted from air, 30% from classic rail, 15% from road (predominantly car) and 25% is generated. In developing economies, where domestic air markets are not yet mature, abstraction from air will be lower and generation will be higher. For road, abstraction from car may be lower in developing economies but abstraction from bus and coach may be higher.

A feature of HSR is the high capital costs that are required to achieve the grade separation, curvature and gradient needed for high speeds. The costs will be higher where there are high population densities, high land values and unfavourable topography. Given the variety of locations and the types of systems, it is not surprising that these costs may vary from below EUR 10 million per route km (in China) to over EUR 100 million per km (in the UK, for the HS1 approaches to London). It is these high fixed costs that lead to expectation of economies of density – that average operating costs will reduce as usage of the HSR lines increases. Design operating speeds seem to be a key driver of capital costs. In China, increasing speeds from 250 to 350 kph appeared to lead to a near doubling of capital costs per route km.

As with capital costs, there is a high degree of variability in demand for HSR schemes, ranging from below 4 million passengers per annum (Madrid – Seville) to over 200 million passenger per annum (for the Tokaido and Sanyo Shinkansen). Much of this variation relates to urban spatial structure and the spatial distribution of population, but may also relate to fare levels (in relation to both income and to classic rail) and structure (with revenue yield approaches permitting higher load factors than a standardised fare scale), the location of HSR stations and to socio-cultural barriers to travel across national and sometimes regional borders. Most of these factors can be captured by gravity model formulations, whilst abstraction from (for example) air can explained by logistic curves (see Figure 1 in the main text for an example of a logistic curve) based on time (or preferably generalised cost) differences. A feature of many HSR markets is the long term growth in demand, with significant compound annual growth rates (in excess of 2% (Japan) and 8% (Korea)) found over protracted periods (27 years for Japan, 7 years for Korea), although some of this growth will be due to external factors, such as rising incomes and changes in economic structures.

Most HSR services have faced intermodal competition, with competition from low cost, no frills operators in the air, road and sea markets being an emerging feature. Intramodal competition has been less commonplace, either between classic rail and HSR or between alternative HSR services. An exception is Italy where head-on competition between Trenitalia and NTV appears to have led to a 30% reduction in fares, a 45% increase in service and a 30% increase in demand but it is not clear if this competition will be sustainable. High track access charges, which typically account for 25% to 45% of the revenue of HSR operators, can limit the amount of competition that can be sustained within the HSR market.

Two extreme positions on the use of economic analysis to assess HSR schemes may be observed, 'paralysis by analysis', typified recently by the UK and the US where despite a plethora of studies the amount of HSR service in operation is extremely limited, and 'build it and see' typified recently by China and Spain, where there have been large increases in the HSR network, with further extensions under construction. Related to this, a 'step by step' approach to developing an HSR network will permit the staged involvement of private sector funding, whereas a 'big bang' approach will entail a greater reliance on public debt.

A four stage test for HSR investments is suggested. First, does the HSR make a commercial return? If so, arguments concerning HSR being an elitist investment are redundant. Returns can be reinvested in other social projects or the project can be financed and operated by the private sector. However, there seem to be very few HSR schemes that have made a financial return that would pass a commercial benchmark, with the Tokaido Shinkansen (Tokyo-Osaka) and the TGV Sud-Est (Paris –Lyon) being possible exceptions. Of four recent openings in China studied, only one (Jinan – Qingdao) is covering financial costs. These commercial schemes have relatively high levels of first year usage (in excess of 20 million passengers per annum).

Second, does the HSR investment make a social return, based on rail transport benefits only? This is the basis of the social break-even approach developed by Gines de Rus, Chris Nash and colleagues, which postulates 9 million passengers per annum in the first year of operation as a typical break-even threshold. It appears that many, but by no means all, current HSR schemes may achieve this pass-mark. However, this approach is based on an assumption of a pass-mark BCR of 1. With constrained budgets, opportunity costs might mean that a BCR higher than 1 is required, with the UK focussing on 2 as a key threshold until recently, whilst Germany uses 3. This is a tougher test and as a result will require either higher demand levels or non-rail transport benefits.

This leads to a third test, does the HSR make a social return including quantified impacts on other transport systems (air and road) and wider economic benefits? These benefits have been important in establishing the case for HS2 in the UK. However, estimating these benefits requires modelling of the entire transport system (rather than just rail) and there remain great uncertainties as to the magnitude of wider economic benefits (particularly as a result of improved business-to-business connectivity) and the extent to which such benefits are additive.

Lastly, does HSR have social returns when qualitative wider benefits are taken into account? For example, the ex-post evaluations of Madrid – Seville and Madrid – Barcelona (both of which had initial usage levels of 5 million passengers per annum or less) have shown there to be negative social returns which are unlikely to be offset by wider economic benefits. Such, as yet, non-quantified benefits may include the role of HSR in nation building and as a spur to the development of indigenous technology and the modernisation of the economy.

A key metric is the level of passenger demand, with gravity model formulations providing a useful basis for high level strategic forecasts in advance of subsequent detailed modelling estimations. The application of these tests should be consistent and as rigorous for the last HSR investment in a particular nation-state as for the first. This suggests that HSR investments should be considered incrementally at a network level. The best lines should be identified and then the network evolution planned. It seems likely that line extensions can exhibit economies of scale/density, e.g. the extension of the TGV south of Lyon or of HS2 north of Birmingham. However, the development of brand new lines may rapidly exhibit diseconomies of scope. This in turn suggests a step-by-step approach to HSR investment may be more appropriate than a big bang.

# 1. Introduction

This paper summarises a roundtable held in New Delhi, India, on the 18th and 19th December, 2013. This round table was convened to examine the key factors that drive the costs of High Speed Rail (HSR) investment and review the economic benefits delivered by HSR services. This summary draws on a series of presentations made to the roundtable including an international review (Nash, 2013a) and national reviews from France (Crozet, 2013a), Japan (Kurosaki, 2013a), China (Wu, 2013a), Italy (Croccolo, 2013), the UK (Nash, 2013b) and Chinese Taipei (Chang, 2013). In addition, a series of presentations surveyed the prospects for HSR in India, including contributions from Singh, Pillai, Goel, Raghuram and Pal (all 2013), whilst a presentation on Korea (Lee, 2012) and earlier work on HSR (Asian Institute of Transport Development, 2007) were tabled. This report is also informed by introductory remarks made by Montek Singh Ahluwalia of the Planning Commission of the Government of India, Mallikarjun Khan of the Indian Railways, and K.L. Thapar of the Asian Institute of Transport Development.

In the rest of this introductory section we will outline what is meant by HSR for the purposes of this roundtable and set out a very brief history. We will then in section 2 outline some of the key objectives of the roundtable. In section 3 we will consider the related issue of the key objectives for HSR investments. The kernel of this paper will focus on the cost and benefits of HSR (section 4), including consideration of demand impacts (section 4.1), costs (4.2), benefits (4.3) and pricing and competition (4.4). The conditions for financial and social break-even will be considered in section 5 and funding issues examined in section 6. The Indian context will be considered in section 7, before some conclusions are drawn in section 8.

HSR services as we now know them originate with the Tokaido Shinkansen opened in 1964, followed by the Direttissima in Italy in 1977 and the TGV Sud-Est in France in 1981 (Nash, 2013a). Germany joined the HSR world in 1988 with the opening of the line between Fulda and Wurzberg, whilst Spain joined in 1992 with commencement of AVE services between Madrid and Seville. In Asia after Japan, HSR service commenced in Korea in 2004 and in Chinese Taipei and China in 2007. By November 2013, the UIC estimated that the World HSR network was 21 472 km, of which almost 7 400 km was in Europe and over 13 700 km was in Asia. China's rapid development has given it the largest national network at 9 867 km; followed by Japan (2 664 km), Spain (2 515 km),) and France (2 036 km)[1]. A further 13 964 km are under construction, led by China (9 081 km), Spain (1 308 km), Japan (779 km) and France (757 km), with Saudi Arabia (550 km) expected to join the HSR 'club' in 2015.

1. Source: http://www.uic.org/IMG/pdf/20131101_high_speed_lines_in_the_world.pdf

Although there is no single definition of HSR services, the most commonly cited is that used by the European Commission in Directive 96/48 (CEC, 1996). This defines HSR services as being provided on dedicated, new lines with the infrastructure capable of operating speeds of 250 kilometres per hour (kph) or more – often up to 350 kph. In addition, services capable of 200 kph or more on upgraded existing lines are classified as HSR. The roundtable focused on case studies of dedicated lines, whilst recognising the intermediate option of upgrading existing lines may be particularly pertinent in some countries.

Even where dedicated infrastructure is provided, it is important to distinguish between largely freestanding systems (such as the Shinkansen in Japan) and systems integrated with conventional rail networks. Integrated options may come in a number of forms, for example, HSR passenger services using classic rail tracks (such as the TGV in France), classic rail passenger services using HSR tracks (such as the AVE in Spain) or a complete mixing of classic and HSR services, including freight on HSR tracks (such as the ICE network in Germany) (see also Campos et al., 2009). The roundtable noted that the primary focus of HSR was to serve long distance business and leisure travel markets, with distances between major origin and destination pairs of at least 200 km and often much more (with 500 km being suggested as a typical distance)[2]. However, it was noted that where there was spare capacity, then regional commuting services (typically serving markets less than 200 km apart) may be important. For example, this is a feature of HS1 in the UK, where Kent commuter services are able to use the capacity not required by international services.

