HS2 Outline Business Case

Economic Case

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1. Executive Summary

Introduction

1.1. This Economic Case is intended to assess the value for money of HS2 whilst also considering the range of alternative options for delivering the strategic objectives of HS2. It adheres to the general guidance on evaluating proposals published by HM Treasury in the Green Book and the more detailed advice provided by the Department for Transport (DfT) on how to apply Green Book principles to transport investments (WebTAG).[1]

1.2. This document reproduces previously published analysis on both the HS2 proposal[2] and the alternative options.[3] In compliance with both the Green Book and WebTAG it intends to provide a consolidated assessment of the costs and benefits of each of the options considered.

1.3. WebTAG has been developed over many years and has benefited greatly from the UK's long tradition of applying cost benefit analysis to transport infrastructure investment proposals. Comparisons show that the UK appraisal system compares very well with those in other countries and the UK has led the world in setting out its guidance on analysing the impact of proposals in an open and transparent way[4].

1.4. At each key stage of the development of HS2 we have conducted an analysis of the costs and benefits to allow us to understand the value for money of the proposed investment. Over the course of the last year, HS2 Ltd, in their role in providing advice to Government on the value-for-money of the scheme, has made some significant improvements to their analytical tools. We are therefore able to provide a much improved understanding of the costs and benefits of the proposal. This document provides an updated economic appraisal of the scheme based on HS2 Ltd's latest advice on the scheme's impacts on people's travel choices.

[1] Department for Transport, 'Transport Analysis Guidance – WebTAG', https://www.gov.uk/transport-analysis-guidance-webtag

[2] HS2 Ltd (2013), 'The Economic Case for HS2', http://assets.hs2.org.uk/sites/default/files/inserts/S%26A%201_Economic%20case_0.pdf

[3] Department for Transport (2013), 'The Strategic Case for HS2', https://www.gov.uk/government/publications/hs2-strategic-case and Atkins (2013), 'Appraisal of Rail Alternatives to HS2', https://www.gov.uk/government/publications/rail-alternatives-to-hs2

[4] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/209530/final-overview-report.pdf

Our assessment of the Economic Case for HS2

Standard Assessment – the 'reference case'

1.5. The appraisal aims to capture all of the impacts – positive and negative – as well as the associated risks and uncertainty, so that the decision-maker is provided with a full assessment of the pros and cons of different courses of action. Where possible, these impacts are expressed in units of money, and it is from these monetary valuations that the benefit cost ratio – a measure of the return to the investment - is calculated.

1.6. A wide range of benefits are quantified in monetary terms, ranging from direct benefits to transport users from travel time savings, reductions in crowding and improvements in reliability to wider economic impacts, safety and environmental impacts such as noise and air quality. The table below provides a breakdown of these benefits and the extent to which they contribute to the case for HS2. HS2 is expected to generate significant levels of benefits with benefits totalling £28.1bn for Phase 1 and £71.0bn for the full network (NPV 2011 prices).

Table 1 - Breakdown of the benefits from the HS2 proposals

£bn (2011 PV)	**Phase One**	**Full Network**
Time Savings	20.0	51.2
Crowding benefits	4.1	7.5
Car User Benefits	0.6	1.2
Transport User Benefits	**24.6**	**59.9**
Agglomeration	2.4	8.7
Imperfect Competition	1.7	4.0
Increased Labour Force Participation	0.2	0.5
Wider Economic Impacts	**4.3**	**13.3**
Other Impacts	0.4	0.8
Loss to Government of indirect tax	**-1.2**	**-2.9**
Total	**28.1**	**71.0**

Notes: Other impacts include: reduction in car noise, carbon impacts, HS1 link, reduction in car accidents and the noise from HS2 trains. Numbers may not add due to rounding. The Time Savings relate to overall time savings not solely in-vehicle time savings.

1.7. The standard appraisal does not solely account for the benefits resulting from the scheme but also assesses the net costs to Government of the scheme. It accounts for the upfront costs of building the full HS2 network combined with the costs of operating the network once built as well as the implications for revenue. The table below summarises the net costs to Government which are subsequently combined with the benefits to generate a Benefit Cost Ratio (BCR) for the scheme.

Table 2 - Breakdown of the net cost to Government from HS2

	Phase One £Bn (2011 PV)	**Full Network £Bn (2011 PV)**
Capital Costs	21.8	40.5
Operating Costs	8.2	22.1
Total Costs	**29.9**	**62.6**
Revenues	13.2	31.1
Net Costs	**16.7**	**31.5**

1.8. Using the typical assumptions presented in WebTAG and used in standard transport appraisals, for the full Y-Network the scheme represents high value for money with a Benefit Cost Ratio of **2.3 to 1** implying a return of over £2 for every £1 invested. While the BCR for Phase 1 (London to the West Midlands) is lower, only offering medium value for money with a BCR of **1.7 to 1**, it still yields substantial benefits totalling £28.1bn.

Other impacts

1.9. For a transformational scheme of the scale of HS2 it is right that we undertake a rigorous assessment of all its impacts. While we are using the best methods and tools available to assess these, there are certain impacts for which either it is not currently possible to express in monetary terms or the tools available are less robust.

1.10. Landscape impacts consider the effects of a scheme on the visible features of a landmass combined with the cultural aspects of the land itself. Any valuation of something which is intangible such as landscape is challenging, and while the Department has used the best available methods to quantify landscape impacts there remains inherent uncertainty.

1.11. The Landscape impacts have been estimated at £1.0bn for Phase One and £2.9bn for the Y-Network which would reduce the BCR in both cases by 0.1. It is therefore concluded that consideration of landscape impacts are unlikely to substantially alter the value for money of the scheme.

