**Direct and Indirect Effects of High Speed Rail**

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1. **Background and Introduction**

This chapter draws on an International Transport Forum Round Table that considered the economics of investment in High Speed Rail (HSR). This Round Table included presentations from China, Chinese Taipei, France, Italy, Korea, India, Japan and UK, along with a summary and conclusions paper (Preston, 2014)[[1]](#footnote-1). This work has been updated here with respect to recent developments, particularly in the UK, along with a more detailed consideration of the role of wider economic benefits.

In the rest of this introductory section we will briefly define HSR, posit four key classifications and examine the global extent of HSR. In section 2, we will assess the objectives of HSR schemes and their key costs and benefits. We will make a key distinction between direct and indirect effects. We will define direct effects as the traffic impacts of HSR services. We will define indirect effects as the traffic impacts on non-HSR services (air, car, classic rail, coach) as well as the non-traffic impacts, principally related to economic development, but also to environmental and social impacts. In section 3, we will outline the key demand and supply (cost) features of HSR. In section 4, we will examine the balance between costs and benefits and the role of wider economic benefits. In section 5 we will review the recent experience of HS2 in the UK, before drawing some conclusions in section 6.

In defining HSR, we use the definitions of EC Directive 96/48, itself derived from the work of the International Union of Railways (UIC) (CEC, 1996). HSR services are thus those operating on dedicated new lines capable of operating speeds of 250 kph or more or on upgraded existing lines capable of speeds of 200 kph or more. However, the work of Campos et al. (2009) indicates that there are four broad types of HSR, as illustrated by Figure 4.1, each of which might be expected to have a different mix of direct and indirect effects.

**< FIGURE 4.1 HERE >**

Model 1 (Exclusive exploitation) is where there is separate infrastructure for HSR and classic rail. This is the model used by the initial Shinkansen services in Japan from 1964, but Japan has moved away from this model with the development of the mini-Shinkansens from 1992, with HSR operating on conventional alignments that have been enhanced to standard gauge. We might expect that the direct impacts of HSR are maximised under the exclusive exploitation model. Model 2 is referred to as mixed high speed. This is still a predominantly segregated system but with high speed trains occasionally using conventional tracks, in particular to access central rail stations. This was the basis of the French TGV system developed from 1981 onwards. Model 3, mixed conventional, permits conventional trains to use high speed tracks, so that other cities off (or beyond) the HSR route can be served. This was the essence of the Spanish AVE system developed from 1992 onwards, permitting cities such as Malaga to be served off the HSR trunk route between Madrid and Seville. Model 4, fully mixed, allows complete interchange between high speed and conventional services, both for passenger and freight. This is the basis for the German ICE network developed from 1988 onwards. It might be expected that the indirect impacts of HSR are maximised under this model.

At least, three further nuances to this categorisation might be added. The first relates to the location of termini and intermediate stations. These may be in established central termini (London St Pancras, Paris Gare du Nord and Gare du Lyons), in new locations on the edge of the central area (Shin Osaka, Lyon Part-Dieu, Eurolille) or at the edge of the city itself (typical in China and Chinese Taipei and also for some greenfield intermediate stations in France). It may be hypothesised that central locations will maximise the direct benefits of HSR but out of town locations may maximise indirect benefits, particularly where there is provision for car-based park and ride or scope for unlocking land for development. The second relates to the extent of grade separation and the preponderance of elevated sections and tunnels. For fully segregated systems, such as Chinese Taipei, such structures account for the vast majority of the system (and hence lead to higher costs). For mixed systems, the preponderance of such structures is much reduced (as are costs but also benefits). The third relates to the extent to which a network of HSR lines and services exist, with the expectation that direct effects will be greater, the greater the extent of the HSR network. However, so will indirect effects, with the balance between the two effects a matter of empirics.

