End of the line for HS2?
A review of the UK Government's Cost Benefit Analysis
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Over the last 20 years the demand for rail travel has increased by 20%, with even higher increases in demand for long distance journeys (Department for Transport, 2013). To increase capacity, and to modernise Britain's ageing rail network a second high speed rail link has been proposed (HS2). The project has proved highly controversial, partially due to its cost, which is currently estimated to be £50.1bn, including the cost of rolling stock (Butcher, 2015).

The government used cost-benefit analysis in its economic analysis to determine if HS2 would be value for money for taxpayers. Cost-benefit analysis assesses "all potential gains and losses from a proposal are identified, converted into monetary units, and compared on the basis of decision rules to determine if the proposal is desirable from society's standpoint" (Nas, 1996). In other words, a monetary value is given to all the benefits and costs. This is used to calculate a benefit-cost ratio, which we can use to assess a projects value to society. However there are various difficulties in using cost benefit analysis for HS2. This is partially because of the difficulty in monetising certain benefits, but also because the project has a very long lifespan.

Time Savings
The government has highlighted many potential benefits that the HS2 rail link will bring. One of the largest benefits the project is expected to yield is significant time savings. Overall time savings are estimated to yield benefits of £24.5bn, of which £18.7bn will specifically benefit businesses (Department for Transport, 2013). However, the estimated benefits of time-savings can vary drastically, depending on the methodology used by the appraising body. The government currently uses a cost-savings (also known as wage-savings) approach, where time is valued in accordance with how much the employer gains from the gained time (Batley, et al., 2012). However, this method has been criticised for being over-simplistic. There are several factors not included in the 'cost-savings' approach which are worthy of consideration, some of which can be represented using a variation of The Hensher Equation. The following

\[ VBTT = (1 - r - pq)MP + (1 - r) VW + rVL + MPF \]

Where \( VBTT \) is the value to business of travel time, \( r \) is the proportion of time saved allocated to leisure, \( p \) is the proportion of time that would have been spent working rather than travelling, \( q \) is the productivity whilst travelling relative to workplace productivity. \( MP \) is the Marginal Productivity of Labour, \( VW \) is the employees valuation of work time respective to travel time, \( VL \) is the employees valuation of leisure time with respect to travel time, and finally \( MPF \) is the value of additional output that arises from reduced travel time. The government's own analysis ignores a number of these factors.

Firstly, the Department for Transport assumes that all time saved from reductions in journey time are spent in the workplace (Batley, 2015). Whilst this assumption simplifies the model, it may not be a true reflection of reality. Workers on an hourly wage are generally paid only for the time spent in the workplace, and not for time spent travelling. Similarly, salaried workers are generally expected to spend a certain amount of time in the workplace each week, and this generally does not include time spent commuting. As such, time spent travelling may actually come from a person's leisure time, and not their time spent in the workplace. It is therefore feasible that the value of \( r \) will be greater than zero and therefore should not be left out of the government's calculations. By failing to include values for \( r \), the government may overestimate the benefits of travel-time savings to business. This does not mean that the saved time would not be beneficial, as employees will gain utility from increased leisure time (assuming monotonicity), but this will not directly benefit business.

Similarly, the department for transport does assumes that whilst travelling workers are not productive (i.e. the value of \( q \) is zero). Again, this assumption is a poor reflection of reality as business travellers are increasingly working on their commutes. This has been facilitated by an increase in the availability of plug sockets, and Wi-Fi which is "more commonly available on long distance inter-city routes" (National Rail, 2015). Furthermore, recent studies suggest that travel-time is now used "highly-efficiently" by business travellers, and that 80% of
business travellers work at some point in their journey, and those that did spent approximately 57% of their journey working (Fickling, et al., 2009). This survey also suggests that a travelling worker is not as productive as a workplace worker. The reasons for this could include: that workplace workers work for a higher proportion of their time whilst at work, less noise, more space, faster internet and access to co-workers. For this reason it is right that \( q \) is a proportional measure of productivity compared with workplace productivity. Although the value of \( q \) is difficult to measure, if the government fails to include the parameter \( q \), it may overestimate the business benefits of the HS2 project. Unlike with \( r \), the overestimation of the benefits will not be experienced by employees. The Department for Transport Report *Review of the value of travel time assumptions for business travellers on HS2* argues that including such detail in calculations is problematic, as reduced overcrowding may increase worker productivity (Batley, et al., 2012) and including this depth of detail is too complex for calculations to be accurate.

