

High Speed Rail, Transport Investment and Economic Impact

A paper written for HS2 Ltd on the economic impacts of HS2,
by Bridget Rosewell (Volterra Partners) and Tony Venables (University of Oxford).

Contents

1	What might HS2 do?	1
2	Expanding places	3
3	Connecting places	4
	3.2 Goods and services to market	5
	3.3 Specialisation and productivity	6
4	Evaluation and the evidence base	9
5	References	12

1 What might HS2 do?

- 1.1.1 This paper focuses on the impact of new railway investments in the UK, in particular HS2. The UK is a relatively small country with an existing high density railway network providing both intercity and commuter networks. These are carrying record numbers of passengers and trains so that additional capacity is necessary to meet demand. Previous analysis and experience has shown that upgrading the existing network to meet demand is both extremely disruptive, costly and can only add limited capacity.
- 1.1.2 We therefore start from the proposition that new capacity is required. Such new capacity can also be designed to operate at higher speeds to reduce the effective distance between cities. The paper looks at how to assess the potential benefits of higher speed and higher capacity connections between cities by rail.¹
- 1.1.3 A new high speed network between cities in the UK would:
- Reduce times between city centres (and edge of cities)
 - Increase capacity between cities
 - Shift mode share for existing trips
 - Free up train paths on the existing network for commuter and freight trains
- 1.1.4 These effects are not well modelled in the existing historical or policy literature. The proposals consist of a significant and costly change to an already well developed system. This is distinct from the initial introduction of a new system – rail in the nineteenth and roads in the twentieth century – on which the longer term historical analysis has necessarily concentrated. But the current system was designed for an age with a quite different technology and pattern of economic activity. Responding to changing economic circumstances requires greater flexibility and capacity in underlying infrastructures (not just transport) and hence what might be described as extra-marginal changes.
- 1.1.5 The challenge therefore is to identify the benefits of reinvestment in an existing system which also changes that system in a significant and structural way. The addition of new capacity at new speeds is distinct from investment in, for example, re-signalling of the existing rail system. While re-signalling is also a large project, it has direct cost saving implications which can be directly evaluated; the implied capacity and speed changes are marginal (even when substantial) and will not change the basic nature of the services. Conventional cost benefit analysis (CBA) provides the logical framework for evaluating investments of this type.

¹ It is also of course possible that road investment could be used to achieve this. We assume that this is ruled out by considerations of climate change, and by congestion impacts in city centres.

- 1.1.6 The new rail system to be put in place by HS2 is sufficiently different from the current network to be extra-marginal and potentially disruptive of existing patterns of social and economic behaviour. It has the potential to cause a spatial re-organisation of economic activity which can unlock efficiency gains and thereby bring additional economic benefits, the regional distribution of which is uncertain. These effects are on top of those captured by standard CBA (and are sometimes termed 'wider benefits'), as they may change efficiency and productivity not just for those who travel, but also for those affected by the changing pattern of economic activity.
- 1.1.7 A useful distinction about the effects of better transport connectivity is drawn by historian Tim Leunig: "What history teaches us is that transport matters when it connects up two places that are synergistic, or when it allows a confined place to grow. The creation of the Silk Road, the discovery of the New World, and connecting the Midwest to the East Coast all come in the former category. Expanding the City of London falls into the second, which is generally a rarer category"².
- 1.1.8 The wider benefits of investments that 'allow a confined place to grow' have been recognised and formally included in transport appraisal. The initial context was Crossrail³, and the UK Department for Transport's WebTAG methodology includes an assessment of agglomeration benefits arising as more commuting capacity enables more economic activity to take place – at a high level of productivity – in city centres. We review these arguments in section 2.
- 1.1.9 HS2 is not primarily about improving commuting access to city centres, but is about connecting different centres. However, the full impacts of 'connecting places that are synergistic' have received less attention and are not included in the formal appraisal of HS2. Yet wider benefits may be at least as important for a 'connecting places' project as they are for an 'expanding places' project.
- 1.1.10 Section 3 of this note develops the arguments for the wider benefits of connecting places. A number of mechanisms are important, some similar to those that occur in 'expanding places', and others quite distinct and based on the development of regional comparative advantages. Our emphasis is on setting out possibilities and creating a framework for analysis rather than giving definitive answers. We offer some evidence in support of the arguments although much of it is drawn from related, but different experience; the evidence base for the arguments we make needs further development. We also note that the impact of improvements in connectivity depend on other conditions being in place; a transport system may be necessary, but is rarely by itself sufficient to unlock the full range of potential benefits.