Another important distinction with respect to HSR services is the extent to which stations are located near city centres versus edge of city location. The dilemma of where to site stations goes back to the first HSR line, the Tokaido Shinkansen, opened in 1964 with Shin Osaka station some 3 km from the more central Osaka station. Off centre stations may assist in the expansion of the Central Business District and establishment of new business districts – a feature of both Lyon Part-Dieu and Euralille in France. Most HSR lines have attempted to gain access to the central areas of the major cities served, but with out of town stations serving smaller intermediate locations. Examples in France include Aix, Avignon, Belfort-Montbéliard, Besançon, Le Creusot, Macon-Loché and Valence. This reduces the cost of providing service to towns of 100 000 population or less. In France, such towns typically have a service of only three trains per day, increasing to five where there is a population of 200 000 and to ten or more for larger settlements (Crozet, 2013b). However, there are also systems that focus on edge of city locations – a feature of the systems in China, Chinese Taipei and Korea.

Another important issue identified by the roundtable, that should be dealt with up-front, relates to the approaches to planning HSR investments, with a contrast at the extremes between those systems where there was relatively little ex-ante analysis (characterised as a 'build it and see' approach, and believed to be typical of China and Spain) and those systems that have not yet been built which might be

2. Dunmore and Smith (in Asian Institute of Transport and Development, 2007) note that the average stopping distance on HSR systems is between 100 and 30 km.

characterised as having had too much analysis (‘paralysis by analysis’), perhaps the case of both the UK and the US (see Preston, 2012, and Perl, 2012). In part, this may reflect differences between the planning regimes in countries with common law codes, such as the UK, the US and India, and civil law codes, such as continental Europe. What constitutes the optimal amount of analysis, both ex-ante and ex-post, is of more than academic interest. With respect to ex-ante analysis, it might be expected that, at least up to a point, greater expenditure on analytical studies will lead to more accurate forecasts and hence lead to more robust decisions as to whether and when to invest in HSR and to help determine the optimal combinations of infrastructure, services and prices. However, there will come a point where more sophisticated approaches may involve more measurement error, which reduces the benefits from reduced specification error (Alonso, 1968). The roundtable seemed to concur that there may be a happy medium between the two approaches to ex-ante analysis highlighted above, but also noted that the ex-post evaluation of HSR is particularly limited, with the exception of France, and that such evaluation may be particularly important in improving the planning cycle.

## 2. Objectives

Given the above, the primary aim of the roundtable was to achieve a better understanding of the economics of HSR.  This in turn leads to a number of secondary objectives. First, to determine what HSR is for. What is it good at? What is it irrelevant for?  These issues will be considered in section 3.

Secondly, there are a series of objectives related to determining the costs and benefits of HSR, considered in section 4, and the financial and social break-even points, considered in section 5. Have some lines been profitable – showing a commercial return on investment? If so, under what conditions is this possible/likely? Where not possible, which non-commercial lines show a social return? What conditions need to be fulfilled? Which lines have proved a net loss in terms of socio-economic welfare, and are there as yet unquantified benefits that might offset these losses? Does competition (such as the current head-on competition between HSR services in Italy) change the outlook for costs and benefits?

Thirdly, as well as issues concerning economic efficiency, there are important issues concerning equity – the distributional effects of HSR investments. HSR has sometimes been criticised as ‘a rich man’s toy’ – but who benefits from public support for HSR?

Lastly, the wider context needs to be considered by examining the rationale for spending public money on HSR instead of other transport investments, including investments in conventional rail, roads and airports. There is also the issue of very large transport investments such as HSR competing against investments in, for example, education, health care and housing. This was perceived to be particularly important in a developing country context.

## 3. The role of high speed rail

HSR has multiple objectives (see Table 1), although the dominant rationale has been the perceived twin benefits of speed and capacity, which are inter-related attributes. Capacity and speed (to assist in competition with air) were the main drivers behind the development of the original HSR, the Tokaido Shinkansen. With average operating speeds (as opposed to top operating speeds) of around 250 kph, HSR can bring settlements 500 km apart within two hours of each other and hence within scope for return travel within a day. Moreover, it means that rail can compete with air for city centre to city centre travel over such distances and beyond e.g. Paris – Marseille (over 750 km) – indicative of a three hours journey time threshold. However, this rationale has been criticised. Crozet (2013b) highlights the concept of effective speed, associated with, amongst others, Illich (1974). This modifies speed to take into account the cost of speed in terms of the fare per km divided by the average hourly wage rate.[3] This indicates that ultra-fast but also ultra-expensive transport, such as Concorde, has a very low effective speed and as a result experienced commercial difficulties. It is conceivable that HSR could exhibit similar features where fares are based on full cost recovery and where hourly wage rates are low. The other main criticism of speed is that, given a constant travel time budget (which is itself contentious,) the resultant time savings will be dissipated in terms of longer journeys rather than more economic activity (Metz, 2008). A counter-argument is that higher speeds and longer journeys will permit better matches (of workers with jobs, of businesses with customers) that will increase both the quantity and quality of activities and raises productivity.

As noted, capacity was one of the main motivations for the Tokaido Shinkansen, as the existing narrow gauge railway between Tokyo and Osaka was heavily congested. The new standard gauge line would permit larger rolling stock but more crucially would permit the separation of fast and slow trains as service homogeneity is a key factor in determining line capacity (UIC, 2004). Moreover, separation of service types by the provision of dedicated rights of way for fast services can improve service performance in terms of reliability and has been an important motivation in developments in Italy and the UK (particularly for HS1, which replaced high speed trains initially operating on conventional lines) (Nash, 2013b). In China,

3. Suppose the speed (s) of Concorde is 2 000 kph. Suppose the fare is EUR 12 000 for 12 000 km, so that the fare per km (f) is EUR 1 but the average wage rate (w) is EUR 6 per hour. Effective speed is given by $[s^{1} + (f/w)]^{-1}$. In this (extreme) case this is equivalent to around 6 kph, only a little greater than walking speed.

it is intended that the capacity freed-up on the classic rail system would be taken up by freight.

There are also non-transport reasons for the development of HSR. Technological development policy may aim to promote the rail supply industry (and the potential for exports). This was a feature of the early developments in Japan and France and led to the emergence of national champions such as Hitachi and Alstom respectively. National prestige is also an important motivation, for example in China where HSR development was an integral part of recent Five Year Plans, whilst political integration/centralisation has arguably been the main motivation for the HSR network in Spain (Albalate and Bel, 2012, Bel, 2012).

Table 1. **Objectives of HSR Schemes**

| | **France** | **Japan** | **China** | **Italy** | **UK** | **Chinese Taipei** | **Spain** |
|---|---|---|---|---|---|---|---|
| Speed | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Capacity | ✓ | ✓ | ✓ | ✓ | ✓(HS2) | ✓ | |
| Reliability | | | | ✓ | ✓(HS1) | | |
| Econ. Development | | | ✓ | | ✓ | ✓ | |
| Environment | | | | | ✓(HS2) | | |
| Supply Industry | ✓ | ✓ | ✓ | | | | ✓ |
| Prestige | ✓ | | ✓ | ✓ | | | ✓ |
| Political Integration | | | ✓ | | | | ✓ |

Economic development is also an important objective of HSR. The key intention of HSR in Chinese Taipei was to unlock development lands at the edge of existing urban areas (Chan, 2013). China's investment in HSR can be seen as a form of Keynesian pump priming at a time when growth rates in other sectors of the economy were declining (Wu, 2013a). In the UK, the arguments for HS2 (described as an 'engine for growth') moved away from transport issues towards wider economic benefits, both in terms of connectivity to labour markets (and hence promoting agglomeration economies) and connectivity between businesses and consumers (thus reducing imperfections in competition transport using sectors of the economy, as well as promoting agglomerations through better business linkages). The argument is now shifting back to capacity and the potential to liberate tracks for the expansion of overcrowded commuting services to the country's major cities.

Environmental betterment is also seen as an objective of HSR. For example, in the UK the key objectives of transport policy are currently creating (economic) growth and cutting $CO_2$ emissions. However, faster rail services necessarily entail greater energy consumption, and where electricity generation is carbon intensive this also means greater carbon emissions than for conventional rail, although this can be offset by increased load factors and improved train design. Moreover, the construction of HSR lines can be carbon intensive. For example, Booz Allen and Hamilton (2007) estimated that taking into account construction adds around 35% to the $CO_2$ emissions that result from operation in a UK context. Kageson (2009) concludes that though investment in high speed rail is under most circumstances likely to reduce greenhouse gases from traffic compared to a situation when the line was not built, the reduction is small and it may take decades for it to compensate for the emissions caused by construction. Where HSR attracts large volumes of patronage from air and car, then it is feasible that it will lead to net environmental betterment, at least with respect to $CO_2$ emissions. Where such abstraction is limited, the converse is likely to be true.

The perceived combination of transport and non-transport advantages of HSR may lead to the setting of targets for HSR development. For example, the European Union Transport White Paper of 2011 (European Commission, 2011) set targets of completing the European HSR network by 2050 and tripling the length of the existing high-speed rail network by 2030[4]. In addition, by 2050 the majority of medium-distance passenger transport in Europe should go by rail (where medium distance refers to inter urban trips of less than 1 000 km) according to the Commission. However, the objective basis for these targets is not clear.

## 4. The costs and benefits of high speed rail

Table 2 outlines a (simplified) schema for the analysis of the costs and benefits of HSR investments. The original HSR schemes in Japan and France were developed under the auspices of vertically integrated and publicly owned national rail operators, but with separate accounts from other Government activities.  In this simple schema, we assume a single rail operator and a single Governmental body but recognise that reality will be more complex. Where the rail markets is both vertically and horizontally separated (as in the UK), a more atomistic (and hence complex) schema is required. It is interesting to note that in Japan, vertical separation in the form of the Shinkansen Holding Corporation (SHC) was relatively short lived (1987-91), with the pre-1987 lines re-instated to the rail operators, although new Shinkansen lines that are not expected to show a commercial return have been developed in a vertically separated manner. In Europe, since Directive 91/440, vertical separation (at least in terms of organisation, if not always in terms of ownership) has become the norm. In some jurisdictions, it may be necessary to distinguish between central and local Government. For example, in Japan since 1996 central and local Government must bear the financial burden of the new, non-commercial projects designed to promote regional development by a ratio of 2:1 (Kurosaki, 2013b). As HSR networks expand, it is likely that regional governments will play a greater role in the development of HSR – a phenomenon that is evident in France.