The extent of HSR systems is shown by Table 4.1 (from UIC as of 1/9/14). Four nations (China, Japan, Spain and France) dominate the list – accounting for 80% of the HSR system build. The rapid pace of growth can be ascertained as by 1/4/15 UIC was reporting 29,792 km of HSR route in operation (up 30%). Two recent extremes may be noted. The first is the ‘build it and see’ approach of China and Spain which has led to a very rapid development of national HSR networks. The second is the ‘paralysis by analysis’ approach of the UK and the US, where there have been a large number of feasibility studies but very little in terms of system build (Perl, 2012, Preston, 2012). In between, there has been the more gradual expansion of the Japanese and French systems, albeit against a background of concern that network economies may have been exhausted (Crozet, 2013) and that further extensions will not be viable.

**< TABLE 4.1 HERE >**

1. **Objectives and Impacts**

As might be expected from what after all are mega-projects, HSR projects have multiple objectives. Of course, speeding up services (and the improved connection between places this engenders) is always present as an aim, but perhaps not as dominant as might be thought. For both the Tokaido Shinkansen and TGV Sud-Est, enhancing capacity was arguably just as important an objective and one of the most effective ways to enhance capacity for rail services is to segregate fast and slow services. In both Japan and France, promotion of national champions in the railway supply industry was also an important factor, along with Government-led initiatives to modernise the sector. In France, an important prestige factor was associated with the desire to establish leadership of the supply industry at the European level and the development of export markets (e.g. Korea). For Italy and the UK, where there are perceived (and actual) problems with the reliability of conventional services, the reliability of HSR is an attraction.

**< TABLE 4.2 HERE >**

For both China and Spain, HSR has been seen as an important tool for nation-building and political integration (Albalate and Bel, 2012)). In China, Chinese Taipei and the UK, HSR has been argued to bring wider economic benefits. In the UK, this is often cast in terms of re-balancing regional economies, attracting development to more peripheral regions from the core region of London and the South East as a result of better connecting places. In China and Chinese Taipei, it is more about developing new areas of urban growth around out-of-town HSR stations – and hence may be more associated with expanding places (Leunig, 2011). The environmental credentials of HSR have also been pushed, most notably at COP15 in Copenhagen in 2009 (Oxera, 2009). In the UK, HS2 was originally promoted as a tool in reducing carbon emissions, although this would depend on reducing the carbon intensity of electricity generation and the embodied carbon in construction and on maximising abstraction from air and car. What seems clear from the above, is the over time the indirect effects of HSR have been perceived to become relatively more important.

An impact matrix for a typical HSR scheme is given by Table 4.3. To simplify matters a vertically integrated monopolist is assumed. In reality, infrastructure and operations are likely to be vertically separated and horizontal separation means there could also be competition between HSR operators, as exists at the time of writing in Italy and Sweden. Similarly, we assume only one governmental body – typically of a highly centralised state. In reality, devolution means that Regional and Local governmental bodies will also be involved – which is particularly a feature of mature systems in France and Japan.

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For rail operators, the key costs relate to the construction and operation of HSR and are thus a direct impact. For a horizontally integrated rail operator, operating costs will include adjustments to classic rail services. Horizontal separation adds further complexities and increased scope for competition. A rail operator may receive support from Government in terms of capital grants and (less commonly) operating subsidies, although these are pecuniary transfers. 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 from HSR users but where the industry is vertically integrated and outputs are diversified (as in Japan) may also come from commercial developments in and around HSR stations. This is again a direct impact. 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 as a result of the competitive response by the operators of these rival modes or services. 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 with respect to the wider economy applies to generated revenue. An alternative approach is to directly estimate the cost reductions of the other modes or the changes in government support for such modes where they are state controlled (e.g. state owned airlines).

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 but higher where motorways are free at the point of use. Intermodal comparisons may be distorted by indirect taxation. In particular, motoring is usually more highly taxed than rail travel.

HSR users benefit from the increased reliability, speed and comfort of services (including the guarantee of a seat in pre-booking systems) 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, although more precise estimation techniques (such as numerical or direct integration) are preferable (Nellthorp and Hyman, 2001). This is another direct impact.