1.12. There are a set of environmental and socio-economic impacts resulting from HS2 which are not possible to quantify in monetary terms but have been considered qualitatively. The work undertaken by HS2 Ltd to develop the Environmental Statement for Phase One and Appraisal of Sustainability for Phase Two ensures that we have a thorough understanding of these impacts. The main impacts include:

- Heritage – Buildings, parks and sites of architectural or historical significance;
- Townscape – The physical and social characteristics of the built environment and the way we perceive those characteristics;
- Biodiversity – Degree of variation of life forms;
- Water environment – The availability of water resources;
- Option values – The value of the option of using a transport service for trips not yet anticipated or currently undertaken by other modes;

1.13. Consideration of these additional environmental and socio-economic impacts does not conclusively alter the case for the scheme, as there are both adverse and beneficial impacts. It is also important to note that HS2 has and will be designed to minimise adverse impacts on the environment and mitigate impacts as far as possible where they occur. Further mitigation measures not yet considered in this assessment are therefore likely which will further reduce any negative impacts.

The robustness of the 'standard' appraisal

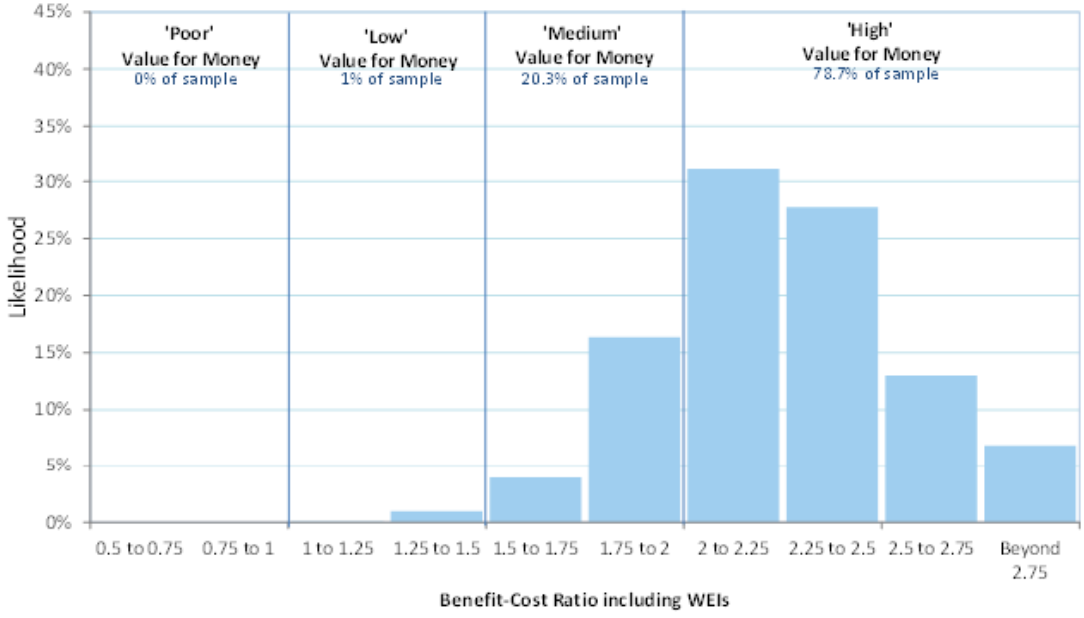
1.14. HS2 will generate benefits for the UK for generations to come. Forecasting such a long way into the future is inherently challenging. It is particularly important to understand the uncertainty attached to those factors in the appraisal which will have the greatest impact on the investment case. In the case of HS2, as with many transport investments, this means understanding in particular the impact of a range of different assumptions about economic growth, growth in demand for rail travel, construction costs and the valuation of time savings.

1.15. Section 5 assesses the resilience of the economic case to a range of different assumptions associated with these factors. It uses the assumptions underpinning the standard assessment as the starting point. This analysis captures the range of benefit cost ratios that could result from combinations of different assumptions and is based on an understanding of the probability of different events occurring. It provides a systematic way of assessing the range of different outcomes that could occur. However, it is unable to capture all possible outcomes because there are some events that cannot be described in terms of probabilities in this way.

1.16. Figure 1 below illustrates the results of this analysis for the full Y-network and shows the range of possible BCR outcomes mapped