² Leunig (2011)

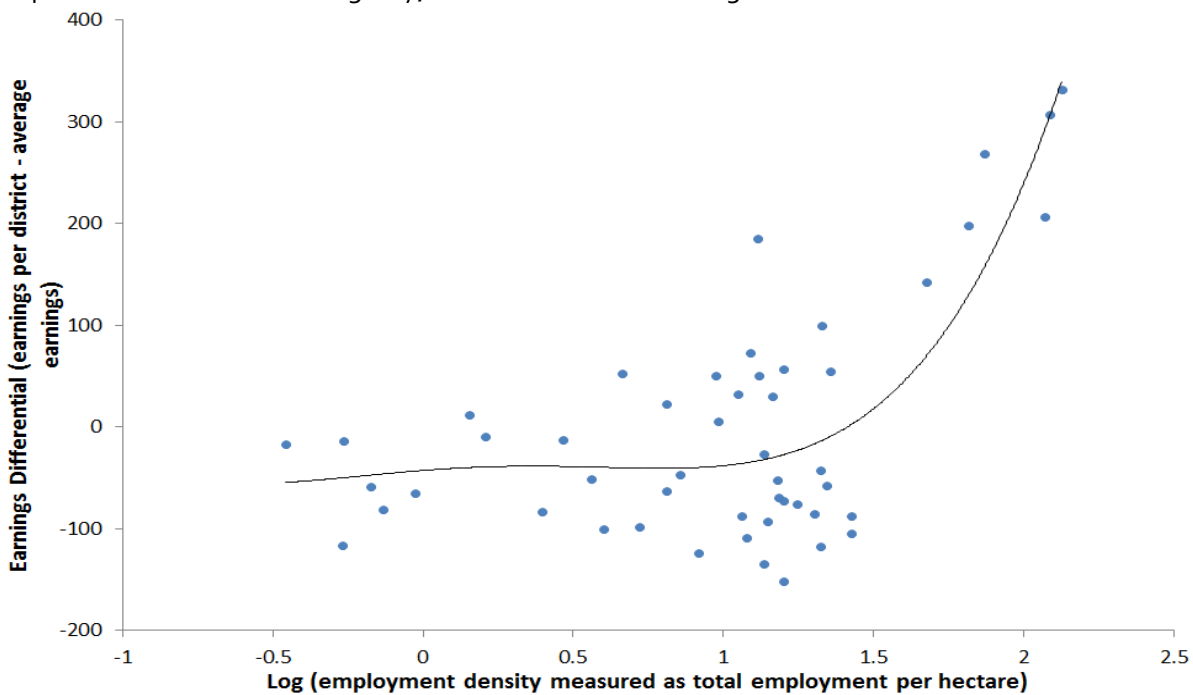
³ A 73 mile east-west rail link involving 26 miles of tunnel under central London, see <http://www.crossrail.co.uk/>

2 Expanding places

2.1.1 Transport improvement can allow more economic activity to concentrate, at high density, in a particular place. Commuting capacity enables this, giving rise to a larger and more effective labour market. This was a core argument for the investment in Crossrail. A large body of empirical work tells us that large and high density agglomerations of activity are highly productive. Figure 1 has earnings on the vertical and employment density on the horizontal, and the observations are for the highest earnings UK urban locations. There is a clear positive relationship once density hits a tipping point. Econometric estimates, much of it for the US but some also for the UK, suggest that doubling economic mass (defined as number of workers in a city or travel to work area) increases productivity by some 4-8%.⁴ This is a very large amount, when one considers the range of differences in working population across UK towns and cities.