4. As of November 2013, UIC report 2,565 km of HSR line under construction in Europe, with 8 321 km planned. If delivered this would achieve a network of 18 264 km – an increase of 148%.

Table 2. **The Cost and Benefits of High Speed Rail**

| **Incidence Group** | **Costs** | **Benefits** |
|---|---|---|
| Rail Operator | Construction Costs<br>Operating Costs | Increased Operating Revenue<br>Increased Other Revenue<br>(Grants & Subsidies) |
| HSR Users | Higher (net) fares | Faster services<br>More reliable services<br>More comfortable services<br>(Indirect tax reductions) |
| Other Transport Users | | Congestion relief on competing rail, road and air services. |
| Other Transport Operators | Reduced Revenue | Reduced Operating Costs<br>Reduced Capital Investments |
| Government | (Grants & Subsidies)<br>(Indirect tax losses) | |
| Wider Society | Noise and Vibration<br>Land take<br>Visual intrusion<br>Shadow price of public funds | $CO_2$ emissions reductions<br>Accident reductions<br>Additional wider economic benefits |

*Notes:* Fiscal transfers between Government and other groups identified in brackets. Revenue will also have a transfer element and this need to be taken into account.

For rail operators, the key costs relate to construction and operation. For a horizontally integrated rail operator, operating costs will include adjustments to classic rail services. A rail operator may receive support from Government in terms of capital grants and (less commonly) operating subsidies, although these are pecuniary transfers (and do not, therefore, have a direct effect on GDP, welfare or the results of CBA)[5]. In cases of public ownership, the support may take the form of the write-off of historic debts. This may reflect general support for the rail system and hence attribution to HSR is difficult and depends on accounting conventions.

For rail operators, the key benefit comes in the form of increased revenue from fares but may also come from other sources, in particular commercial developments in and around HSR stations. However, fare revenues need to be treated with caution (Sugden, 1972). Fares are a transfer between rail users and operators, but if we are concerned with the distributional impacts of HSR these transfer should be highlighted. Furthermore, HSR revenue abstracted from other modes is also a transfer and ideally should be highlighted as such, along with the reductions in operating costs and user benefits of these other modes. Typically, rail revenue is expressed as the net increase over the classic rail system, with the operating cost reductions of the classic rail system (and the impact on user benefits) also taken into account. For other modes (air, car, coach) the usual assumption is that these are perfectly competitive markets and that the HSR revenue gains from these modes reflect the reductions in capital and operating costs that take place, with no impact on the benefits to remaining users of the rival modes. A similar assumption applies to generated

5. But grants and subsidies do have an indirect effect in term of collection/administration costs, opportunity costs and distortion costs (particularly related to income tax), leading to an expectation that the shadow price of public funds is greater than one. For example, a shadow price of 1.2 suggests the deadweight loss of GBP 1 of subsidy is 20 pence.

revenue. An alternative approach is to directly estimate the cost reductions of the other modes or the increase in government support for such modes where they are state controlled (e.g. Alitalia).

HSR users may be expected to pay higher fares than classic rail services, and a substantial proportion may be expected to be abstracted from classic rail. HSR fares may also be expected to be higher than coach fares. HSR fares may be lower than air fares (although this may not be the case where low cost carriers are present) and lower than out-of-pocket motoring costs where tolled motorways are the norm. However, intermodal comparisons may be distorted by indirect taxation. In particular motoring is usually more highly taxed than rail travel, whilst in some countries (including India, where there is a jet kerosene tax) air travel is also more highly taxed.

HSR users benefit from the increased reliability, speed and comfort of services and, despite likely increases in out-of-pocket costs, generalised costs of travel will have reduced, both for abstracted traffic and for generated traffic, with the resultant changes in benefits often estimated by the rule of half[6], although more precise estimation techniques (such as numerical or direct integration) are preferable.

Overall, it may be expected that there are benefits to other users of the transport system, largely due to congestion relief. On classic rail, where there is latent demand, released capacity may permit enhancements to commuter and regional services, increasing frequencies and reducing overcrowding. Some paths may also be released for rail freight services. However, where large amounts of classic rail demand is abstracted by HSR, there will be reductions in the frequency of classic rail services, possibly initiating a spiral of decline. Intermediate stations may particularly suffer reductions in service, as initially occurred in the cases of Arras and Dijon in France. On the road system, there may be reduced congestion due to some modal shift to both HSR and classic rail services. For air services, there will be reductions in directly competing air services, to the disadvantage of remaining air travellers. However where hub airports are congested, reduced short- and medium-haul services will release slots for long-haul flights. Where airport slots are not allocated using market mechanisms, this may even lead to commercial gains. Furthermore, HSR can be a complement to air services, where hub airports are connected to the HSR network as in the case of Amsterdam, Frankfurt and Paris (Charles de Gaulle) and this in turn may reduce land-side congestion at these airports. In certain circumstances, avoided expenditure on air and road systems as a result of HSR investments may be considered a benefit. An issue here is whether the analysis focuses on the rail network or the wider transport system. Although preliminary analysis might focus only on the rail network, it is advisable that more detailed analysis covers the whole transport system.

Governments may be expected to be adversely affected where grants and subsidies are required and where there are reductions in the indirect tax take, as a result of the switch of traffic from heavily taxed road (and in some instances, including India, air) to more lightly taxed rail.

Costs and benefits to wider society may be classified in three categories. Environmental benefits may relate to reductions in emissions of carbon and other air pollutants but there

6. Let the generalised cost of travel before HSR be $GC_1$ and the generalised cost of travel after HSR be $GC_2$. In the case of a transport improvement we would expect $GC_1 > GC_2$. Also let the volume of travel before HSR be $Q_1$ and the volume of travel after HSR be $Q_2$, where for a transport improvement $Q_2 > Q_1$. Assuming a linear demand curve, the benefit to users is $Q_1 (GC_1 - GC_2) + ½(Q_2 - Q_1) (GC_1 - GC_2)$. This can be rearranged as $½ (GC_1 - GC_2) (Q_1 + Q_2)$ (see Jones, 1977).

may be issues along HSR routes with respect to noise and vibration, land take (and the impacts on biodiversity and on water courses), severance and visual intrusion. The main social impact is related to the likely reduction in accidents as a result of the transfer of traffic to HSR, which has an excellent safety record. Although some of these benefits accrue to transport users, the majority may be seen as accruing to wider society. Finally, there are economic impacts. A key feature of these is that they should be additional. Changes in patterns of economic activity may be redistributive rather than generative, although this redistribution may have benefits when it leads to more regionally balanced patterns of economic development. Changes in land values may similarly be redistributive rather than generative, with increased values close to HSR lines at the expense of locations further away. Moreover, these changes in values may be simply downstream manifestations of the changes in the generalised cost of travel and hence changes in accessibility, so to include them would be double counting unless HSR has reduced imperfections in land markets. Another economic impact is the shadow price of public funds, which largely arises due to distortion effects on the economy of taxation, particularly on incomes. In the UK, this deadweight loss might be equivalent to 20% of Government support, in France (with a higher tax regime) the figure may be more like 30%.

In developing the cost benefit schema, it is important to recognise transfers, particularly if distributional effects are a concern, and to avoid double counting (see, for example, Mohring, 1993).

### 4.1 Demand Levels

A key factor in any cost-benefit analysis will be the level of demand for HSR services. An issue here is the unit that should be used. The most common unit is the number of passengers per annum. However, this does not take into account trip length, in which case passenger kms per annum is a better measure. Kurosaki (op cit.) posits traffic density (passenger kms divided by route kms) as a key measure for particular routes.

Table 3 summarises evidence presented at the roundtable on the demand for some 34 HSR services, or groups of services for a variety of dates, with demand growth over time presented for five services, making 39 observations overall. The mean annual demand level for these 39 observations is 29.2 million, but with a standard deviation of 37.1 million, which emphasises the highly variable nature of the demand for HSR systems. The highest level of annual demand is 207 million for the combined Tokaido and Sanyo lines in Japan in 2011, which compares to 128 million recorded in 1984. The lowest level of annual demand is less than 4 million for the Madrid – Seville AVE service (Nash, 2013c).