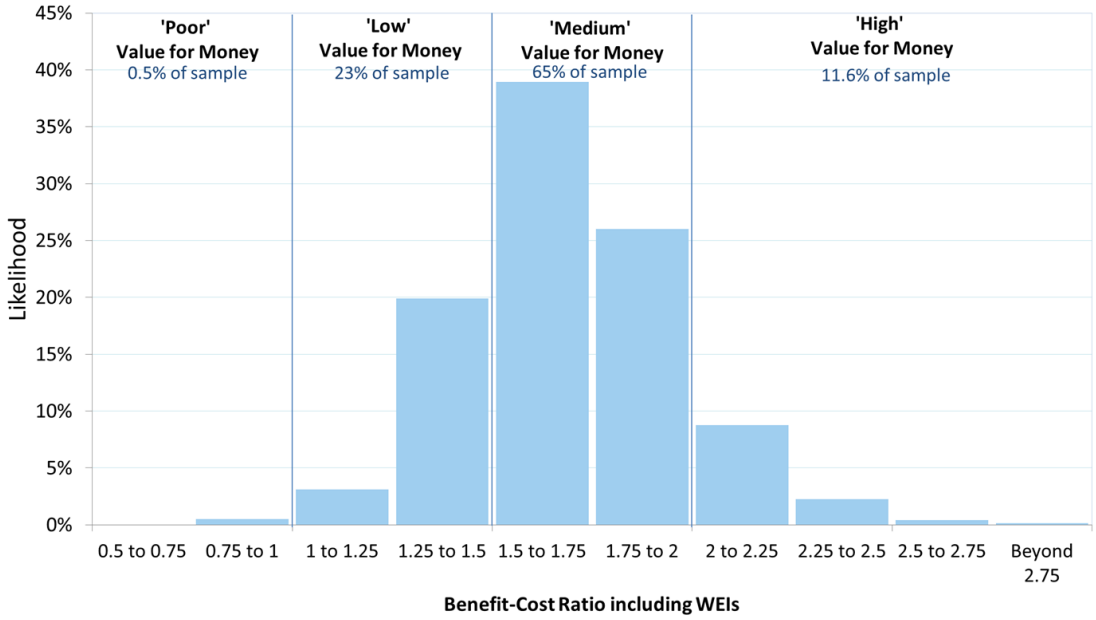
against the Department's value for money categories to allow comparisons with other schemes. From this analysis, we can have confidence that the scheme will offer high value for money with more than three quarters of the scenarios tested offering benefit cost ratios higher than 2, offering a return of more than £2 for every £1 invested. Even under the most pessimistic scenarios with high construction costs, historically low economic growth, low values of time and low growth in demand, the scheme would still offer positive returns on investment.

Figure 1 – Y-Network distribution of Benefit-Cost Ratios



1.17. Figure 2 shows the results of this analysis for Phase 1 of the scheme. It also provides us with some degree of confidence that our conclusions on the value for money of Phase 1 are sound. While the overall return is lower than for the full Y-network, in over 75% of scenarios tested, Phase 1 is at least medium value for money – that is delivering benefits of over £1.50 for every £1 invested.

Figure 2 – Phase 1 distribution of Benefit-Cost Ratios



Key Issues

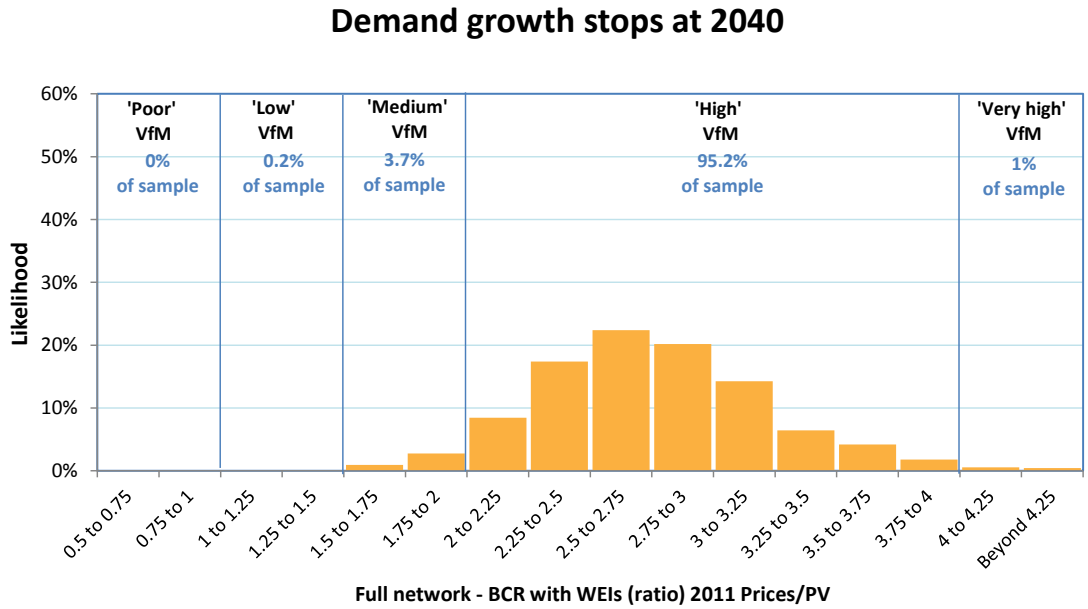
1.18. HS2 is unlike most other transport schemes. It is a project with high up-front capital investment producing benefits over a very long life-span. There are therefore certain standardised assumptions used in a conventional economic assessment that have a substantial impact on the BCR, for which alternative and potentially reasonable approaches exist. To understand this further, specific sensitivity tests were undertaken on the impact of different key assumptions, most notably demand forecasts and different valuations of time savings.

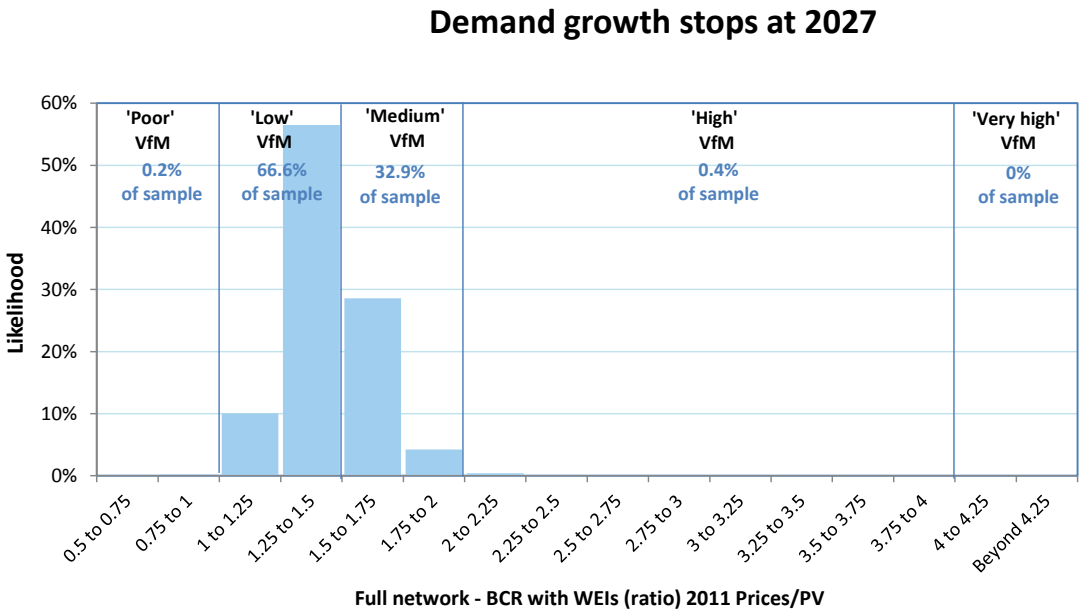
Demand Cap – 'long term BCR'