Figure 1: Earnings Differential vs. Log Employment Density

Top 100 UK districts excluding City, Westminster and Kensington



Source: Nomis/Volterra

⁴ For a survey of international evidence see Rosenthal and Strange (2003). For the UK, see Rice et al. (2006); Graham (2007) produces sectoral estimates used in DfT processes.

- 2.1.2 The purpose of the Crossrail investment was to facilitate expansion of employment in central London, and make more jobs possible in such high density locations. The London underground system could be shown to be already crowded and expected employment growth would lead to gridlock, with potential station closures (which already happen in peak hours at some stations), and lengthening dwell times as passengers try to leave and board trains. The capacity of the stations as much as the trains and track was a major developing constraint. The agglomeration argument showed that being able to fulfil demand for employment in central London added value to the UK economy – both value in creating jobs which would otherwise be crowded out, and for existing employees likely to attain higher productivity because of the larger scale of the agglomeration. Benefits to existing employees that came from growing the London agglomeration were recognised as being central, and so were added to the cost benefit criteria.⁵
- 2.1.3 Unlike Crossrail, the primary purpose of HS2 is to connect places rather than relieve constraints on their growth. Nevertheless, some of these effects may occur. There are several mechanisms. One arises as there will probably be some commuting on HS2, even if small. Another comes as HS2 will free up space for commuter rail on the classic network. The potential is primarily in London, where commuter rail is well established. In other cities, travel to city centres is traditionally by car, and city centre employment in many northern cities was traditionally as much manufacturing as services. However, HS2 will catalyse and complement city authorities' plans to refocus their city centres. Development around stations will be promoted, and this may increase density and facilitate higher productivity.

3 Connecting places

- 3.1.1 The primary purpose of HS2 is to connect cities. Increased connectivity increases the potential for trade, whether by improving freight connections or by improving the ease with which meetings can take place. This allows a reorganisation of economic activity between places, with firms, plants and offices moving to new – and now more efficient – locations. The changes arise because better connectivity improves both 'market access' and 'supplier access'. Firms in London can access the Manchester market more easily, and vice versa.⁶ And firms in Manchester have better access to specialist intermediate suppliers and business services located in London, and vice versa.
- 3.1.2 The consequences of better market and supplier access depend on the characteristics of the places connected. If these places are different, then classical trade theory (and its modern extensions) point to economic activity relocating in line with comparative advantage, bringing the benefits of specialisation and higher productivity. If they are similar, there is still likely to be reorganisation as firms develop new ways of accessing markets and suppliers.

⁵ Department for Transport (2005). For formal analysis of CBA including these effects see Venables (2007) and for a survey Mackie et al. (2011).

⁶ We will refer to the connected cities as London (large) and Manchester (smaller), without prejudice to other cities en route.

- 3.1.3 Connectivity is necessary, but not sufficient, for such changes to occur. Whether they take place will be contingent on the ability of market participants to take up the opportunities, or the extent to which poor connectivity has constrained them. A key question is therefore whether firms and organisations in areas of increased accessibility have growth potential, economies of scale potential, and a willingness and ability to invest in these. Areas of high accessibility can still be depressed if such potential cannot be tapped. For example, Croydon has strong rail accessibility to central London, and to the M25. Yet employment in the borough has been falling for several decades as investors have found alternative locations more attractive for expansion.