Table 3. **Evidence on HSR Demand.**

| Source | Line/ City Pair) | Level of Demand (m pa) | Year. |
|---|---|---|---|
| Nash, 2013c (Table 3.2) | TGV Sud Est | 19.2 | 1987 * |
| | TGV Atlantic | 29 | 1995 * |
| | TGV Nord | 20 | 1994 |
| | TGV Connexion | 16.6 | 2000 * |
| | TGV Rhone-Alpes | 18.5 | 1995 |
| | TGV Mediterrane | 20.4 | 2001 |
| | Madrid Seville | 3.6 | 1998 * |
| | Madrid Barcelona | 5.4 | 2009 |
| | Tokyo – Osaka | 80 | 1970 * |
| | Seoul - Busan | 28 | 2010 * |
| NAO (2012) (In Nash, 2013c) | HS1 International | 9.7 | 2011 |
| | HS1 Domestic | 8.4 | 2011 |
| Kurosaki, 2013b (Table 2 and inferred from Table 5[7]) | Tokaido & Sanyo | 128.3 (207.4) | 1984 (2011) |
| | Tohuku | 24.1 (76.1) | 1984 (2011) |
| | Joetsu | 11.3 (34.8) | 1984 (2011) |
| Wu (2013b) | Hefei – Nanjing | 21.3 | 2012 |
| | Beijing – Tianjin | 21.0 | 2012 |
| | Qingdao – Jinan | 28.0 | 2012 |
| | Shi – Tai | 22.6 | 2012 |
| | Hefei – Wuhan | 11.0 | 2012 |
| | Coastal HSL | 15.1 | 2012 |
| | Wuhan – Guangzhou | 19.7 | 2012 |
| | Zhenghou – Xian | 5.8 | 2012 |
| | Chengdu –Dujiangyan | 4.7 | 2012 |
| | Shanghai –Nanjing | 29.2 | 2012 |
| | Shanghai – Hangzhou | 28.3 | 2012 |
| | Nanchang – Jiujiang | 30.2 | 2012 |
| | Changchun – Jilin | 8.4 | 2012 |
| | Hainan East Circle | 6.4 | 2012 |
| | Beijing - Shanghai | 24.8 | 2012 |
| Croccolo and Violi, 2013b. | Italy HS Network | Over 12.1 | 2012 |
| Chan, 2013 | Chinese Taipei HSR | 36.6 | Average 2007 – 13. |
| Jun, 2013 | G-Line (Gyeongbu) | 22.2 (39.1) | 2004 (2011) |
| | H-Line (Honam) | 4.2 (7.3) | 2004 (2011) |

* Equilibrium demand approximately six years from opening.

There is some evidence of strong growth. Three groups of lines in Japan appear to have had strong demand growth between 1984 and 2011 of 94%, representing compound annual growth of 2.5%, In Korea, demand grew by 76% between 2004 and 2011, representing compound annual growth of 8.4%[8]. Data presented by Chan (2013) for the Chinese Taipei HSR indicates a mean annual usage since opening in 2007 of around 37 million, but with

7. Information provided by Fumio Kurosaki, 25 February 2013.

8. The Korean data was presented in terms of trips per day and has been multiplied by 365 to get an annual total

current usage levels indicating 45 million trips per annum. An issue here is the extent to which this demand growth would have occurred anyway (e.g. due to general increases in population and income or structural changes in the economy) and the extent to which the growth has been stimulated by HSR (e.g. due to changes in land use and activity patterns). A further issue is when the 'equilibrium' level of demand is achieved. HSR will have a take-off curve like any other new product. Nash (2013c) implies that this ramp-up effect takes around six years. This is substantially longer than the 2.5 years postulated for new inter-urban rail services by Preston and Dargay (2005) and is an area that is worthy of further investigation as more data on HSR services emerges.

Wu (2013b) presents patronage data for some 15 HSR lines in China, although it should be noted that these are based on traffic density rather than patronage per se. This will underestimate patronage where there is substantial intermediate traffic. The mean demand for these lines is 18.4 million (some 36% lower than the overall mean for all countries) but the standard deviation is also much lower (at 8.9 million). HSR demand in China has been dampened by fares that are relatively high as a proportion of income (and hence HSR has a relatively low "effective speed") and are relatively high compared to classic rail (often three times higher). It should be noted that some of the Chinese lines in Table 3 are segments of bigger schemes and demand may be expected to be higher when the whole scheme is completed.

The variation in HSR demand can be explained by the standard gravity formulation, which has been used in this context by SDG (2004) and by SNCF (see Crozet, op cit.). It may be expressed as follows:

$$T_{ij} = K A_i A_j R_{ij}^{-\varepsilon}$$

where:

$T_{ij}$ is the number of (HSR) trips between zones i and j;

$A_{i(j)}$ is the attractiveness of zone i (j);

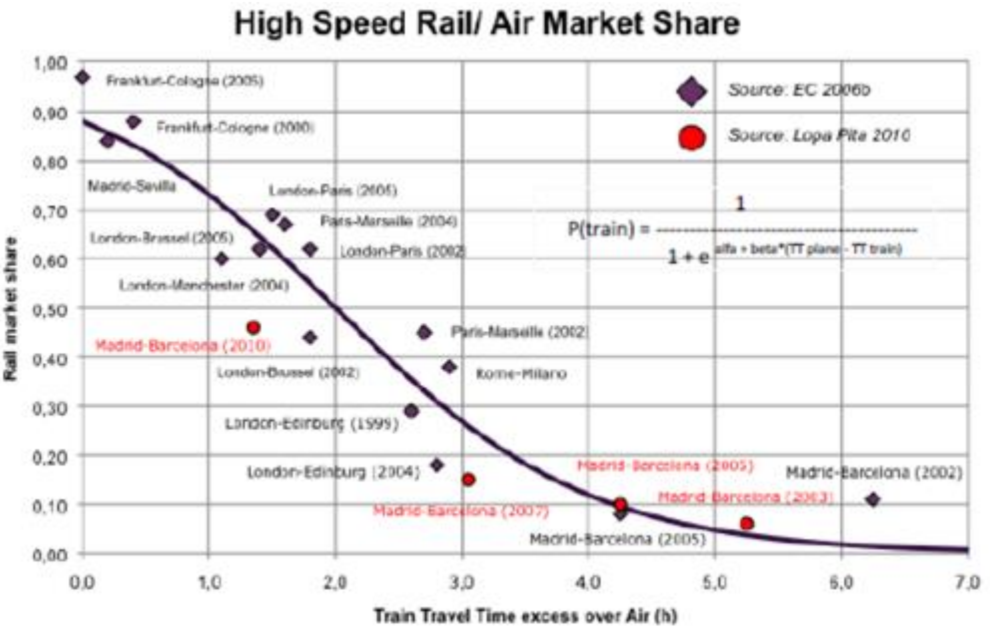
$R_{ij}$ is a measure of repulsion between zones i and j;

$\varepsilon$ is the elasticity of demand with respect to the repulsion factor;

and K is a constant.

The gravity model may be either mode specific or refer to all travel, with a mode split model (usually based on a logit curve) then used to determine HSR shares (see also Figure 1). Attraction measures are normally based on population, but ideally these would also take into account income (by using city GDPs, or an equivalent measure). Repulsion measures are usually based on distance or journey time, but ideally should be based on generalised cost that also takes into account out-of-pocket expenses and income levels. The relatively low levels of demand to date for HSR in China may reflect low income and high fares, but may also reflect the fact that services are new and insufficient time has elapsed for services to build-up. Station location, typically out of town in areas earmarked for new development, is also a factor. National and regional borders can have an important effect on supressing demand. This is partially the explanation for demand on the international services using HS1, the Channel Tunnel link in the UK, being 30% below even the most recent forecasts, with border security arrangements preventing some potential services to intermediate stations being offered. The high degree of regional autonomy in Spain may partly explain the relatively modest levels of usage of AVE services, although the urban spatial structure and spatial distribution of population are more likely factors.

Figure 1. **(from Crozet, 2013b)**




Source: European Commission, Air and Rail Competition and Complementarity, 2006.
López Pita, A., "High-speed rail modal split on routes with high air traffic density", 2010.

Figure 1 shows a typical logistic curve that may explain the market shares between rail and air in terms of the travel time excess of rail over air – the key threshold journey time difference appears to be two hours (consistent with an absolute rail journey time of around three hours that permits a return journey within the same day). One of the main outliers is for Madrid – Barcelona (2010) which is below the curve after the introduction of HSR. This might suggest that other factors may be important on this route, including competition from air in terms of frequency and price.

Figure 1 refers to day travel. There may be a threshold for overnight travel of around ten hours. There may be some origin- destination pairs that might fall in this range e.g. New Delhi – Chennai (2 176 kms by the Chennai Rajdhani Express) and Beijing – Hong Kong (2 475 kms), although the huge capital costs of construction could only be justified if there was also significant intermediate day time traffic. This hypothetical market would generate a second peak, off to the right of the graph. For intermediate journey times passengers may prefer overnight services on conventional rail (as appears to be the case in China) as well as air.

It is important to note that market share between rail and air will also be a function of fare levels and, importantly, structure. Where HSR operators practice revenue yield maximisation techniques (e.g. Eurostar, SNCF) then the fill-up approach will boost market share, whilst also maintaining a high average fare through price discrimination, with the possibility of increasing both commercial returns to the operator and benefits to users.

## 4.2 Costs

Nash (2013b) notes the wide range of construction costs of HSR lines (see also Table 4), with the lowest costs being achieved in France, Spain and China (although some lines on the eastern seaboard of China have been built on expensive raised viaducts) and the highest costs being recorded in Chinese Taipei and in the UK.

Table 4. **Construction Costs per route km of new high speed lines (million Euros, 2005 prices)**

| | |
|---|---|
| **Belgium** | |
| **France** | 4.7 – 18.8 |
| **Germany** | 15.0 – 28.8 |
| **Italy** | 25.5 |
| **Japan** | 20.0 – 30.9 |
| **Korea** | 34.2 |
| **Spain** | 7.8 – 20.0 |
| **Chinese Taipei** | 39.5 |

Source: Campos, de Rus and Barron, 2009 (in Nash, 2013c)

If the data in Table 4 are treated as 12 independent observations, this suggests a mean cost of almost EUR 22 million per route km, with a standard deviation of EUR 10 million. Nash notes that the lowest costs are achieved for passenger only HSR lines, as in France and Spain, with gradients up to 3.5% permitted. By contrast, gradients on mixed traffic lines are not normally more than 1.5%.

Evidence from elsewhere is similarly mixed. NAO (2012) reports that, in the UK, the out-turn construction costs of HS1 (excluding station fit-outs and a new depot) were GBP 25.9 (EUR 31) million for Phase 1, rising to GBP 96.9 (EUR 117) million for Phase 2 (that included 21.5 km of tunnel out of 39 route km). The construction costs for HS1 in its entirety (including stations and depot) was GBP 54.5 (EUR 66) million per route km.