1.19. To date, the HS2 economic case has used an approach of capping demand in the year at which demand for long distance journeys reaches a certain level, a point expected to be reached in 2036. This is despite very strong rail demand growth over the last 20 years; in the decade from 2002 to 2012 the annual growth in long distance rail travel was 5.2%. While it is unreasonable to expect demand for rail travel to continue growing indefinitely, there is no evidence to suggest demand growth will stop at that particular point in time.

1.20. Figure 3 below shows that modest changes to the demand cap can lead to significant changes in the benefit cost ratios.

Figure 3 – Full Network distribution of Benefit-Cost Ratios with different demand cap assumptions





Business Value of Time

1.21. The appraisal of benefits requires that we attach a value to the time savings travellers enjoy as a result of HS2. The evidence suggests that those travelling in the course of their work are typically willing to pay considerably more to reduce travel time than people making leisure or commuting trips.

1.22. The valuation of business travel time savings should reflect people's willingness-to-pay (WTP) for them. The standard approach assumes that employee wages are a suitable approximation of WTP. We've looked at the evidence on people's WTP and it shows that the values of time adopted in the standard analysis are a suitable representation of what business passengers travelling by rail are willing to pay for quicker journeys. [5]

1.23. There are, however, reasons to believe that high speed rail schemes should be assessed with values of time higher than those applied to conventional rail schemes. A review of both UK and international evidence on the valuation of travel time savings was recently undertaken for the Department by the Institute for Transport Studies, University of Leeds (ITS Leeds)[6]. This study concluded that when considering values of time for high speed rail the existing evidence points to a valuation in excess of that applied in the economic analysis by as much as 40 – 50%. A sensitivity test which considers a 40% uplift to the standard values has been applied to the appraisal. [7],[8] Given the relatively limited number of High Speed rail specific studies a low value of time scenario which considers the wider evidence for the willingness to pay for travel time savings across all rail travel is also presented. Evidence presented in the ITS Leeds (2013) study suggests applying a figure 20% lower than the WebTAG 2013 values of time.

1.24. As indicated in the charts below, the BCR for the Y-Network in the case of a lower value of time is expected to be approximately 2, while consideration of a High Speed Rail specific value results in a BCR greater than 3 and in this case taking account of the risks and uncertainty which have been quantified there is a limited chance that BCR will fall below 2.

[5] Wardman M, Batley R et al (2013), 'Valuation of Travel time Savings for Business Passengers, ITS Leeds, https://www.gov.uk/government/publications/values-of-travel-time-savings-for-business-travellers

[6] Wardman M, Batley R et al (2013), 'Valuation of Travel time Savings for Business Passengers, ITS Leeds, https://www.gov.uk/government/publications/values-of-travel-time-savings-for-business-travellers

[7] Wardman M, Batley R et al (2013), 'Valuation of Travel time Savings for Business Passengers, ITS Leeds, https://www.gov.uk/government/publications/values-of-travel-time-savings-for-business-travellers

[8] On the basis that some of this variation is likely to be related to the longer trip lengths served by high-speed rail, the standard non-work values of time have also been adjusted to reflect the longer distances served by HS2.

Figure 4 – Full Network distribution of Benefit-Cost Ratios with HSR specific value of time