3.2 Goods and services to market

- 3.2.1 Even if the places being connected are quite similar there will be trade between them, as firms in London supply Manchester and conversely.⁷ Better connectivity will tend to increase trade volumes, bringing benefits of more choice for consumers and more intense competition between firms. More efficient firms will be able to expand, possibly at the expense of less efficient ones.
- 3.2.2 If the connected places differ – in size or initial income levels – is the spatial reorganisation and trade likely to be a force for convergence or divergence? Both theory and empirical work suggest that the city with the larger economic mass (London rather than Manchester) will have higher wages and land prices. This is because it benefits from better market access, supplier access and agglomeration effects, with the empirical consequences outlined in section 3 and figure 1 above. Will better connectivity amplify or mitigate these differences?
- 3.2.3 There are opposing forces at work. Initially, firms with headquarters in one city might have served the other through branch offices. These may now close as better connectivity enables each firm to supply from a single office or plant. Closures will tend to reduce employment in the smaller location (Manchester) which was deriving proportionately more of its employment from these branch offices. But pulling in the other direction, Manchester now becomes a more attractive location for headquarters; it starts off with lower wages and rents, and improved connectivity means that it will get better access to London's large market and large base of suppliers. It is therefore likely to attract headquarters and other business activity, creating new sources of employment in the city. Combining these forces, theory suggests that better connectivity is a force for convergence.⁸

⁷ This is intra-industry trade, as explored in 'new' trade theory, Krugman (1995).

⁸ This result holds if the initial level of transport costs/ trade barriers is not too high. The standard result from economic geography modelling is that there is an inverse-U shaped relationship between trade barriers and spatial inequality, with inequalities greatest at some intermediate level of barriers. For an application of these ideas to integration in the EU see Forslid et al. (2002).

- 3.2.4 There is some empirical support for these arguments. A number of studies have looked at the relocation of business activity from New York and other major US cities to secondary cities. For example, Strauss-Kahn and Vives (2009) study the location decisions of 30,000 US headquarters, around 5% of which relocate every year.⁹ Headquarters have become increasingly concentrated in medium sized service-oriented metropolitan areas. The areas that have received most inwards moves (and moves which have not then been reversed) are those with a high level of business activity, relatively low wages and, above all, good business transport links (in the US, airports). Giroud (2013) establishes that opening an airline route which reduces travel time between a firm's HQ and a plant increases, on average, investment in that plant by around 9% and productivity by 1.3%. Studying the effect of telecommunications, Ioannides et al. (2008) argue and present some evidence that better communications have tended to promote convergence of city size.

3.3 Specialisation and productivity

- 3.3.1 The idea that trade between areas with different economic characteristics is in general mutually beneficial is one of the most fundamental insights of economics. The basic idea, which still underpins most trade theory, goes back to the great English economist David Ricardo in the early 19th century.
- 3.3.2 Ricardo illustrated his theory with a simple example of two countries, each capable of producing the same two products (cloth and wine). One of the countries, A, was assumed to be able to produce both these commodities more efficiently than the other, B. Ricardo showed that, nevertheless, both countries would be better off if they traded. The key is that each country should specialise in making the product in which it has the greatest 'comparative advantage'. In other words, it should specialise in producing the product for which the efficiency gap between the two countries is higher. Both are better off as a result, the gains from trade arising from the principle of comparative advantage. At a very general level the theory has strong empirical support, as witnessed by dramatic increases in trade to GDP ratios accompanying growth in OECD countries since the 2nd World War, and the same phenomenon in fast growing emerging market economies today.
- 3.3.3 Most work on this, and the associated empirical examination of data to test the theory, is set in the context of trade between countries. Trade data is collected at the country-level, and it is natural to think of trade in this way. But the same principles apply to trade between regions of any given country, or between towns either within the same region or in different regions. More trade within a country would improve overall prosperity just as more trade between countries does.

⁹ Between 1996-2001. 'Headquarters' are defined as management centre for a firm's operations, administration and marketing activity. It may include regional managerial centres and sales offices.