Finally, the value of \( MPF \) is worth considering. This is the additional output a worker can give when at work due to reduced travel fatigue. Although this is a worthwhile consideration, and may have a very real impact on a worker’s productivity, it is understandable that this may be excluded from the government's analysis. This is because it is extremely difficult to calculate. Unlike with the values of \( r \) and \( q \), failing to include a value of \( MPF \) may lead to an underestimation of the business benefits of HS2.

To conclude this section, the estimation of time-savings can be significantly affected by the choice of methodology. At present, the Department for Transport uses a cost-savings approach. However, a more accurate estimation of business benefits may be attained by using *The Hensher Equation*, similar to that used by Fowkes, et al., (1986), but the exclusion of the \( MPF \) parameter is acceptable. If the *Hensher Equation* calculation method is not adopted, the government may be inaccurately estimate the value of benefits from time savings to different economic agents.

**Connectivity and Agglomeration Effects**

Standard cost-benefit analysis of HS2 may not take connectivity and agglomeration benefits fully into account because of the methodology involved. Therefore the government
commissioned KPMG's report into the regional benefits that HS2 could bring to incorporate into their CBA. Estimates suggest that improved connectivity "could boost the economy by as much as £15bn per year" (Department for Transport, 2013) and that these would predominantly benefit regions outside of London. In addition the report finds that HS2 could increase annual productivity by £8bn (Department for Transport, 2013).

These benefits may come from reduced labour market frictions and boost productivity within the UK through improvements in connectivity between regions and cities. Improved connectivity entices new businesses to relocate to highly productive areas, leading to more densely concentrated economic activity. These agglomeration affects localisation, geographic and temporal economies (See Rosenthal & Strange, 2004). Localisation economies exist when businesses within a particular industry benefit from being densely located. For example if particular skilled workers may move to an area if there is a high demand for workers of that type, as the probability of employment may be higher, such as the concentration of oil companies and engineers within Aberdeen, Scotland. Similarly geographical economies exist because if firms are located closer together there is more scope for firms to interact with each other. Finally temporal economies (or Dynamic Agglomeration Effects) are more likely when firms are densely populated. These benefits may include gaining knowledge about other business supply chains, allowing firms to adapt to reduce their costs (Rosenthal & Strange, 2004). By improving connectivity through transport links, businesses may benefit from the economies of scale discussed above. This could lead to an additional 22,000 jobs and increase in average wages of £300 per employee in the West Midlands in 2026. These benefits would be concentrated predominantly in central Birmingham (KPMG, 2013).

**Demand Forecasting**

A large proportion of HS2's forecasted benefits depend upon the level of rail demand in the future, as many of the benefits, such as reduced crowding and increased capacity are heavily reliant on an accurate prediction of future passenger levels. Data from the Office of Rail Regulation show that the number of passenger journeys and the total distance that passengers have travelled has doubled between 1993-1994 and 2013-2014 (Office for Rail Regulation, 2015). This trend seems set to continue in the future.
To calculate future demand, the government has used an elasticity-based approach, from the *Passenger Demand Forecasting Handbook* (PDFH), similar to the method used by Crockett, et al., (2010). Demand is forecasted using predictions of GDP and the elasticity of rail demand to changes in GDP. However critics argue that using this approach to forecast future rail demand beyond 10 years is flawed. One criticism of the elasticity approach is that it does not take into account technical change. Worsley (2012) argues that technical change has improved access to rail services and "enabled passengers to make better use of their time while travelling by rail". This suggests that the PDFH method is thereby underestimating the future level of rail demand.

However it could also be argued that changes in technology may reduce future demand. As internet speeds improve and bandwidth limits increase, the ability for workers to telecommute has increased significantly, and may continue to do so in the future. As recently as the 2012 London Olympics, up to 40% of Whitehall civil servants worked from home, rather than travelling to work (Everett, 2012). Similarly, the rise in telework centers may discourage rail travel in the future. Telework centers allow workers to reduce their commute by hot-desking in the local area, whilst maintaining a workplace atmosphere. Telecommuting, or allowing employees to work from Telework centers may reduce a firms costs, reduce environmental damage and benefit employees utility (Madsen, 2003). The rise of teleworking presents an attractive new option which may lead to a decrease in rail demand. Whilst it is difficult to say whether technology will increase or decrease future rail demand, considering technological change increases the uncertainty of future rail demand forecasts.