Overall, it may be expected that there are benefits to other users of the transport system, largely due to congestion relief. These are indirect impacts. On classic rail, where there is latent demand, as is believed to exist in London and South East England, released capacity may permit enhancements to commuter and regional services, increasing frequencies and reducing overcrowding, which will have also reduced due to transfers to HSR. Some train paths may also be released for rail freight services. However, where large amounts of classic rail demand are abstracted by HSR, there will be reductions in the frequency of classic rail services, possibly initiating a spiral of decline. Intermediate stations that are by-passed by HSR may particularly suffer reductions in service, as initially occurred in the cases of Arras and Dijon in France, although in both case service levels have subsequently been strengthened. On the road system, there may be reduced congestion due to some modal shift to both HSR and classic rail services, although these benefits may be limited where origins and destinations are dispersed. 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 (and social) 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.

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 to more lightly taxed rail. These may be interpreted as direct impacts.

Costs and benefits to wider society may be classified in three indirect impact categories related to the sustainability concept. Firstly, environmental benefits may relate to reductions in emissions of carbon and other air pollutants but there may be issues along HSR routes with respect to noise and vibration, land take (and the resultant impacts on biodiversity and on water courses), severance and visual intrusion.

Secondly, the main social impact is likely to be the 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. Pagliara et al. (2016) also highlight that HSR may engender social exclusion and fieldwork suggests that geographical exclusion is an issue in Italy, whereas economic exclusion is a feature in the UK. This in turn suggests that the higher fares in the UK are having an exclusionary effect.

Thirdly, 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 (Mohring, 1993). Another economic impact is the shadow price of public funds, which largely arises due to the distortion effects on the economy of taxation. 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 some countries (e.g. Sweden) this deadweight loss is taken into account explicitly, in others (such as the UK) it is taken into account implicitly by looking for a Benefit Cost Ratio of at least 1.5, although this is also driven by the opportunity cost of alternative investments.

1. **Demand and Supply**

In an Appendix, 52 data points on the usage of HSR schemes of varying degrees of maturity are presented. The mean usage is 26.0 million passengers per annum, but there is considerable variation as indicated by a standard deviation of 23.4 million. Factors that might explain this demand include: the size of cities served (in terms of population and income), distance, speed, service frequency, fares, station accessibility, competition and time since opening – with long build-ups over time being a feature. Cultural factors may also be a factor, with national boundaries tending to deter traffic as may regional borders (e.g. between Catalonia and Castille in Spain). For example, Shires (1998) estimated that for the European Union crossing a national boundary reduced passenger traffic by between 30% to 60%.

For day trips, a travel time (one-way) of three hours is recognised as a key threshold. The journey time difference between rail and air will be approximately two hours (although that can be considerably narrowed when check-in and access/egress times are taken into account). Around this level, the mode split between air and rail is around 50:50. Where the time difference is less rail share increases sharply, in extremis eradicating air as a mode (e.g. Paris – Brussels). This pattern may be replicated by an S-shaped logistic curve (see, for example, Esplugas et al., 2005).

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Table 4.4 shows that sources of HSR traffic are context specific, varying from scheme to scheme and according to the definition of what constitutes generated travel (e.g. the treatment of re-distributed traffic), 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 (such as China), 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. Indirect effects might be expected to be greatest where there is substantial abstraction from car, such as for the Thalys services.

Given the amount of grade separation required HSR has substantial capital costs. Campos et al. (2009) estimate a mean construction cost of €22 million per km (2005 prices) and a standard deviation of €10 million. More generally, these costs may vary from below €10 million per route km (in China) to over €100 million per km (in the UK, for the HS1 approaches to London). Factors that explain these variations include wage rates, land costs, the extent of planning regulations and of health and safety regulations, the quantity and type of structures (in turn related to topography and geology), track type (slab compared to ballast) and operating speeds. In China, increasing speeds from 250 to 350 kph appeared to lead to a near doubling of capital costs per route km (Wu, 2013).

There are also considerable variations in operating costs which are again substantial with infrastructure maintenance around €100,000 per track km per annum and train services costs (capital, operating and maintenance) around €0.06 per seat km. Rolling stock acquisition costs may vary between €33,000 to €65,000 per seat. Overall, 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 to some extent. To the extent that higher costs reflect higher service quality, they should be associated with greater direct and indirect effects, with the balance again a matter for empirical study.