At the other extreme to the UK, Wu (2013b, Appendix 2) reports on the construction costs of HSR lines in China. For the 12 schemes with design speeds of 250 kph, a mean construction cost of EUR 8.8 million per km is found (2010 prices).[9] For the 10 schemes with design speeds of 350 kph, an average construction cost of EUR 16.5 million is reported, almost 90% higher.[10] Wu notes that the split between infrastructure, superstructure and land/other costs are typically 60:20:20, with station costs adding an additional 10% to 30%.

Aside from design operating speeds and gradients (which are inter-related), another key cost driver is population density. This will impact on land costs but will also increase requirements in terms of bridges, viaducts and tunnelling. Topography is also important with costs higher in mountainous terrain (as in Chinese Taipei, where over 76% of the route is

9. If the 12 schemes are treated as independent observations the mean costs are EUR 9.4 million per km, with a standard deviation of EUR 3.6 million.

10. If the 10 schemes are treated as independent observations the mean costs are EUR 17.9 million per km, with a standard deviation of EUR 4.4 million.

elevated and 14% is in tunnel). Nash (op cit.) notes that central area access is a key issue. Where this is provided by existing rail rights of way, as in France, HSR costs may be relatively low. Placing classic rail operations underground as for the RER in Paris, Crossrail in London or the S-bahn systems in Germany, may be one way of releasing rights of way for HSR. Where new rights of way need to be established, as for HS1 in the UK, HSR costs will be correspondingly higher.

In terms of operating costs, HSR has higher energy and maintenance costs than classic rail, but the high speeds lead to high utilisation of rolling stock and accompanying staff, thus offsetting these costs. There may be some trade-offs between construction and operating costs. Compared to conventional ballasted track, concrete slab track may be expected to have higher construction costs but lower maintenance costs, but also greater carbon intensity (Lee et al., 2008).

An important issue is the extent to which HSR construction costs are increasing over time. On the one hand, economies of experience and technological advances might lead to expectations of declining costs over time. On the other hand, higher regulatory standards concerning safety and the environment might be expected to drive costs up. Furthermore, it might be that the lowest cost routes, exploiting existing rights of way and terminal capacity, are developed first and later lines are more expensive.

### 4.3 Benefits

Appraisals in the UK have provided indications of the relative size of HSR benefits. The initial appraisal of HS1 (NAO, 2001) suggested 53% of benefits were to users of international services, 29% were to users of domestic services, 15% were regeneration benefits, 3% environmental benefits and 1% were road congestion benefits. More recently, the appraisal of the full HS2 network (DfT, 2013), indicates that, ignoring tax adjustments and revenue, 61% of benefits will be due to time savings, 10% will be due to benefits from reduced crowding, 7% will be due to reliability benefits, 2% will be accrued by road users and 18% are associated with wider economic benefits. Other impacts (including on the environment) constitute 1% of total benefits.

A fairly consistent picture emerges from HS1 and HS2 with around 80% of benefits (excluding revenue and indirect tax adjustments) accruing to rail users. To the extent that rail users have higher than average incomes, and those with the highest incomes will have the highest values of travel time savings this may be seen to be regressive in terms of income distribution. These distributional effects may be ameliorated in the presence of price discrimination, which will involve higher fares to price inelastic markets (usually higher income groups) and lower fares to price elastic markets (usually lower income groups).

The results that Nash (2013a) presents for Madrid to Barcelona give a slightly different picture with 39% of benefits in terms of time savings to existing users, 15% to generated travellers and 6% due to environmental effects, but with 40% related to costs saved on other modes (although these may reflect the impact of revenue changes). It should be noted that for HS2, revenue is estimated to be worth GBP 31.1 (EUR 38) billion, compared to welfare benefits of around GBP 73.9 (EUR 90) billion i.e. revenue is around 30% of the combined total of revenue and benefits, excluding tax adjustments. The differences between the HSR assessments in Britain (based on market prices) and Spain (based on resource costs) thus reflect a different way of presenting the outcomes, rather than necessarily a real difference. In Britain cost savings on other modes are not directly estimated, just revenue and net user benefits.

Business travellers, despite only being a minority of rail users (typically around 30% of forecast demand), account for over 50% of gross benefits on HS2. This is due to the high value of time ascribed to business travellers, typically the wage rate plus around 25% for employer's costs, whilst the value of time for non-work travel is typically between 25% and 40% of the wage rate. As rail business travellers are in high income occupations, this equates to a value of time of around GBP 32 (EUR 39) per hour (at 2010 incomes and prices), compared to GBP 6 per hour for leisure travellers and GBP 7 per hour for commuters. Recently there have been arguments put forward that given business travellers can work productively on trains, a lower value of time should be used as the assumption of zero productivity whilst on the move is not valid (Lyons et al., 2007).

These arguments are not new, and can be traced back to Hensher (1977). Castles and Parish (2011) have argued that the value of business travel time savings should be based solely on the loss of utility to the traveller, as represented by the value of commuter time (almost 80% less than the value of business time). This assumes that all time savings will be at the expense of work done whilst travelling, that working on the move is as productive as working in an office and that there are no benefits from being able to schedule multiple meetings, avoid overnight stays and arrive at meetings more alert. Where business travellers are able to work more productively on HSR services than alternative modes (which is a realistic proposition), it is possible that adjustments for this effect would in fact increase the value of the benefits of travelling by HSR, although this would reflect the value of travelling in different conditions rather than travel time savings per se.[11] Furthermore, there is a good deal of (but by no means unanimous) empirical support for values of business travel time in excess of the wage rate (see, for example, Wardman, 2013). This evidence also suggests that the value of time will grow over time, broadly in line with income.

A contrasting view is that developments in information technology and communications will continue to reduce the disutility of travel and hence reduce the value of travel time over time. This could be an important issue as current appraisals assume strong growth in the value of travel time savings. In a study of HSR between Edinburgh and Glasgow, Preston et al. (2009) found that in year 1 increases in user benefits were 57% greater than increases in revenue. By year 60, as a result of increasing values of time, increases in user benefits were over nine times greater than the increased revenue (assuming that fares were fixed in real terms). Given the countervailing uncertainties, the conservative response is to moderate business travel time values somewhat. Indeed, the UK government recently reduced the value applied in assessment of HS2 from GBP 45 (EUR 55) per hour (in 2010 prices) to GBP 32 (EUR 39) per hour, primarily as a result of revised estimates of the incomes of rail business travellers (HS2, 2013).

There have been a number of different approaches to estimating the impact of the wider economic benefits of HSR in the UK (Nash, 2013c). For HS1, regeneration benefits (particularly around Stratford) were calculated by estimating the number of new jobs created and this was multiplied by the amount the Government was willing to pay to create jobs in priority areas for regeneration. For HS2, in the most recent assessment, wider economic impacts were calculated by estimating the impact on agglomeration, reductions in imperfect competition (as a result of benefits to business users) and increased labour force participation (and the resultant increases in income tax) arising from reduced commuting

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11. Suppose in the before situation a mode is being used that does not permit work on the move, this mode take three hours and the value of travel time is estimated at GBP 96 (3 times GBP 32). HSR reduces the journey to two hours, but this time can be used productively. The value of travel time is GBP 14 (2 time GBP 7). The value of travel time savings is GBP 82 – substantially in excess of GBP 32.

costs. The agglomeration benefits were estimated in terms of the reductions in the costs of travel between areas and places of employment as a result of HS2 and associated released capacity on the conventional rail network (HS2, 2013). This assessment approach has been developed using frameworks originating with Venables (2007) and Graham (2007) and outlined in detail in the Department for Transport's guidance for assessment set out on its WebTAG[12] internet pages. Rosewell and Venables (2013) argue that the WebTAG approach focuses on the benefits of expanding places rather that connecting places. Even this relatively narrow definition permits wider economic benefits to constitute 18% of gross benefits (or an up-lift on conventional benefits of 22%). Some 65% of these wider economic impacts are related to agglomeration, over 30% to increased competition and less than 5% to increased labour force participation. This assumes that land-use is fixed and does not take into account the potential for gains from trade and regional specialisation resulting from HSR promoting business-to-business and business-to-customer connectivity and permitting re-location of activities.

Work by Graham and Melo (2010) shows that although economic theory does not preclude the existence of wider economic benefits across inter-regional distances, the empirical evidence suggests that these may be very small, at least in relative terms. For example, a transport investment that directly affects 25% of long distance rail trips by increasing speeds by 25% might increase output by only 0.0006%. This is because of the small proportion of long distance rail trips in the total travel market. However, it might be argued that there are certain key business markets, focused on major city centres, where rail has a much larger market share. Work undertaken by KPMG (2013) attempted to examine labour and business connectivity by assessing the relationships between labour productivity, rail connectivity and road connectivity, using a framework that permits land-use to change over time. However, these connectivity indicators are correlated with each other (and other indicators such as the quality of labour and land). Furthermore, bi-directional causality needs to be addressed. It is plausible that high productivity areas attract transport investments as well as are generated by such investments. A causal relationship between productivity and rail connectivity was inferred (without a theoretical justification) and there was an estimate that this could lead to benefits of GBP 15 billion (EUR 18 billion) per annum by the year 2037 (at 2013 prices), although this would include conventional benefits. This would represent an increase in GDP of 0.8% in 2037 – a figure that is an order of magnitude different from the theoretical estimations of Graham and Melo. The GBP 15 billion per annum compares to the gross benefits (excluding indirect tax adjustment) of around GBP 74 billion (EUR 90 billion) (2011 prices) for the whole HS2 network over a 60 year project life and with an interest rate of 3.5% for the first 30 years and 3% for the next 30 (from Nash, 2013c, Table 4.5). The KPMG methodology thus seems to give much higher estimates of benefits,[13] that many may consider implausible.