Due to the high level of uncertainty the Government produced several forecasts of future rail demand. These forecasts include a *demand cap*. The Department for Transport suggests that for most infrastructure projects a demand cap should be set at 20 years but that in exceptional cases demand caps can be set at a different point (Transport Modelling and Strategic Modelling Division - DfT, 2014). In the unique case of HS2 a demand cap has been set for 2036, after which "benefits and revenues are effectively held constant for the remaining 57 years of the appraisal period" (Department for Transport, 2013). The analysis also incorporates risk, meaning that probabilities are calculated for each possible outcome. The report experiments with different scenarios, with demand caps in 2027, 2040 and 2049. For each scenario the
Probabilities of outcomes are calculated and used to calculate value for money in different situations. A *Benefit-Cost Ratio* (BCR) of less than one (i.e. the costs outweigh the benefits) is said to be poor. If the BCR is greater than one (i.e. the costs outweigh the benefits) it is split into a further four classifications. The table below details the value for money classifications.

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<thead>
<tr>
<th>Value for Money Classification</th>
<th>Benefit Cost Ratio</th>
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<tbody>
<tr>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td>Poor</td>
<td>0.5</td>
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<tr>
<td>Low</td>
<td>1.0</td>
</tr>
<tr>
<td>Medium</td>
<td>1.5</td>
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<tr>
<td>High</td>
<td>2.0</td>
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<tr>
<td>Very High</td>
<td>4.0</td>
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*Source: (Department for Transport, 2013)*

The later the demand cap is implemented the better value for money the project appears. The analysis suggests that if the cap is set for 2027, there is a 66.6% chance the project will have a low level of value for money, and a 32.9% chance that the project will be medium value for money. However with the cap set for 2040 there is a 95.2% chance that the project will present high value for money, and with a 2049 cap there is a 65.9% chance of the project being very high value for money and a 33.8% chance of the project being high value for money.

It is clear from the results of the *Department for Transport*’s report that the estimated benefits vary greatly depending on when the demand cap is set, and by their own admission "It is difficult to predict with any certainty when long-distance rail market saturation might occur" (Department for Transport, 2013). Because the level of uncertainty over rail demand is so high, it is difficult for any analysis to be convincing, which reduces the usefulness of a cost-benefit analysis in determining whether the HS2 project should be undertaken.

**Cost Assumptions**
The HS2 project has been widely criticised for its cost forecasts. Originally HS2 was estimated to cost just over £30bn (Aizlewood & Wellings, 2011). However critics argue that the projects costs could plausibly exceed £80bn (Wellings, 2013). Even if we use the current forecasted cost of £50.1bn (Butcher, 2015), rather than £80bn, forecasted costs have risen by approximately two thirds. This is unsurprising as historically the public sector is very poor at managing large infrastructure projects, where costs often exceed original estimates.

For this reason the government uses an *optimism bias* approach within their cost-benefit analysis. Optimism bias has been a significant problem for the public sector. It exists when governments’ analysis underestimates costs or project duration, or over-estimates the benefits a project will bring. One study finds that this is not only a problem in the originally forecasts but that "decision makers are very likely to escalate commitment to a failing project because they have a perception that the benefits from the project's product will exceed the benefits that were calculated in the project's business case" (Meyer, 2014).

When conducting their economic analysis of transport projects, the government issues guidance on procedures to deal with optimism bias. The current recommendation is that for rail projects, if we want the risk of overrunning cost projections to be 10% then we need to use an optimism bias uplift of 68%, which should be applied when the decision is made to initiate or reject the project (Flyvbjerg, 2004). However the report: *The Economic Case for HS2: Cost and Risk Status Report* states that optimism bias uplifts had been reviewed, and in some cases uplifts of just 15% and 20% were used for some capital costs (Department for Transport, 2013). Whilst the current guidelines, by their own admission should only be a starting point, this suggests that the optimism bias uplift applied to the project was far below what would be expected. This may explain in part why cost projections continue to rise. It is important that all aspects of cost-benefit analysis are conducted as accurately as possible, as poor cost predictions could lead to an incorrect benefit-cost ratio being calculated. This means that projects that are poor or low value for money may be perceived as being medium or high value for money, resulting in a poor use of public finance. For this reason the government’s cost-benefit analysis used to make the economic case for HS2 is significantly flawed.
Environmental Impacts

The impact of the HS2 on the environment has been a contentious one. The Department for Transport’s report on the strategic case for HS2 argues that the project can deliver benefits. These include reduced demand for road haulage and domestic air travel, lowering the UK’s carbon emissions (Department for Transport, 2013). However after lengthy reviews by the Environmental Audit Committee it is now thought that "at best, the savings are likely to be relatively small" (Environmental Audit Committee, 2014). However the report goes on to argue that "a bigger issue is the potential effect of the decarbonisation of the generation of electricity used by the trains; a matter that has been largely absent from the HS2 debate so far". If there was a significant increase in low-carbon energy generation, it is possible that HS2 could achieve greater than expected environmental benefits from reduced carbon emissions. However the uncertainty about the future of the UK’s energy supply makes such considerations difficult to include in the cost-benefit analysis.