Track access charges and prices should equilibrate demand and supply but HSR is rarely operating in perfectly competitive markets and government intervention is the norm. This partly explains the large variations in HSR prices, for example €0.20 per passenger km for the Tokaido Shinkansen, €0.12 for TGV Sud Est and €0.06 in China. There are similar variations in track access charges, typically varying between 25% to 45% of HSR revenues, depending on the emphasis placed on full cost recovery. In pricing, it is important to distinguish between the revenue yield approaches typified by SNCF (France) and Eurostar and the more traditional mileage charge plus supplement typified by DB (Germany) and JR (Japan). The former might be seen to be an attempt to implement perfect (first order) price discrimination, the latter an attempt to implement multi-part tariffs. As a result of the variations in prices there will also be variations in load factors. Typically they will be quite high - such as the 70% achieved by TGV service in France. In Germany, a load factor of 50% is more typical for ICE services, although this is due in part due to the shorter distance between city pairs and the greater churn this engenders. Another important factor is the extent of competition. The head-on competition between Trenitalia and NTV in Italy has reduced average fares by 30% (Croccolo and Violi, 2013). Clearly higher prices and track access charges will reduce the direct and indirect effects of HSR,

1. **Cost, Benefits and Wider Economic Benefits**

One approach to HSR appraisal that has been championed by de Rus, drawing on his extensive experience of undertaking cost-benefit analyses of HSR in in Spain (de Rus and Inglada, 1997, de Rus and Nombela, 2007, de Rus and Nash, 2009, de Rus, 2012), is to develop iso-welfare curves for HSR investments. This approach is illustrated by Figure 4.2.

**< FIGURE 4.2 HERE >**

These iso-welfare lines illustrate the value of first year time-savings required to cover investment costs, given a fixed level of demand and assumptions concerning the amount of generated traffic and the annual rate of growth of benefits. For example, suppose we assume mean construction costs of €22 million/km (as above) and a value of time of around €25.5 per hour, based on latest UK values, assuming 50% business/50% leisure (DfT, 2015). If we also assume a mean time saving 90 minutes for a 500 km journey (and this would be substantially less for traffic abstracted from air – see for example Oxera, 2009) this would give a value of time savings of €38.25. These calculations of time savings are on the generous side but reflect that less than 50% of non-revenue benefits may be attributed to reductions in train journey times (see Table 4.8). Under such a set of assumptions, the break-even ridership would be in excess of 9 million abstracted trips and almost 11 million trips in total – substantially in excess of the levels achieved in Spain, but not elsewhere in the world.

However, it has long been postulated that HSR may have additional economic benefits that are not captured by a conventional cost-benefit analysis – these are referred to as wider economic benefits. For example, Blum et al. (1997) highlighted the importance of reductions in imperfect completion in transport using sectors, the promotion of economics of scale and agglomeration benefits and the benefits from regional rebalancing.

**< FIGURE 4.3 HERE >**

As Figure 4.3 indicates, there may be potential gains from trade from connecting places that are not accounted for in a conventional cost-benefit analysis that assumes perfect competition (Dodgson, 1973). Assuming a transport-using sector is monopolised, private benefit will be determined by the marginal revenue curve and the private benefits of a transport related cost reduction in a transport-using sector will be denoted by the areas A and B. However, this neglects the social benefits of expanded trade given by the quadrilateral C. These gains may be particularly large where transport promotes competition and/or permits specialisation and hence increased outputs. However, HSR has little impact on freight, which might be expected to be the main driver for changes in competition in primary and secondary economic activities but HSR can have important impacts on business passenger travel, which will be important for tertiary and quaternary economic activities. In the UK, these benefits are measured by an uplift on business travellers’ time savings and account for around 32% of full network wider economic benefits for HS2 (see Table 4.8).