Thus a relatively narrow definition of wider economic benefits based on improvements to the classic rail network in the case of HS2 uplifts gross benefits by over 20%. A more generous definition, including the inter-regional business and labour connectivity effects of HS2 might lead to higher estimates but these have not yet been accurately estimated. Other wider economic benefits of HSR might relate to one-off events such as the World Expo in Seville in 1992 and the London Olympics in 2012, although these can be overstated. For example, the World Expo in Seville attracted around 42 million visitors over a six months

12. WebTAG is the UK Department for Transport's online Transport Analysis Guidance – see: https://www.gov.uk/government/publications/webtag-tag-unit-a2-1-wider-impacts

13. If GBP 15 billion per annum is discounted over 60 years in a similar manner then a present value of benefits of around GBP 398 billion (EUR 486 billion), some 5.4 times the original estimate, is obtained.

period, whilst the first year usage of the Madrid-Seville AVE was only 2.5 million. In the United States, a key area of debate is the extent to which HSR could avoid (or indeed reverse) urban sprawl though, as HSR only affects short distance commuting by releasing capacity where there is already a well-developed conventional rail passenger network, this is unlikely, except to the extent that HSR can reinforce the role of those central cities that have significant rail commuting.

Another line of argument is that the above discussion downplays the diseconomies of agglomeration, not least in the non-traded sectors of the economy, leading to higher costs in, for example, education, health-care and public administration. This could be an important factor in the mega-cities of developing countries, not to mention environmental and congestion diseconomies. Furthermore, much of this economic development may be abstractive (relocated activity) rather than generative (new activity). Studies in France (Bazin et al., 2006, Mannone, 1995, Mannone and Teleme, 1997) and in Spain (Hernandez, 2011) have shown how areas around HSR stations abstract activity from more peripheral areas of the City and/or Region.

### 4.4 Pricing and Competition

Economic theory teaches that pricing and investment should be joint decisions (see, for example, Glaister, 1976), but HSR is one of many areas where the practice diverges from the theory. Pricing for railways often has at least two components. The first is the price that the infrastructure authority charges the HSR operator. The second is the price the HSR operator charges the end user. With respect to track access charges, it has been demonstrated that the level of usage will be determined by whether the charges are based on short run marginal costs or long run average costs (Preston, 2009a). Where full cost recovery is required, this may be based on a uniform rate or on Ramsey-Boiteaux discrimination. Crozet (op cit.) demonstrates that such discriminatory mark-ups are essentially a function of the opportunity cost of public funds (set at 0.3 in France) and the elasticity of demand with respect to price. He indicates that for Paris – Lyon the mark up over marginal costs is around six (suggesting a low elasticity in absolute terms or that the mark up is set inefficiently). For other routes it is between 1.5 and 2, suggesting higher price elasticities. UIC (2008) finds that track access charges account for between 25% and 45% of the revenue of high speed operators. This in turn affects the profitability of HSR services and the ability to compete with other modes (Adler et al., 2007).

For passenger fares, the key distinction is between proponents of revenue yield (such as SNCF, NTV and Eurostar) and those that base HSR fares on the standard fare (itself related to distance) plus express and seasonal premia (essentially the approach adopted by the JRs)[14]. Both approaches may have group travel, advance purchase and loyalty discounts, but revenue yield maximisation is based on a book-ahead system whilst more uniform pricing can have an element of turn-up and go. This may in turn explain variations in load factors, with TGVs achieving around 70% but ICEs more like 50% (though this is also due to stopping patterns). Wu (Appendix 4) estimates that the mean tariff in 2010 for the Tokaido Shinkansen equates to EUR 0.195 per passenger km and for Paris–Lyon TGV it is EUR 0.121, whilst the mean for China HSR (with operating speeds of 350 kph) is only EUR 0.056. Different charging regimes will have important implications on the cost-benefit analysis results in terms of overall demand levels and the extent to which user benefits are captured through the fare box. It should be noted that in the assessment of HS2, even without premium pricing, revenue is equivalent to around 30% of total benefits. The fares that HSR

14. There can also be hybrid systems – the revenue yield system for Trenitalia is based on adjustments to the historic distance based fare.

can charge will be determined in part by the pricing regime for the classic rail network – and the extent to which pricing off excess rail demand is being practiced. Different charging regimes will also have equity implications. A revenue yield maximising, book-ahead system that offers cheap advance tickets will be perceived as more equitable than a fixed premium fare, turn-up and go system.

Pricing is closely linked to competition. In Italy, the head-on competition between Trenitalia and NTV HSR operations has reduced average prices by 30%[15], although some of this is believed to reflect increased productivity (Croccolo and Violi, 2013). The head-on competition appears to have increased service levels by around 45% and demand by 40% (first half 2013 compared to first half 2012). Rail's market share on the key Rome to Milan route increased from around 30% to over 65%, mainly at the expense of air. The new entrant is providing 26% of HSR train kms and carrying 36% of traffic in terms of passengers. The key unknown is the extent to which this competition can be sustained. The operations are not believed to be currently profitable and continuation will depend on the depth of the pockets of the shareholders. Competition between classic rail and HSR could also be intense, particularly in the price dimension, but there has been no evidence of such competition to date. Indeed, in France, Italy and Spain, parallel conventional services have often been withdrawn, thus improving the commercial prospects of HSR. Inter-modal competition has been a feature of HSR services with low cost air carriers and ferry operators, providing strong direct competition on some routes, whilst flag air carriers have experimented with shuttle services (e.g. on Madrid – Barcelona). Low cost carriers also provide indirect competition through offering a wide range of non-HSR served destinations. This is believed to have constrained the growth of the leisure market on routes between London, Brussels and Paris, with cheap flights to locations further afield reducing the overall growth in the market for travel between London, Paris and Brussels. There is clear evidence that inter-modal competition places limits on HSR demand levels and fares (Campos and Gagnepain, 2009).

Initial estimates for HS2 indicated that for Phase 1 some 57% of journeys would switch from classic rail, 8% would be from air, 8% from car and 27% would be generated (HS2, 2010, quoted in Preston, 2010). HS2 would thus have a higher level of abstraction from rail and a lower level of abstraction from road and, particularly, air than the five HSR schemes shown in Table 5. On average, for these five schemes 32% of demand is abstracted from air, 26% is abstracted from classic rail, 16% is abstracted from road and 26% is induced. The variations shown in Table 5 are due to the route-specific nature of the modal split. For instance, according to Coto-Millán et al. (2007), around 70% of journeys on the Madrid-Barcelona route were undertaken by air prior to the introduction of HSR compared to only 25% of journeys from Madrid to Seville. The level of induced journeys seems to be around 10-30% with the main exception of Madrid-Seville. Givoni (2006) suggests that some of this induced traffic may in fact be due to external growth and this may have been a particular factor on the Madrid – Seville line. Induced traffic may also include re-distributed trips which would have previously gone to a different destination by rail. Differences in definitions may explain the findings of PWC (2010) that induced traffic accounted for around 26% of traffic for Madrid – Seville and 9% for Madrid – Barcelona.

15. Minimum prices have had greater reductions. For example, the minimum fare for Rome – Milan declined from EUR 75 to EUR 29 (and even down to EUR 9 for a period, which triggered a predatory pricing competition case).

Table 5. **Diversion Factors resulting from introduction of HSR**

| **Route** | **Paris-Lyons**[1] | **Madrid-Seville**[2] | **Madrid-Barc'a**[3] | **Thalys**[4] | **Eurostar**[4] |
|---|---|---|---|---|---|
| % HST traffic generated from: | 1980 to 1985 | 1991 to 1996 forecast | 'Before HSR' to 'After HSR' | Range not given | Range not given |
| Induced | 29 | 50 | 20 | 11 | 20 |
| Road | 11 | 6 | 10 | 34 | 19 |
| Conventional rail | 40* | 20 | 10 | 47 | 12 |
| Air | 20 | 24 | 60 | 8 | 49 |

*Note*: * All Paris-Lyon's 'after' rail travel is presumed to be by HST (i.e. no conventional rail following introduction of HST), since alternative journey time is ~5 hours compared to ~2 hours by HST.

*Sources*: [1]Bonnafous, 1987. [2]de Rus and Inglada 1997. [3]Coto-Millán et al., 2007. [4] Segal, 2006. Quoted in Preston, 2009b.

Wu (op cit.) provides some evidence on traffic sources for China, with the best data being for the Beijing – Tianjin line where in 2011, 48% of traffic was diverted from conventional lines, 9% diverted from road and 44% was generated. It should be noted that in China domestic aviation services are relatively under developed – but might be expected to have grown rapidly in the absence of HSR.

For Mumbai-Ahmedabad, Pal (2013) estimates that current modal shares are 34% by coach, 28% by rail, 28% by car and 10% by air. It is estimated that 15 years after HSR opening (2035), 46% of demand would be by HSR, 24% by car, 16% by bus, 10% by classic rail and 4% by air. Assuming no generation or changes in modal shares due to other factors (such as income growth), a comparison of these modal shares would suggest that 39% of HSR demand would be from classic rail, 39% from bus, 13% from air and only 9% from car.

## 5. Breakeven conditions

There has been considerable work on ex-post evaluations in France, based on both financial and social criteria, which are compared with the ex-ante appraisals. Some key results are shown in Tables 6 and 7.