- 3.3.4 Recent work has added two further dimensions to thinking about comparative advantage and gains from trade. One is that the appropriate level at which to think about comparative advantage and trade is not necessarily broad sectors of economic activity, but may be more or less narrowly defined 'tasks' ('it's not cloth for wine anymore', Grossman and Rossi-Hansberg 2006¹⁰). These 'tasks' are generally intermediate goods or services. On the service side, examples might be the provision of advertising or legal services. On the goods side, the growth of regional production networks illustrates how different countries or cities specialise in particular parts and components which are then traded and put together in final assembly.
- 3.3.5 The second innovation is the recognition that while comparative advantage in these tasks may be partly to do with inherent characteristics of the location (e.g. abundant cheap labour or land), it is also acquired by a process of learning and by building economies of scale. Thus, the concentration of financial services in London, IT in Silicon Valley, or buttons and zips in Qiaotou¹¹ is not to do with inherent characteristics of these locations, but has come from a cumulative process of learning. In some instances this might be internal to a firm (e.g. Philips at Eindhoven) while in others it occurs within a cluster of separate firms. Skills and knowledge are transmitted between firms by a well functioning labour market, formal or informal communication channels, and by the availability of local specialisms. The effect is to raise productivity and create a self-reinforcing comparative advantage for the location with the cluster.
- 3.3.6 The importance of connectivity is apparent. To make the point most starkly, consider a final good the production of which involves two tasks. Two unconnected cities will each perform both tasks at small scale. Two connected cities will each specialise in one task at double scale, and consequently higher efficiency levels. Connectivity allows each location to gain scale in a particular range of activities, thereby gaining a comparative (and absolute) advantage in what it does, while buying in the other task from a similarly specialised and efficient source.
- 3.3.7 The key point for present purposes is that the benefit of this 'connecting places' productivity gain is not included in a standard CBA.¹² It arises from an external economy of scale, like the agglomeration arguments outlined in section 2, and is a further source of 'wider benefit' from transport improvement.
- 3.3.8 How important is this task specialisation in practise? There is plenty of evidence for task specialisation across countries, but less work has been done (and less data is available) for cities; such evidence as there is is consistent with the arguments above. Duranton and Puga (2005) point to the fact that cities have gone from being sectorally specialised to functionally specialised. In particular, larger metropolitan areas have acquired services and headquarters and small ones manufacturing, although the authors do not disaggregate down to different sorts of business services. Rauch et al. (2013) use highly disaggregated occupational descriptions (12000 occupations) to establish the fact that US metro areas have become increasingly specialised in interactive tasks. Duranton and Jayet (2011) work with French data and more than 6000 tasks defined by sector/occupations; they find a division of labour between cities, with scarce occupations (i.e. those with few workers in total) being over-represented in large cities.

¹⁰ See also Y. Shiozawa (2007).

¹¹ Qiaotou produces 200,000km of zippers per year http://en.wikipedia.org/wiki/Qiaotou,_Yongjia_County

¹² For technical analysis of how to include it, see Venables (2013).

3.3.9 The studies cited above are econometric. Further evidence comes from case studies of particular examples. Benefits of clustering are particularly pronounced in R&D, but successful start-ups require access both to R&D and to a wide range of business services. The Cambridge Science Park has developed over the last 40 years to include start-ups, growth companies, and inward investors who are developing new products and services. Connectivity to the university matters, but so does connectivity to London which supplies many of the business services and the access to markets. Oxford's equivalent started later but is now developing its distinct specialism largely in bioscience, and again drawing on connectivity within the local area and to London for provision of complementary inputs.¹³ Had all these complementary inputs been supplied from Oxford (resp. Cambridge), their supply might well have been less efficient and (given constraints on land and labour in these cities) would have drawn resources away from the respective Science Parks.

3.3.10 The implications of this thinking are that better connectivity creates potential gains for all the connected places. Long run prosperity requires that each region has a strong tradable sector (or export base¹⁴), and this in turn requires the presence of firms that are 'world class', competitive against international competition. Attaining this efficiency requires both competency in core tasks and ready access to inputs of intermediate goods and services from other firms that are world class in their field. For most economic activities, this is simply not possible in an autarkic or remote region. Specialisation is needed to attain efficiency, and connectivity is needed to foster business linkages and allow this specialisation to develop. Neither is competition static, so that business linkages are necessary to keep up innovation and development to prevent falling behind.

¹³ The motor industry provides another example in which a successful cluster requires a substantial range of activities to be undertaken close to the assembly plant (Nissan in Sunderland has attracted more than 20 major component manufacturers to the region), while requiring good connectivity outside the region for access to other parts and components and for sale of final output. For the context of HS2, trade in services is probably more relevant than trade in physical goods.