The high speed rail project may also have significant impacts on biodiversity. Whilst the government has pledged to ensure that there is no net biodiversity loss, at the time of writing the government has undertaken no surveys concerning the ancient woodland and protected animal species that may be affected. This means that "The Government has not been able to establish a full environmental baseline against which the aim of 'no net biodiversity loss' can be assessed" (Environmental Audit Committee, 2014). This means that if the costs of mitigating biodiversity loss are higher than expected, the projects costs could be higher than anticipated. Although it is difficult to say at this stage whether this is likely to be the case, it adds further uncertainty to the full costs the HS2 project might incur. By failing to accurately cost environmental considerations, it could risk an incorrect benefit-cost ratio being calculated, meaning the project could be undertaken when it does not represent value for money to the taxpayer.

Conclusions

The HS2 project has been highly controversial. To establish whether the project should go ahead the government used a cost-benefit analysis approach (CBA). However the application of CBA has been queried on a number of points.
Firstly, a large proportion of the benefits of HS2 are attributed to time savings. However the government’s valuation of time makes assumptions which may not be an accurate reflection of reality. The government used a simple 'cost-savings' approach, which assumes that workers have zero productivity whilst travelling. However with the increased availability of Wi-Fi and power sockets on trains, workers have increasingly used their commute productively. Whilst the government also did not consider the impact of 'travel fatigue' on productivity, this is difficult to measure, and it is right to exclude this from cost-benefit analysis at this time.

However the government did realise that under a standard cost-benefit analysis, the benefits of improved business connectivity may not be recognised. They therefore rightly commissioned KPMG to compile an independent report concerning the potential benefits. This ensured that potential benefits that may not have been included were measured.

The government also recognised the difficulty in forecasting demand in the future. However they continued to use an elasticity model, which has drawn criticism. Whilst demand for rail travel, particularly long-distance rail travel, has been increasing, it is unlikely that this will continue indefinitely. As such, a demand-cap model has been introduced to help calculate the total benefits the project is likely to yield. However the government's analysis fails to include the impact of technical change. Whilst it is unclear whether this will positively or negatively impact rail demand, it increases the uncertainty of the project yielding the benefits that are expected. For this reason the potential benefits of HS2 should be considered with caution.

The government has also poorly applied their own guidance concerning optimism bias. To be 90% sure that the costs would not exceed the initial budget, the government should have applied optimism bias uplifts of 68%, however in some cases the uplifts applied were as low as 15%. This in part explains why the forecasted costs of HS2 continue to rise, and has risen by almost two thirds more than its original forecast. Poor calculation of the costs reduces the usefulness of using the cost benefit analysis approach, and increases the uncertainty about HS2’s potential value for money.

Finally, the environmental impacts of HS2 may not be as beneficial as first thought. Any carbon emissions reductions are likely to be minimal, and the full costs of mitigating
biodiversity loss have not yet been calculated, again leading to an underestimation of the potential costs.

To conclude, the HS2 project has had a benefit-cost ratio calculated at 1.8, or 2.3 if wider economic impacts are included (Butcher, 2015). However underestimation of certain costs, combined with the increasing uncertainty concerning the potential benefits of HS2 have discredited the governments analysis. It is therefore advised that the HS2 project is cancelled, and alternative projects considered.

References


Crockett, J., Mason, A., Segal, J. & Whelan, G., 2010. UK Regional Rail Demand in Britain, s.l.: Association for European Transport and Contributors.

Department for Transport, 2012. Economic Case for HS2: Updated appraisal of transport user benefits and wider economic benefits, s.l.: HS2 Ltd.

Department for Transport, 2013. The Economic Case for HS2, s.l.: HS2 Ltd.

Department for Transport, 2013. The Economic Case for HS2: Cost and Risk Status Report, s.l.: HS2 Ltd.

Department for Transport, 2013. The Strategic Case for HS2, s.l.: HS2 Ltd.

Environmental Audit Committee, 2014. HS2 and the Environment, s.l.: House of Commons.


[Accessed 09 04 2015].

Fickling, R. et al., 2009. The Productive use of Rail Time and Value of Travel Time Saving for
Travellers in the course of Work, s.l.: The Mott MacDonald IWT Consortium.


KPMG, 2013. HS2 Regional Economic Impacts, s.l.: HS2 Ltd..


Transport Modelling and Strategic Modelling Division - DfT, 2014. TAG Unit A5.3 - Rail Appraisal, s.l.: Department for Transport.