**< FIGURE 4.4 HERE >**

There may be additional economic benefits from expanding places e.g. expansion of the City of London into Docklands or by expanding a city’s suburbs. In Figure 4.4, it is assumed that there is a post-tax wage gap between the higher wages in an urban area and the surrounding rural areas, but that this diminishes with city size. At prevailing commuter costs, the number of workers in the city is given by X. If commuting costs reduce, this increases to X\*. The conventional benefits to existing commuters are given by the area α and those to generated commuters are given by the area β. These benefits are included in a conventional cost-benefit analysis. However, there are additional benefits related to the additional income tax raised (ε) and the increased productivity (δ). As can be seen from Figure 4.4, the benefits could be substantial but HSR has limited direct impact on commuter markets – although there are exceptions (e.g. Ciudad Real in Spain). For HS2, such benefits are estimated based on a methodology developed by Graham (2007) that determines productivity gains based on an elasticity with respect to a city’s effective density (in essence a measure of mass). Agglomeration benefits are found to account for around 63% of full network wider economic benefits for HS2.

However, for a scheme like HS2 these benefits are largely as a result of improvements to the classic rail network and enhancements to commuter services to London and the other major cities. 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. 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 in the UK 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. KPMG inferred a causal relationship between productivity and rail connectivity and estimated that this could lead to benefits of £15 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 several orders of magnitude different from the theoretical estimations of Graham and Melo. The £15 billion per annum compares to the gross benefits (excluding indirect tax adjustment) of around £74 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. The KPMG methodology thus seems to give much higher estimates of benefits that many may consider implausible. If £15 billion per annum is discounted over 60 years in a similar manner then a present value of benefits of around £398 billion, some 5.4 times the original estimate, is obtained.

Venables et al. (2014) speculate that there may be further socio-economic benefits of increased employment. In Figure 4.5, there are two thresholds for transport costs to permit economic development and hence employment: T\* (Site 1) and T^ (Site 2). At Site 1, the social benefits of development are above the private benefits. At Site 2, the social benefits of development are below the private benefits. Reducing transport costs to permit development of site 1 will unlock additional social gains: examples might include non-marginal changes in land prices, improved coordination between complementary firms and improved coordination to reduce low level skills traps and the discouraged worker effect. Reducing transport costs to permit development of site 2 will lead to some additional social losses (and too much development) due to business stealing.

**< FIGURE 4.5 HERE >**

However, HSR may have limited regeneration potential. For example, for HS1 the development of Ashford and Ebbsfleet has been slow and has stalled since the economic down-turn of 2008 (Preston and Wall, 2008, Atkins et al., 2015). Development at Stratford has been more substantive but can be related to intra-urban transport investments such the Jubilee Line, Docklands Light Rail and Crossrail. For HS2, these employment benefits account for 5% of the full network wider economic benefits, although HM Treasury remains sceptical of such benefits given an assumption of full employment. These benefits could be more substantial in economies characterised by widespread under- or un-employment. There could also be a danger that the employment created by HS2 is typified more by site 2 than site 1 and these benefits are hence negative.

Table 4.5 brings together some of the evidence on wider economic benefits from a number of rail studies. This gives a range of additional wider economic benefits compared to traditional benefits of between 13% and 80%. Empirical work for the Eddington Review suggests multipliers on BCR of 1.09 for international gateways and 1.07 for inter-urban corridors, compared to 1.24 for urban networks (Eddington, 2006). This suggests a multiplier for HSR towards the bottom end of the range given in Table 4.5.

**< TABLE 4.5 HERE >**

1. **Case Study: HS2**

Although the UK is something of a laggard in terms of HSR, it has a long and well documented history in appraisal and evaluation. The only existing service is High Speed 1 (HS1), between the Channel Tunnel and central London, developed as a Public Private Partnership, with London and Continental Railways (LCR) given the award in 1996. The railway itself opened in two phases in 2004 (from the Channel Tunnel to mid-Kent) and in 2007 (from mid-Kent to central London), with domestic HSR commencing in 2009. The out-turn project costs were £6.2 billion for 108 km of new line, 18% over budget and some 11 months late. The National Audit Office estimated an ex-ante Benefit Costs Ratio (BCR) of 1.5 in 2001(1.75 if regeneration is included – implying a multiplier of 1.17) and an ex-post BCR of 0.8 in 2012. A more recent evaluation by Atkins et al. (2015) estimates a BCR of 0.53 without wider economic benefits and 0.64 with wider economic benefits (implying a multiplier of 1.21), in part due to additional financing costs of £4.8 billion in present value terms and 2010 prices.