¹⁴ Rowthorn (2010) analyses the gap in the relative prosperity of the South and North of the UK which has emerged since 1970. He sets up a simple but persuasive model in which the long-run prosperity of a region is determined primarily by the strength of its export base. The empirical evidence strongly supports the model. In other words, the poorer regions of the UK need to increase their trade with the rest of the country. Neither public subsidies to the North nor migration will be able to solve their problem. Only trade can do it.

3.3.11 Once again, we stress that connectivity is necessary – but not sufficient – to achieve these ends. A supportive business environment is needed if the structural changes are to occur. A positive note is struck by current city developments which suggest that there is considerable potential and will to exploit existing connections. Local authorities are showing energy for working together to foster growth, and collaboration with universities for research purposes is also stronger than ever. There is increasing understanding that investing in distinctiveness is more effective than chasing the same mobile investments. This is true in Leeds, Manchester, Birmingham and the North East of England. Research for the Manchester Independent Economic Review¹⁵ suggested that an effective supply chain was more important to innovation than numbers of companies doing the same thing. An effective supply chain is itself fostered by scale as the example of the North East automotive industry shows. Central London is also a supply chain agglomeration, where financial services firms work with ranges of advisers across all professional services, and it is the ability to find the right adviser for the right project which creates the additional value.

4 Evaluation and the evidence base

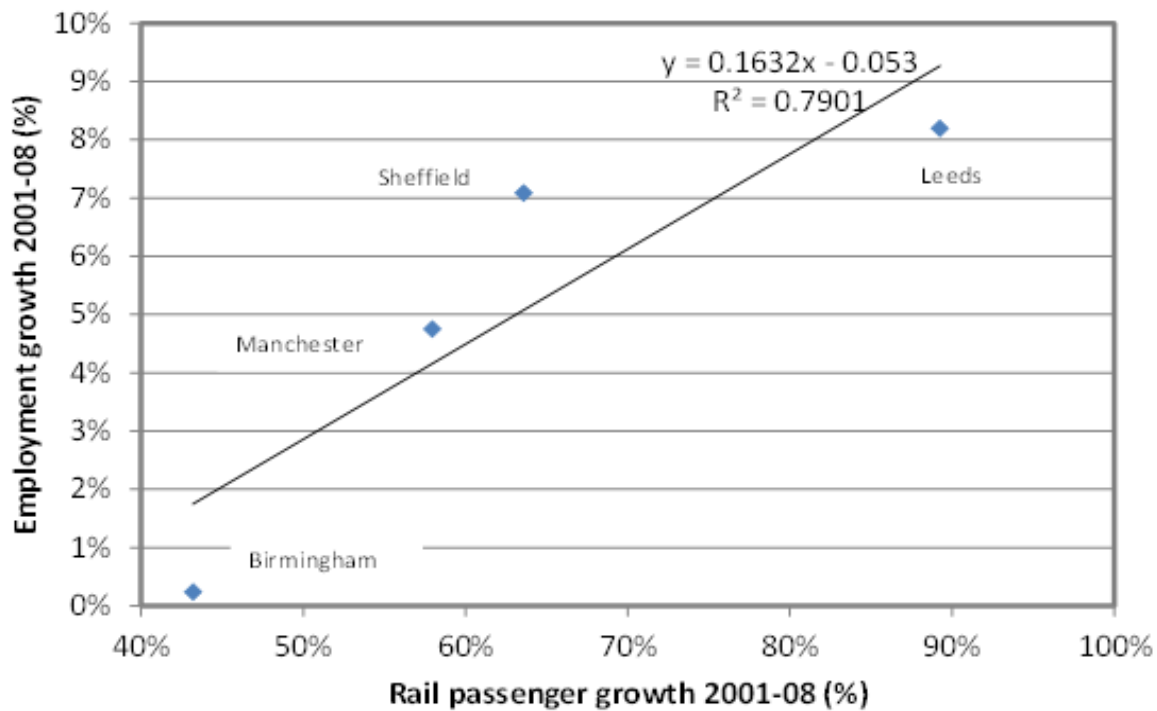
4.1.1 The impact of HS2 is surely 'extra-marginal', with an estimated increase in the London to Manchester capacity of 160% (40000 seats per day), as well as time saving.¹⁶ As we have argued, standard benefit cost analysis rests on assumptions concerning behavioural relationships and elasticities which are unlikely to remain true when investments of this scale are made. An investment such as HS2 will bring about changes going well beyond the proximate impact of the project. A comprehensive evaluation should therefore include a full description of possible mechanisms through which such effects occur, and of evidence suggestive of the likelihood of various changes occurring. One way to do this is to concentrate on what would be required to make an investment worthwhile and whether these conditions are either in place or likely to be so.