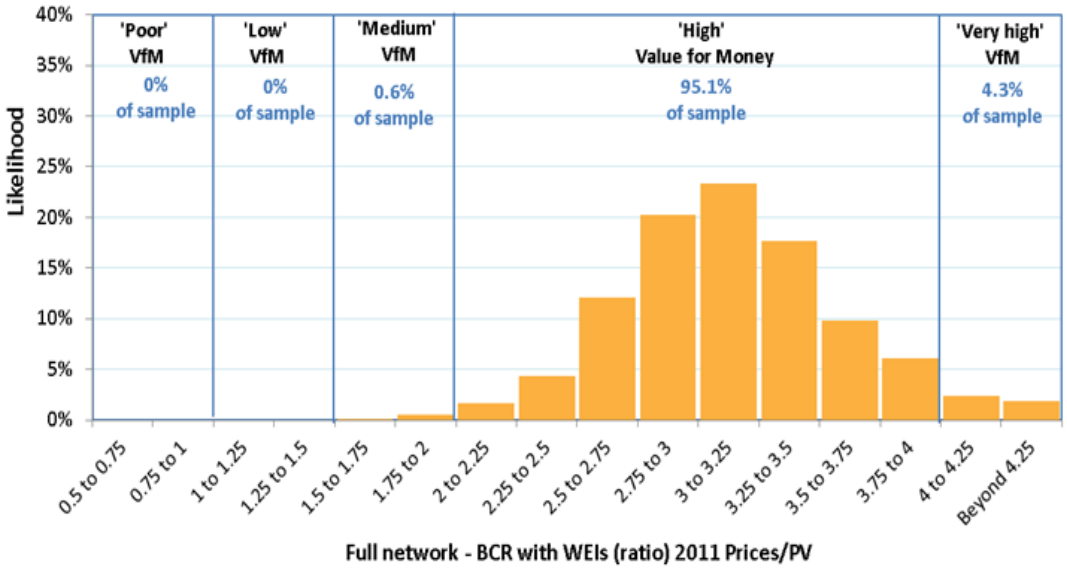
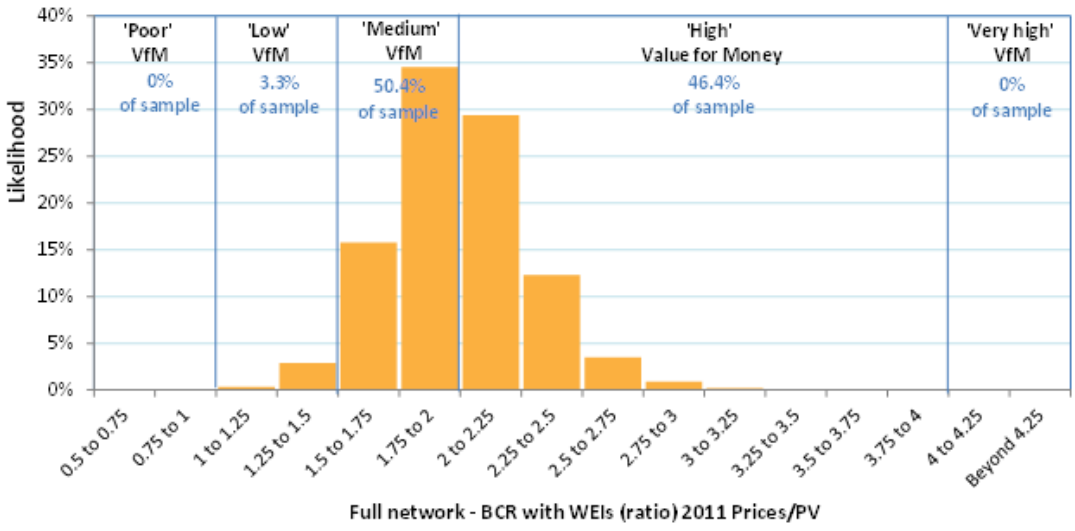


Figure 5 – Full Network distribution of Benefit-Cost Ratios with low value of time



Strategic Alternatives

1.25. A key component of the economic case is consideration of the alternatives to HS2. The alternatives to HS2 can offer means of providing more capacity on the rail network while also generating high value for money. Nevertheless, the Benefit Cost Ratio should not be

taken to unequivocally represent the right answer; analysis indicates that the alternatives are likely to:

- Be unable to provide as much extra capacity for passengers;
- Lead to significant levels of disruption to passengers during construction;
- Worsen network resilience or performance reliability; and,
- Be unable to offer the same level of journey time savings as HS2.

2. What is the role of this Economic Case?

2.1. The Government's commitment to develop a High Speed Rail network in the UK is at a key stage in programme development which necessitates revisiting the Economic Case for the scheme.

2.2. This document provides an update to the economic case for HS2 that was published in January 2012 and subsequently updated in August 2012[9]. Its purpose is threefold:

- to assess the value for money of HS2;
- to assess a range of alternative options for delivering the strategic objectives of HS2; and
- to provide an up to date economic assessment of the Phase 2 route and station choices currently being consulted upon.

2.3. The economic case consolidates analysis on HS2 and the alternatives already published in October 2013. It should therefore be read in conjunction with these documents, which are listed below:

- The Strategic Case for HS2 - provides a comprehensive overview of the HS2 scheme proposal[10]
- The Economic Case for HS2 – economic advice for Government on the case for HS2 prepared by HS2 Ltd[11]; and

2.4. The main role of the Economic Case is to consider whether all of the collective impacts (including on existing transport networks) delivered by the preferred scheme represent good value for taxpayers' money. The assessment of the HS2 scheme itself draws heavily on the analysis presented in the economic advice of HS2 Ltd to Government published in October 2013. However, in order to robustly answer the value for money question, this Economic Case also assesses the case for the various investment alternatives.

[9] January 2012: https://www.gov.uk/government/publications/economic-case-for-hs2-value-for-money-statement
August 2012 update: http://assets.hs2.org.uk/sites/default/files/inserts/Updated%20economic%20case%20for%20HS2.pdf
[10] Department for Transport (2013), 'The Strategic Case for HS2', https://www.gov.uk/government/publications/hs2-strategic-case
[11] HS2 Ltd (2013), 'Economic Case for HS2', http://www.hs2.org.uk/news-resources/economic-documents

2.5. By bringing together and summarising information on costs, benefits and risks, the Economic Case is able to support decision making. However, it should not be seen as unequivocally providing the 'right' or only answer i.e. the option which appears to offer the best value-for-money is not necessarily the optimal proposal. The Department carries out investment appraisals following the recommendations in HM Treasury guidance on the five case model for public sector business cases[12]. Decision-makers are presented with evidence against all five cases (strategic, economic, financial, commercial and management) when considering investment decisions such as HS2[13]. Therefore while value for money is important, it is only one factor that is taken into account when choosing whether or not to proceed to the next stage in the decision making process.