Despite the problematic nature of HS1, the UK Government has continued to examine the case for HSR linking London to Birmingham and onwards to Leeds and Manchester. Somewhat inevitably this has become known as HS2 and has been subject to a series of cost-benefit analyses – three of which are presented in Table 4.6.

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It can be seen that the initial appraisal for Phase 1 (London to Birmingham) in 2010 resulted in a standard BCR of 2.4, which increased to 2.7 when wider economic benefits were included (implying a multiplier of 1.13). However, subsequent analysis in 2012 indicated that capital costs had been under-estimated and benefits over-estimated, with the BCR reducing to 1.4 (1.7 if wider economic benefits are included – implying a multiplier of 1.21). The rise in costs was partly associated with environmental mitigation measures. Further estimates in 2013 gave the same BCRs, albeit with higher costs and benefits and with a change in the treatment of indirect taxes, which were now treated as a benefit change and hence appeared on the numerator in the BCR calculation.

Figure 4.6 gives the investment curve for the project. Major construction is scheduled to start in 2017, following completion of Crossrail – continuity of work for the civil engineering industry is a factor here. It can be seen that expenditure for Phase 1 (London to Birmingham) peaks in around 2019, whilst that for Phase 2 (Birmingham – Leeds/Manchester) peaks in 2021. Phase 1 is scheduled to open in 2025, with Phase 2 opening in 2031, although there are plans to bring some sections of Phase 2 (Birmingham – Crewe) forward in time. Benefits in Present Value terms are forecast to increase up to 2036, but are then capped to be constant in undiscounted terms.

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**< TABLE 4.7 HERE >**

Table 4.7 gives some more details of the breakdown of costs and benefits in 2013. It can be seen that the full network is more beneficial than phase one – indicating some network economies exist, at least initially. In addition, it is noticeable that over two-thirds of transport user benefits accrue to business users.

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Table 4.8 indicates that around 70% of the full network transport benefits can be classified as direct, associated with reduced journey times, improved reliability and improved access and interchange as a result of a number of new stations, whilst 30% may be classed as indirect, related to impacts on the classic rail network (due to reduced waiting time and overcrowding) and reduced congestion on the roads.

Whilst the initial analysis in 2010 was based on a deterministic point estimate, subsequent analysis has been probabilistic. For example, Figure 4.7 shows that there is a 65% chance that the Phase 1 scheme will exhibit medium value for money (BCR>1.5).

**< FIGURE 4.7 HERE >**

The National Audit Office (2013) has raised concerns about the initial cost-benefit analysis, unclear objectives and project management. There have been particular difficulties in modelling competition (especially within rail) and realistic pricing policies. The primacy of travel time savings has come under particular scrutiny. One line of argument, associated with David Metz (Metz, 2008), is that time savings have little meaning if there is a constant travel time budget, with higher speeds dissipated by longer trips. The counter argument is that the increased travel distances that HSR permits allows a better matching of people with economic activities and, assuming perfectly competitive markets, these benefits will be accurately reflected by time savings. Given the ability to use time productively on trains (Lyons et al., 2007), there are concerns about whether the values of time for business users are too high, particularly those abstracted from classic rail. Moreover, strong growth in business travel in the recent past may have been due to changes in company car taxation (Le Vine and Jones, 2012) and this may be one-off increase. There also might be concerns over competition from ‘disruptive’ technologies, whether they are autonomous road vehicles, video conferencing or car sharing.

1. **Conclusions**

Overall, we conclude that there is a reasonable body of evidence on the direct and indirect impacts of HSR, that these costs and benefits are substantive and that the balance between costs and benefits will be context specific. Given this evidence, we suggest a four stage test for HSR.

1. Does HSR make a commercial return? Based on Crozet (2013), the key patronage threshold seems to be around 20 million passengers per annum. From the Appendix, we find that 22 schemes (or combination of schemes) pass this threshold, some 42% of our data set. The majority of schemes in this category are from East Asia, although the TGV Sud-Est is a notable exception.