Table 6. **Financial Internal Rates of Return for HSR in France**

| **High Speed Line** | **Ex-Ante** | **Ex-Post** |
|---|---|---|
| **South East** | 16.5% | 15.2% |
| **Atlantic** | 12.0% | 7.0% |
| **North Europe** | 13.0% | 3.0% |
| **Paris Interconnection** | 10.8% | 6.9% |
| **Rhone-Alps** | 10.4% | 6.1% |
| **Mediterranean** | 8.0% | 4.1% |

*Source:* Crozet, 2013b

Interpretation of Table 6 depends on assumptions concerning the minimum acceptable rate of return. For purely commercial organisations, 10% is often used, in which case, ex-post, only LGV[16] Sud-Est is financially viable. However, Crozet reports that financial costs were covered because the interest rates applied were lower than those shown in Table 6, although it seems that the financial case for LGV Nord is marginal. It is also apparent that the ex-post returns are less that those forecast ex-ante. This is most severe for LGV Nord where outturn traffic was only around 50% of that forecast, reflecting the difficulties in forecasting international traffic. In addition, for some lines, cost overruns of 15% to 25% were found.

Table 7. **Socio-Economics Internal Rates of Return for HSR in France**

| High Speed Line | Ex-Ante | Ex-Post |
|---|---|---|
| **South East** | 28.0% | ? |
| **Atlantic** | 23.6% | 12.0% |
| **North Europe** | 20.3% | 5.0% |
| **Paris Interconnection** | 18.5% | 15.0% |
| **Rhone-Alps** | 15.4% | 10.6% |
| **Mediterranean** | 12.2% | 8.1% |

*Source:* Crozet, 2013b.

As might be expected, the socio-economic returns are greater than the financial returns, although again interpretation depends on assumptions concerning the social test discount rate. Detailed figures for TGV Sud-Est are not available but are reported by Crozet to be 'certainly more than 20%' – Conseil General des Ponts et Chaussees (2006) reports 30%. It seems that most schemes would pass any reasonable assumption concerning test discount rates (set at 8% for most of the period under consideration), with again LGV Nord the possible exception, although here international traffic has picked up following completion of HS1 in the UK and France has moved to a lower test discount rate (4% since 2003).

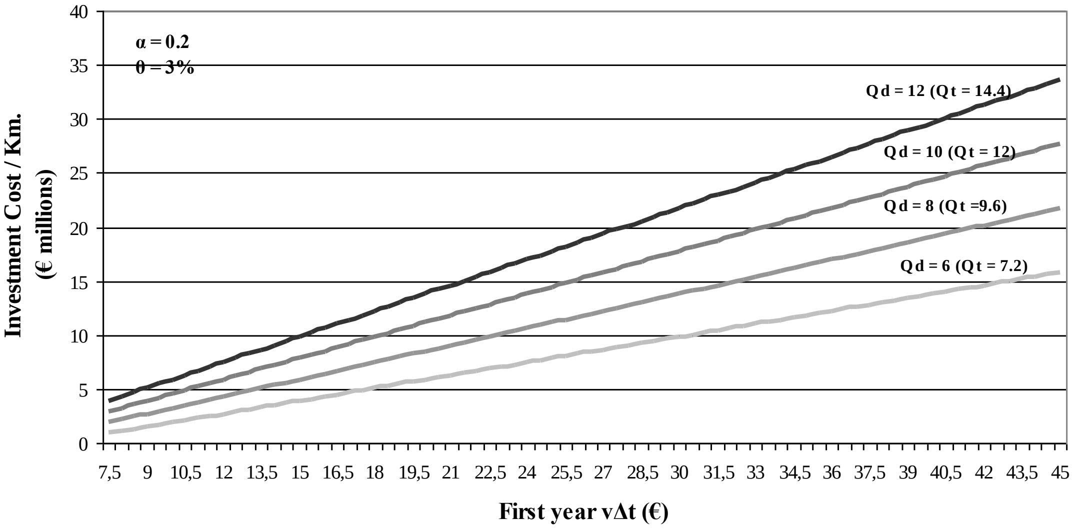
In Japan, Kurosaki (op cit., Table 3) presents results for the financial performance of the first four Shinkansen lines for the period 1982-4. This shows that the Tokaido and Sanyo lines were covering financial costs, but that the Tohuku and Joetsu lines, although covering operating costs, were not covering capital costs. However, it is noted that ridership has increased over time and that the long term debts of the three Honshu JRs, including those related to the Shinkansen, which stood at 12 429 billion yen in 1991, had been reduced to 7 013 billion yen in 2012, a reduction of 44%; although it should be borne in mind that there were substantial debt write offs with the privatisation (or more correctly commercialisation) of JNR in 1987.

For China, Wu (op cit., Tables 1 to 4) estimates that for the period 2010 to 2012, three lines were making a financial loss (Beijing – Tianjin (data from 2009), Wuhan – Guangzhou and Zhengzhou – Xi'an), although the deficits were tending to reduce over time. Only the Jinan – Qingdao service was estimated as covering financial costs. Table 3 shows that this service has the highest ridership of the four services considered, at 28 million per annum.

16. LGV = Ligne de Grande Vitesse, high speed line.

There has been surprisingly little ex-post socio-economic evaluation of HSR schemes. Outside of France, the best known example is the work of de Rus and Inglada (1997) on the AVE services between Madrid and Seville, opened in 1992. This scheme had capital costs of some 238 billion pesetas (1987 prices), but a simple financial analysis suggested a loss of 314 billion pesetas (1987 prices, 30 year project life, 6% discount rate, 2.5% GDP growth), indicating that the scheme does not even cover its operating costs. A social cost benefit analysis indicates a negative net present value (NPV) of 258 billion pesetas, suggesting a benefit cost ratio (BCR) of only 0.18. With regards to benefits, some 44% were estimated as accruing to generated travellers, with 23% accruing to abstracted travellers in terms of time savings, 28% accruing to other transport operators in terms of reduced operating costs and some 5% related to congestion and accidents. The figures quoted in Nash (2013a) for the Madrid – Seville route, based on de Rus (2012), are expressed in billions of Euros and 2010 prices. These indicate a present value of costs of EUR 6.8 billion, a present value of benefits of EUR 4.5 billion and hence a Net Present Value of EUR 2.3 billion and a BCR of 0.66. This suggests there has been some improvement in the performance of the service over time but not to the extent that it has become socially worthwhile. De Rus (op cit.) also finds that the Madrid – Barcelona route fails to achieve social break-even.

Figure 2. **First Year Demand Required for Socio-Economic Break-Even.**




Notes: $\alpha$ =uplift for generated traffic (Qt = Qd $(1+\alpha)$) and $\theta$ = annual growth rate of net benefits. (from Nash, 2013a).

In a number of papers, theoretical models have been developed to examine social break-even traffic levels for HSR investments (de Rus and Nash, 2006, de Rus and Nombelo, 2007, de Rus and Nash, 2009). As shown in Figure 2, this work determines the combinations of investment costs per kilometre (given by the y-axis), demand levels (both abstracted from other modes (Qd) and including generated traffic (Qt)) and the mean value of travel time savings (given by the x-axis and denoted v $\Delta$t, where v = value of time and $\Delta$t= travel time savings) at which HSR schemes just break even in social terms. These break-even lines are referred to as isoquants. As with all economic models, the results depend on the input assumptions. Assumptions include the interest rate (say 5%), the project life (say 30 years), the proportion of traffic that is generated (say a 30% uplift, implying that around 23% of demand is generated), the annual growth of net benefits (e.g. 3%), the construction costs per km (say EUR 20 million) and the mean value of travel time savings (say EUR 45), based on an average time saving of 50 minutes (from SDG, 2004). Under these assumptions, for a

500 km route, it can be estimated from Table 8 that the break-even first year demand is around 9 million passenger per annum – a relatively high figure, especially given all passengers are assumed to travel the full length of the route. De Rus (2012) reports that only around one half of the users of the Madrid – Seville services travel the whole length.

Table 8. **Break-even demand volumes in the first year.**

| Construction cost (£k per km) | Rate of interest (%) | Value of time saved (euros) | % generated traffic (%) | Rate of benefit growth (%) | Break-even Volume (m pass) |
|---|---|---|---|---|---|
| 12 | 3 | 45 | 50 | 4 | 3 |
| 12 | 3 | 30 | 50 | 4 | 4.5 |
| 30 | 3 | 45 | 50 | 4 | 7.1 |
| 12 | 3 | 45 | 30 | 3 | 4.3 |
| 12 | 5 | 45 | 50 | 4 | 4.4 |
| 30 | 5 | 30 | 30 | 3 | 19.2 |
| 20 | 5 | 45 | 30 | 3 | 8.8 |

*Source:* Nash, 2013c.

It is important to note that these calculations do not include environmental effects (which we have seen are negligible) nor network effects on competing air, road and conventional rail services (which are more substantial but still relatively modest). It is interesting to note that there are seven city pairs listed in Table 3 with demand volumes below 9 million passengers per annum. There may be several with demand levels below 4.5 billion passenger kms, as these indicative calculations assume that all passengers travel the length of the HSR route, which is unlikely to occur in practice. For example, Chan (op cit.) reports that the Chinese Taipei HSR has a route length of 345 km but a mean trip length of 200km. Similarly, Kurosaki (op cit.) reports mean trip lengths in 1984 of 329 km for the Tokaido and Sanyo lines (route lengths 553 and 644 kms respectively), 254 kms for the Tohuku line (route length 505 km) and 220 km for the Joetsu line (route length 304 km).