2.6. This economic case has been prepared in accordance with the requirements of HM Treasury's Green Book and the Department for Transport's transport appraisal guidance (WebTAG)[14] and uses the most appropriate tools and evidence available. Nevertheless, there are challenges to appraising the potential benefits and costs of a transformational transport scheme such as HS2. In line with National Audit Office recommendations, full consideration has been made of these challenges and associated uncertainty rather than reliance on point estimates.[15]

2.7. A complete assessment of the value for money of a transport scheme requires comparing a range of options. We have therefore looked in detail at the case for options based on enhancements to the existing rail network (the Strategic Alternatives - see section 4) as well as the case for a new high speed line. All of these schemes have been compared to a common scenario that allows us to assess the incremental economic, social, environmental and public accounts impacts that each package of transport interventions may bring about.

2.8. It is important to remember that as with all business cases, the underlying economic case for HS2 will change over time according to factors such as: changes in the economic outlook, updates to the models used by HS2 Ltd to predict behavioural responses to HS2, the development of non-market valuation techniques, refinement of cost assumptions or scheme design and development of the Department's demand forecasting and appraisal framework. The assessment

[12] '*Public Sector Business Cases using the Five Case model: A Toolkit*' https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/190601/Green_Book_guidance_public_sector_business_cases_using_the_Five_Case_Model_guidance.pdf

[13] See https://www.gov.uk/transport-analysis-guidance-webtag for more details

[14] https://www.gov.uk/transport-analysis-guidance-webtag

[15] NAO (2013), High Speed 2 : A Review of Early Programme Preparation, page 12 http://www.nao.org.uk/wp-content/uploads/2013/07/Full-Report.pdf

presented here will continue to develop in the months and years ahead so this should not be taken as the final word on the Economic Case for either Phase 1 or Phase 2 of the scheme.

3. The Assessment Framework

The Scheme

3.1. HS2 is one piece of infrastructure, being planned and built in two phases. Phase One will see a new line run from London Euston, through Old Oak Common, to new stations serving Birmingham airport and Birmingham city centre. It also includes a connection to the West Coast Main Line (WCML) north of Birmingham allowing 'classic compatible' trains to continue from the high speed line direct to destinations such as Manchester and Glasgow.

3.2. The proposals for Phase Two will extend high speed lines to Manchester in the North West and to Leeds in Yorkshire and Humberside, with intermediate stations at Manchester Interchange (near Manchester airport), the East Midlands Hub at Toton and Sheffield Meadowhall. Trains which can travel on the existing rail infrastructure as well as HS2 will then continue onto the existing network and travel further North to Scotland. It also incorporates a connection with the WCML further south at Crewe meaning key destinations like Liverpool, Runcorn, Crewe and Warrington would benefit from direct services.

3.3. HS2 will link 8 of Britain's 10 largest cities to the High Speed infrastructure with other cities served by compatible trains running on to the existing train network. Further details of the proposed route assessed within this Economic Case are available in the Phase 2 line-of-route consultation document[16].

Assessing the costs and benefits of HS2 – an introduction

3.4. The influence of a major transport scheme such as HS2 is likely to be widespread and complex, and will lead to changes in transport conditions that will affect the decisions of individuals both directly and indirectly. It is therefore imperative that an appropriate level of effort is put into assessing these consequences, to understand the extent to which scheme objectives are met and problems solved, and to estimate the value for money of the project.

3.5. Over the past two years in order to fulfil their duty of providing advice to Government, HS2 Ltd has implemented a very substantial programme of updates and improvements to its transport modelling suite. While HS2 Ltd has appraised the impacts of HS2 using the best available modelling tools, it also recognises that there are inevitable uncertainties and

[16] HS2 Phase 2 Route Consultation: http://www.hs2.org.uk/route-consultation

challenges associated with assessing the costs and benefits of the largest transport infrastructure scheme in the UK since the origin of the motorways.

3.6. Rather than describe in full the modelling tools used for the analysis, the focus here is on the changes implemented since August 2012. Further details of the assumptions, methods and models used to assess HS2 can be found in the methodological overview of the Planet Framework Model and the associated Assumptions Report[17].

3.7. Changes to the assessment framework can be split into four elements:

- The treatment of risk and uncertainty;
- The approach to forecasting demand for HS2;
- Assessing the benefits of HS2; and
- Assessing the costs of HS2.

3.8. The remainder of this section summarises the changes that have been implemented. Further detail of their combined impact on the economic case for HS2 is provided below as well as in supporting material published by HS2 Ltd.[18]

Treatment of risk and uncertainty

3.9. To assess the impacts of HS2, the Department and HS2 Ltd have used the best tools and evidence base available. There are however specific challenges to assessing such a transformational scheme as HS2. HS2 is the largest transport infrastructure project for a generation, the impacts of which need to be assessed almost 80 years into the future at a time when even the short-term economic outlook is uncertain.

3.10. In recognition of these challenges, rather than focus on a single point estimate of the costs and benefits of the scheme, HS2 Ltd in their advice to Government adopt a broader approach. This approach recognises major potential sources of risk and uncertainty and analyses the likelihood of different outcomes.

3.11. In keeping with the advice of HS2 Ltd, this Economic Case provides a thorough assessment of the robustness of the value for money of the scheme to different events and circumstances. While it is still necessary

[17] HS2 Ltd (2013), 'Planet Framework Model (PFM V4.3) – Model Description', and HS2 Ltd (2013), 'PFM v4.3: Assumptions report', http://www.hs2.org.uk/news-resources/economic-documents

[18] HS2 Ltd (2013), 'The Summary of Key Changes to the Economic Case since August 2012', http://www.hs2.org.uk/news-resources/economic-documents

to consider a 'reference case' (i.e. a point estimate of costs and benefits) against which the alternatives to HS2 can be understood, the analysis presented here also explicitly considers the potential range of outcomes given some of the many known sources of uncertainty.