2. Does HSR make a social return based on impacts to the rail system? Here we suggest the key demand threshold may be around 9 million abstracted passengers per annum. However, this is based on relatively generous assumption of the proportion of end to end users, the magnitude of time saving benefits and the value of travel time. Ignoring the issues surrounding trip generation, we find that 35 of the schemes in the Appendix pass this threshold (67% of the data set).

3. Does HSR make a social return when quantitative benefits to the rest of the transport sector and wider economic and environmental factors are taken into account? In such circumstances, we might expect a lower threshold. However, our review of the evidence suggests that this uplift in wider benefits for HSR may only be 25%, reducing the annual demand threshold to around 7 million. We find 39 of the schemes in the Appendix pass this threshold (75%).

4. Does HSR represent a social improvement when other qualitative factors are taken into account? There may be circumstances where demand is so low and or costs high, that no conventional cost benefit analysis will show a social return. Examples include the AVE in Spain and the Channel Tunnel. For the former, De Rus (2012) found BCRs of 0.66 and 0.58. For the latter, which is not exclusively an HSR project, Anguera (2006) found a BCR of only 0.38. From the above, we can infer that something like one in four HSR schemes fall in this category, with a particular concentration in Europe.

With respect to delivery, HSR schemes that pass tests 1 or 2 may be amenable to Public Private Partnerships based on a stand-alone model (where revenue risk is borne by the private operator). For those that go-ahead based on passing tests 3 and 4, a services sold model (in which the revenue risk remains with the public sector) is more likely.

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*Appendix 1: Database of HSR Demand*

|  |  |  |  |
| --- | --- | --- | --- |
| **Source** | **Line/**  **City Pair)** | **Level of Demand**  **(m pa)** | **Year.** |
| Nash, 2013  (Table 3.2)                  NAO (2012) (In Nash, 2013)  Kurosaki, 2013 (Table 2 and Table 5)  Wu (2013)                              Croccolo and Violi, 2013.  Chang, 2013  Jun, 2013  Ortega et al.  (2016)  Beria (2015) | TGV Sud Est  TGV Atlantic  TGV Nord  TGV Connexion  TGV Rhone-Alpes  TGV Mediterrane  Madrid Seville  Madrid Barcelona  Tokyo – Osaka  Seoul - Busan  HS1 International  HS1 Domestic  Tokaido & Sanyo  Tohuku  Joetsu  Hefei – Nanjing  Beijing – Tianjin  Qingdao – Jinan  Shi – Tai  Hefei – Wuhan  Coastal HSL  Wuhan – Guangzhou  Zhenghou – Xian  Chengdu –Dujiangyan  Shanghai –Nanjing  Shanghai – Hangzhou  Nanchang – Jiujiang  Changchun – Jilin  Hainan East Circle  Beijing - Shanghai  Italy HS Network  Chinese Taipei HSR  G-Line (Gyeongbu)  H-Line (Honam)  Madrid – Barcelona  Madrid – Seville  Madrid – Valencia  Turin – Milan  Milan – Bologna  Bologna – Florence  Florence – Rome  Rome - Naples | 19.2  29  20  16.6  18.5  20.4  3.6  5.4  80  28  9.7  8.4  128.3 (207.4)  24.1 (76.1)  11.3 (34.8)  21.3  21.0  28.0  22.6  11.0  15.1  19.7  5.8  4.7  29.2  28.3  30.2  8.4  6.4  24.8  Over 12.1    36.6  22.2 (39.1)  4.2 (7.3)  5.2  2.8  2.4  1.5 (4)  6.5 (13)  11 (18)  9.5 (17.5)  3 (7.5) | 1987 \*  1995 \*  1994  2000 \*  1995  2001  1998 \*  2009  1970 \*  2010 \*  2011  2011  1984 (2011)  1984 (2011)  1984 (2011)  2012  2012  2012  2012  2012  2012  2012  2012  2012  2012  2012  2012  2012  2012  2012  2012  Average 2007 – 13.  2004 (2011)  2004 (2011)  2011  2011  2011  2011 (2013)  2011 (2013)  2011 (2013)  2011 (2013)  2011 (2013) |

1. See: http://www.internationaltransportforum.org/jtrc/DiscussionPapers/jtrcpapers.html [↑](#footnote-ref-1)