4.1.2 The full implications of a change of this magnitude cannot be derived by projections within an existing model, based on historical data and assuming unchanged behavioural relationships. There is however, a reasonable understanding of and consensus about each of the economic mechanisms associated with better connectivity. There are robustly researched gains from trade, patterns of regional specialisation, and agglomeration economies. These are complemented by powerful correlations, such as that between employment growth and rail trips shown in figure 2, although no causality can be attached to such a correlation.

¹⁵ MIER, Volterra

¹⁶ HS2 Ltd Economic Case modelling (August 2012)

Figure 2 Employment Growth and Rail Trips



Source: Volterra./Arup 2011

- 4.1.3 To make progress in evaluation a range of different approaches is needed, each highlighting different aspects of what HS2 might achieve, and combining to give a full narrative of possibilities. The first of these is conventional CBA, giving direct cost-savings and benefits (to existing or projected users) of traffic creation. This probably gives a lower bound of likely benefits, and needs to be extended to include gains from agglomeration and specialisation. The UK led the way in analysing wider benefits of transport improvements, with analysis codified in WebTAG. However, this approach is entirely to do with 'expanding places' not 'connecting places', an emphasis that came out of the particular projects that were under consideration at the time (Crossrail). The WebTAG approach needs to be broadened to include the 'connecting places' arguments, in particular those of specialisation and productivity. There are elements in common; benefits of scale and agglomeration effects are crucial steps of the argument in both expanding and connecting places. For connecting places, the argument turns more on benefits from specialisation, including productivity gains due to growing particular tasks or sectors in a particular location.
- 4.1.4 A second element is detailed studies, at fine spatial scale, as delivered by Land-use and Transport Interaction (LUTI) models. These are typically conservative in assuming that behavioural relationships (elasticities) are reasonably stable with respect to a large project such as HS2, and that there are constant or diminishing returns to scale. However, they may be useful, particularly for looking at possible impacts within cities. For HS2 to have maximum impact each city must understand and have a feasible plan to generate activity in response to the opportunities created.

- 4.1.5 Ultimately, the case for wider benefits from HS2 turns on the way in which it changes the attractiveness of different locations for business investment, and the consequences of these changes for productivity and efficiency. The mechanisms through which this can occur are outlined above, and economic principles suggest how they should factor into extended CBA. Their importance depends on empirical evidence, and there are several ways in which this can be deepened. One is case studies of similar episodes; these are few and far between, but we would surely be better informed if there were more studies on the effects of urban connectivity. They can be supplemented by conversations with the business community in order to assess how behaviour might change due to presence of HS2.
- 4.1.6 A further approach is to understand the evolving pattern of regional and urban specialisation and the trade flows that follow from it. We know that there have been dramatic shifts in what cities do over the last half century. They have become hugely more service oriented, and have increasingly specialised in communication-intensive activities (Michaels et al 2013). There are large agglomeration benefits associated with these activities (Graham 2007). Good communications are likely to be important in facilitating decentralisation of these activities (as in the study of US HQs reported above). Research on the evolving patterns of urban activity may provide insight into the forces at work, enabling a fuller narrative of the effects of HS2 to be developed.
- 4.1.7 This narrative needs to accept that patterns will continue to evolve and capacity can never be right, except for a situation which is already in the past. Additional capacity now offers lower cost and opportunity for competition and trade to flourish. Some of its consequences are unknowable, but we can still use research to estimate the strength and importance of the mechanisms described here.