The approach to forecasting demand for HS2

3.12. HS2 Ltd has specified and implemented a wide-ranging programme of work to ensure that its projections of long-distance travel continue to reflect the best available evidence. These changes apply both to the consideration of HS2 and its alternatives. Model development has focused on the key areas described below[19]:

- Base year demand – forecasting future transport demand requires detailed information on current travel patterns. HS2 Ltd has improved its understanding of why people travel and the mode of travel they use. In particular they have gathered an improved understanding of the categorisation of trips into business, leisure and commuting purposes through using National Rail Travel Survey data to estimate journey purposes at a more disaggregated geographic level;

- The 'without-scheme' scenario - estimating the incremental benefits of HS2 and the Strategic Alternatives requires comparison against a scenario in which HS2 is not built. The Department has announced a number of planned enhancements to transport infrastructure in England and Wales which have been reflected in the 'without scheme' scenario;[20]

- Estimating the size of the market - forecasts of rail demand rely on estimating the relationship between passenger demand and a range of influences that are known to affect rail patronage such as economic growth and rail fares. The demand forecasts have been updated to incorporate new evidence from the Passenger Demand Forecasting Handbook on the behavioural relationships used to forecast rail demand;[21]

- Forecasting external factors - in addition to understanding the sensitivity of rail passengers to a range of influences we must also take a view on how those influences are likely to evolve through

[19] For further details see: 'The Summary of Key Changes to the Economic Case since August 2012', http://www.hs2.org.uk/news-resources/economic-documents
[20] High Level Output Specification 2012, https://www.gov.uk/government/publications/high-level-output-specification-2012
[21] For further information regarding the Passenger Demand Forecasting Handbook see http://www.atoc.org/about-atoc/commercial-activities/passenger-demand-forecasting-council/

time. The updated Economic Case reflects more recent forecasts of variables such as economic growth and fuel costs;[22]

- Train service patterns - to establish the benefits of the schemes a train service specification which covers trains on both the high speed and existing network needs to be developed. Alterations to the demand forecasts have meant revisiting the train service patterns to ensure they correspond to estimated demand.

Assessing the benefits of HS2

3.13. To conduct a cost benefit analysis of all impacts it is necessary to place a value on the changes to the wellbeing of both transport users and non transport users resulting from the introduction of HS2 or its alternatives. To bring these impacts to the same units for comparison, monetary valuations are applied wherever possible.

3.14. As with the methods used to forecast passenger demand for HS2 and its alternatives, the techniques applied to translate this into a complete cost benefit analysis of HS2 have been reviewed and updated in the following key areas:

- Application of crowding values - The Department has updated both the methodology and values used to place a monetary value on crowding relief to bring it in line with the most recent evidence from the Passenger Demand Forecasting Handbook. This suggests that passengers place lower value on reducing crowding than previously thought;

- Business Values of time - The values used previously were based on income and travel data from the National Travel Survey from 1999-2001 and have now been updated with National Travel Survey data from 2008-2010[23];

- Non-work values of time - The Department has reviewed the evidence on how the non-work values of time are likely to increase over time. The most recent evidence demonstrates that the non-work values grow more strongly over time than was previously assumed[24];

[22] As with any appraisal, there is a lead time for producing analysis which in certain cases (most notably GDP forecasts) has prevented the very latest projections from being incorporated.
[23] Department for Transport (2013), TAG Unit A1-3 user and provider impacts, https://www.gov.uk/government/publications/webtag-tag-unit-a1-3-user-and-provider-impacts
[24] A series of research reports, which collect recent evidence on the non-work values of time can be found at: https://www.gov.uk/government/collections/transport-appraisal-and-strategic-modelling-tasm-research-reports

3.15. For further details please see the 'PFM V4.3: Summary of Key Changes since August 2012'.[25]

Assessing the costs of HS2

3.16. In order to establish the value for money of a transport intervention, it is necessary to compare the benefits generated with the costs incurred. In the case of HS2 this covers both the up-front costs of delivering the necessary infrastructure and rolling stock (the capital costs), and the costs required to provide rail services once the infrastructure is available for use (the operating costs). Both cost elements have undergone revision since the last iteration of the Economic Case for the scheme.

Capital Costs

3.17. The cost estimates prepared for the January 2012 Economic Case were estimated when the scheme was at a far earlier stage of development. A public consultation on the route options for Phase 1 had just been completed while Phase 2 was at the preliminary pre-consultation phase. Since January 2012, the capital cost estimates for both phases of the scheme have undergone considerable review and further design development and alterations have been made to the scheme. Changes to Phase 1 include more tunnels, increased certainty of design at stations, increased number of bridges and further refinement of the earthworks and retaining walls. For Phase 2 the initial preferred route has different approaches to Manchester, including the inclusion of a station at Manchester Airport and the recognition of additional mining risks on the Leeds leg.

3.18. Further details of the changes to both capital and rolling stock cost estimates can be found in the HS2 Ltd Cost and Risk Status Report[26].

Phase 1 Construction Costs

3.19. The latest estimate of base costs for constructing Phase 1 of HS2 is £15.65bn (2011 Q2 prices)[27]. This includes all costs associated with:

- purchasing land and property;
- tunnelling works;
- building stations, depots and stabling;

[25] http://www.hs2.org.uk/news-resources/economic-documents
[26] HS2 Ltd (2013), 'Cost and Risk Status Report', http://www.hs2.org.uk/news-resources/economic-documents
[27] This estimate includes certain sunk costs which are excluded from the appraisal in line with the guidance specified in WebTAG Unit 3.5.9.