Wu uses the framework developed by de Rus et al. to determine break-even values for HSR in China. It is found that traffic density of between 40 and 50 million passengers per annum is required to achieve commercial break-even for HSR lines with 350 kph operating speeds, falling to between 25 and 30 million for lines capable of 250 kph operating speeds. It should be noted that Wu bases these calculations on average demand over the whole life of the project (with demand assumed to grow at 5.4% per annum over the next 50 years), whereas the figures quoted above are based on first year demand. Wu also estimates that the break-even socio-economic level of traffic density is between 90 to 100 million passengers per annum, but this assumes a time saving per passenger valued at most at EUR 4, less than a tenth of the value assumed by Nash. Wu notes that if rail travellers have twice the average income, and hence twice the average value of time, (which is not infeasible for the wealthiest parts of China in which much of the HSR investments are concentrated) then the break-even figure comes down to 50 million. Furthermore, the additional demand required to justify HSR compared to an upgrade of classic rail is estimated at 28 million per year. When these numbers are converted into first year demand, they may be broadly consistent with the calculations of Nash, given the rapid growth rates expected in China.

## 6. Funding

Funding was described at the roundtable meeting as 'the main hurdle'. Public capital is generally cheaper than private capital but its supply is limited. There may be scope for channelling 'the irrational exuberance of the private sector' into legacy infrastructure such as HSR. Private risk capital might be accessed through concessions and Public Private Partnerships (PPPs). Crozet (2013b) reports that the extension of the TGV to Bordeaux is financed by a 50-year concession. The concessionaire will provide EUR .8 billion of finance, albeit much of this is underwritten by the French State and the European Investment Bank, whilst the infrastructure authority (RFF) will contribute EUR 1 billion and central and local government will share a EUR 3 billion contribution. By contrast, the extension to Brittany and the Nimes–Montpellier by-pass will be developed as 30 year PPPs, with rents paid by central and local government and in the Brittany case by RFF. A feature of the current expansion of the TGV network is the increased role of local government funding.

In Japan, new Shinkansen lines (built since 1987) are constructed and owned by the Japan Railway Construction, Transport and Technology Agency, although they are operated and maintained by the JRs. The JRs are charged a usage fee calculated to ensure that they are neither better nor worse off as result of the new Shinkansen (i.e. it is based on the difference between the operating profit with and without the Shinkansen, assuming a 30 year project life). Since 1996, the construction costs net of these usage fees are subsidized by state and local governments by a ratio of 2:1. This regime does not appear to incentivise JRs to cooperate in the development of new lines (with the anomalous exceptions of mini-Shinkansens) and it is perhaps not surprising to note that although 2 032 km of Shinkansen were constructed before 1987, only 588 km have been developed since, although a further major expansion (of 779 km) is currently under way.

An issue that may emerge in certain countries, particularly those that have gone for a 'big bang' expansion of the HSR network through debt financing, is the crowding-out of investments in other economic sectors, through a shortage of capital and high interest rates. Wu and Rong (2013) highlight this issue with respect to China. The Ministry of Railways (MoR) debt has increased from 470 billion RMB[17] in 2005 to 2.4 trillion RMB in 2011, and could reach more than 4 trillion RMB in 2015. MoR interest payments have increased from 39 billion RMB in 2005 to 275 billion in 2011, accounting for 55% of revenue in 2011. The MoR debt:asset ratio increased from 37.53% in 2005 to 60% in 2011. Wu and Rong draw a parallel with Japan where they claim JNR debts were equivalent to 10% of GDP by 1987, although this was largely due to high labour costs and over-manning on the rail system as a whole rather than the Shinkansen investments.

17. As of January 2014, the market exchange rate was one RMB (Renminbi or Yuan) equals 0.12 Euros.

## 7. Indian context

Indian Railways is one of the major carriers of passenger traffic in the world, with the golden quadrilateral (Delhi – Kolkata – Chennai – Mumbai) linking the four main cities in India. However, the distances involved between the cities in this core market (between 1 400 and 2 200 kms) are too great for HSR to permit day return trips. Instead, there have been preliminary studies of seven shorter corridors on the quadrilateral or with spurs off it. Of these, Mumbai – Ahmedabad and Chennai – Bangalore – Coimbatore have emerged as favourites. Pre-feasibility work on Mumbai – Ahmedabad indicates that rail currently only has a 28% modal share (the same as for car), with bus having a 34% share (and with luxury bus having higher fares than rail) and air a 10% share (but growing very quickly). However, HSR could reduce journey times from 6 hours 45 minutes to 1 hour 52 minutes. Initial demand estimates are for 12 million passengers per annum and a financial internal rate of return of 12.8%, despite relatively low fares, although this could be affected by appraisal optimism. Construction costs are estimated at EUR 15 million per km. Particular issues for India include the need for a segregated right of way, so to prevent incursion from road traffic, pedestrians and animals, which may be difficult to achieve at grade, hence a likely need for elevated structures. There is also the issue of choice of gauge as broad gauge is the norm. This might suggest the need for a largely freestanding standard gauge system or alternatively development of broad gauge high speed trains just for the Indian market. The other issue is the number of competing demands for rail investment. The conventional network currently has top speeds of around 130 kph, so a move to a semi-HSR of 160 – 200 kph has some appeal. Dedicated freight corridors are being developed (including the western corridor between Delhi, Ahmedabad and Mumbai), whilst passenger network expansions are also being considered.

At least four delivery options might be considered for HSR in India: conventional public procurement; a Design Build Finance Operate Transfer (DBFOT) PPP (either bundled or unbundled); public procurement involving Government-to-Government cooperation and funding assistance from multilateral/bilateral agencies; and public procurement with Government-to-Government cooperation but also a 15 – 20 year concession for operation and maintenance.

For India, the demand side was not seen as a problem at the roundtable, with substantial traffic generation possible and Say's law applying – if you create the supply the demand will come, although there will be constraints on the level of fares charged. HSR investment was seen as more of a political problem – and a national HSR policy is therefore needed and possibly one that takes HSR away from the Government which will be reluctant to fund what might be perceived to be an elitist project and even if it did it would require public ownership and control which could lead to fares being kept too uniformly low. HSR investment in India may also be dependent on reforms in financial markets to permit the development of tradable bonds.

## 8. Conclusions

Overall HSR is seen as more than a hardware investment challenge – the development of accompanying 'soft' measures will be crucial. The key objectives for HSR remain speed and large scale capacity increases, both for conventional rail and other competing transport systems. Wider economic benefits, in terms of the strengthening of central cities and via redevelopment, are also important. Increases in productivity through agglomeration effects can be significant where capacity is released on conventional lines with crowded commuter services. HSR may be a component of proactive urban planning to structure development of new centres of economic activity around HSR stations in rapidly growing metropolitan areas. However, it is likely that most of this economic development will be abstractive rather than generative.

There are a number of subtly different HSR schemes around the world and the spatial and temporal transferability of indicators of the performance of these schemes requires further study. However, it seems likely that optimal HSR schemes are context specific, driven principally by a combination of economics, politics and geography. The ideal geography for HSR has often posited to be major city pairs around 500 km apart (as with Paris - Lyon) but HSR can serve both longer distance and short distance markets and it may be that a more ideal configuration is where there is a string of large cities along a route (as in Japan).

Alternatives to HSR should be considered, in particular the upgrade of classic rail, alternative technologies such as the Maglev system being proposed by JR Central for Tokyo–Nagoya and competing investments in upgrading the aviation and road sectors. These do-something else options need to be given detailed consideration in assessments of net present value and cost effectiveness of public spending. Where such alternatives have been considered (e.g. classic rail upgrades in the UK) they tend to be smaller investments and have higher benefit cost ratios but incremental analysis (that looks at the differences in costs and benefits between HSR and classic rail investment) still indicates that the larger HSR investments are worth taking forward (Nash, 2013c) and this may be in a situation where the disruption costs of classic rail improvements are difficult to estimate.

A four stage test may be considered for HSR investments. First, does the HSR make a commercial return? If so, arguments concerning HSR being an elitist investment are redundant. Returns can be reinvested in other social projects or the project can be financed and operated by the private sector. However, there seem to be very few HSR schemes that have made a financial return, with the Tokaido Shinkansen and the TGV Sud-Est being notable exceptions, with Gourvish (2010) reporting that in the case of the latter, the capital investment was fully amortised after 12 years. Secondly, does the HSR investment make a social return, based on rail transport benefits only? This is the basis of the social break-even approach discussed above which postulates 9 million passengers in the first year of operation as a key break-even threshold. It appears that many, but by no means all, current HSR schemes may achieve this pass-mark. However, this approach is based on an assumption of a pass-mark BCR of 1. With constrained budgets, opportunity costs might mean that a BCR higher than 1 is required, with the UK focussing on 2 as a key threshold until recently, whilst Germany uses 3. This is a tougher test and as a result will require either higher demand levels or compensating non-rail transport benefits. This leads to a third test, does the HSR make a social return including quantified impacts on other transport systems (air and road) and wider economic benefits? These benefits have been important in establishing the case for HS2 in the UK. Lastly, does HSR have social returns when qualitative wider benefits are taken into account? This may include the role of HSR in nation building (although in the case of Spain, Bel (2012) argues this has an unsustainable economic cost) or as a spur to the development of indigenous technology and modernisation of the economy (China and, possibly, India). In all of these tests, a key metric is the level of passenger demand, with gravity model formulations providing a useful basis for high level strategic forecasts in advance of subsequent detailed modelling estimations.

An important issue is the spatial level and intensity at which such a set of HSR investment tests are undertaken. The SNCF economist, Michel Walrave, has been attributed by Crozet with commenting that stopping the last HSR line to be built is even more difficult than getting the first HSR line built. This suggests that HSR investments should be considered at a network level. The best lines should be identified and then the network evolution planned. It seems likely that line extensions can exhibit economies of scale, e.g. the extension of the TGV south of Lyon or of HS2 north of Birmingham. However, the development of brand new lines may rapidly exhibit diseconomies of scope. This in turn suggests a step-by-step approach to HSR investment may be more appropriate than a big bang.

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