5 References

Ciccone, A. and R. Hall, 1996, "Productivity and the Density of Economic Activity" *American Economic Review* 87, 54-70.

Department for Transport (2005) 'Transport, Wider Economic Benefits, and Impacts on GDP' <<http://webarchive.nationalarchives.gov.uk/>>
<http://www.dft.gov.uk/pgr/economics/rdg/webia/webmethodology/sportwidereconomicbenefit3137.pdf>>

Duranton, G. and H. Jayet (2011) "Is the Division of Labour Limited by the Extent of the Market? Evidence from French Cities," *Journal of Urban Economics*, 69(1), 56-71.

Duranton, G. and D. Puga (2005). "From sectoral to functional urban specialisation." *Journal of Urban Economics* 57(2): 343-370

Forslid, Rikard & Haaland, Jan I. & Midelfart Knarvik, Karen Helene, 2002. '[A U-shaped Europe?: A simulation study of industrial location](#)', *Journal of International Economics*, 57(2), 273-297.

Giroud, X. (2013) 'Proximity and investment; evidence from plant level data', *Quarterly Journal of Economics*, 128, 861-95

Graham, D. (2007) 'Agglomeration, productivity and transport investment', *Journal of Transport Economics and Policy*, 41, pp. 317-343

Grossman, G.M. & E. Rossi-Hansberg, 2006. "[The rise of offshoring: it's not wine for cloth anymore](#)," *Proceedings*, Federal Reserve Bank of Kansas City, 59-102

Ioannides, Y.M., H. G. Overman, E. Rossi-Hansberg & K. Schmidheiny, 2008. "The effect of information and communication technologies on urban structure," *Economic Policy*, 23, 201-242.

Krugman, P. (1995) 'Increasing returns, imperfect competition and the positive theory of international trade' in *Handbook of International Economics*, Vol. 3, ed. G. Grossman and K. Rogoff, New York: North-Holland

Leunig, T (2011), 'Cart or Horse: Transport and Economic Growth', International Transport Forum Discussion Paper 04

Mackie, P., D. Graham and J. Laird, (2011) 'The direct and wider impacts of transport projects; a review' in A. de Palma, R. Lindsey, E. Quinet and R. Vickerman (eds) A Handbook of Transport Economics, Edward Elgar, Cheltenham.

Rauch, F., G. Michaels & S. J. Redding, 2013. "[Task Specialization in U.S. Cities from 1880-2000](#)," [Economics Series Working Papers](#) 638, University of Oxford, Department of Economics.

Rice, P., A.J Venables, & E. Patacchini, 2006. "[Spatial determinants of productivity: Analysis for the regions of Great Britain](#)," *Regional Science and Urban Economics*, 36(6), 727-752.

Rosenthal, S. S. and Strange, W. C., 2003, "Evidence on the Nature and Sources of Agglomeration Economies", in *Handbook of Urban and Regional Economics*, Vol. 4, ed. Henderson, J. V. and Thisse, J. F. New York: North-Holland

Rowthorn, R. (2010): Combined and Uneven Development: Reflections on the North–South Divide, *Spatial Economic Analysis*, 5:4, 363-388.

Shiozawa, Y. (2007) A New Construction of Ricardian Trade Theory: A Many-country, Many-commodity with Intermediate Goods and Choice of Techniques, *Evolutionary and Institutional Economics Review*, 3(2): 141-187.

Venables, A.J. (2007) "Evaluating urban transport improvement: cost benefit analysis in the presence of agglomeration and income taxation" *Journal of Transport Economics and Policy*, 41, 173-188.

Venables, A.J. (2013) 'Expanding cities and connecting cities: the wider benefits of better communications', processed, Oxford

Volterra/Arup (2011) 'Understanding the transport infrastructure requirements to deliver growth in England's Core Cities, Core Cities