- laying tracks, signals and associated railway systems;
- insurance; and
- staff costs and other overheads.

3.20. On the current scope and delivery timetable for the scheme, HS2 has been set a 'target price' to deliver Phase 1 within base cost plus a 10% allowance (£17.16bn in 2011 prices), with the allowance designed to manage design changes through the Hybrid Bill process. There are robust mechanisms and suitable allocation of risks that support the achievability of this target.

3.21. In order to understand the opportunities and threats associated with meeting the target price, HS2 Ltd has completed a structured assessment of risks, their likelihood and their consequences. Over three-hundred of these risks have been included within a quantitative risk assessment (QRA). More detail is provided in HS2 Ltd's Cost and Risk Status Report.

3.22. The results of the quantified risk assessment are expressed in terms of the probability that the cost of building Phase 1 will fall below a certain level. So, the higher the level of certainty required, the higher the associated cost threshold.

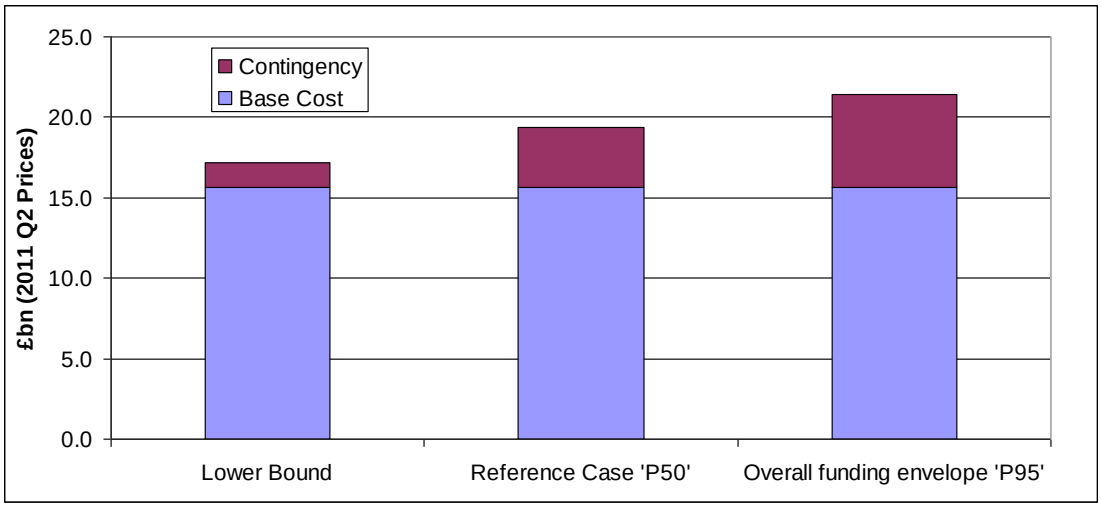
3.23. To inform the standard appraisal within the economic case, the expected or average value of the quantified risks in line with HM Treasury Green Book guidance have been considered. HS2 Ltd's cost estimation work established a 'P50' cost estimate of £19.4bn (2011 prices)[28] which is the basis of the DfT spending allocation in the Spending Review 2013.

3.24. The Treasury will hold an additional contingency as part of an overall funding envelope announced in the Spending Review 2013 of £21.4bn (2011 prices). This represents total allowances of 37% on top of base costs, but the Department and HS2 Ltd are determined to deliver the project below this level at the target price of £17.16bn (2011 prices).

3.25. Figure 6 indicates the range of cost outcomes considered within the economic case. The impact of this range on the relationship between scheme benefits and costs is described in section 5 of this document.

[28] This estimate includes certain sunk costs which are excluded from the appraisal in line with the guidance specified in WebTAG Unit 3.5.9.

Figure 6 – Range of cost outcomes considered



3.26. Basing the level of contingency allowances on the results of a quantitative risk assessment represents best practice. Optimism bias is considered inappropriate to be applied in the appraisal of schemes beyond the Strategic Outline Business Case stage of development on the basis that cost estimates will be mature at this stage of development.

3.27. The approach has been agreed with HM Treasury on the basis that:

- We will do further work to understand and quantify the broadest possible set of risks associated with the delivery of HS2 at the point in time at which it is most appropriate to do so. This will include:

  Developing our treatment of construction cost inflation;

  Further work to develop a procurement strategy for HS2; and

  Working closely with rail industry stakeholders to better understand the impact of HS2 upon their businesses.

- A Cost and Risk Group including HMT and Infrastructure UK oversees a programme of work expected to focus on the following:

  Ensuring a shared detailed understanding of costs, risks and contingency from a delivery and controls standpoint;

  Ensuring a continued focus on cost reduction and control;

  Providing an advisory and challenge function; and

  Ensuring this work takes account of best practice in other projects.

Phase 2 Construction Costs

3.28. Since the base cost estimates for Phase 2 are less mature it is not appropriate to use the same approach to contingency allowances as used for Phase 1. Instead, a similar approach as employed in previous updates to the economic case for HS2 has been used. This involves applying a combination of quantitative risk assessment and optimism bias to generate an expected value of total contingency allowances.

3.29. The latest estimate of base costs for delivering the infrastructure needed for phase 2 of HS2 is £12.5bn (2011 Q2 prices). As for phase 1, to inform the reference scenario within the economic case we have considered the expected or average value of the quantified risks in line with HM Treasury Green Book guidance. The expected value of risk provision at P50 is 34% of the base construction cost excluding indirect costs. Indirect costs have had a risk allowance of 10% applied to them.

3.30. An additional optimism bias of 32% has then been applied to phase 2 construction costs (excluding indirect costs). The overall optimism bias applied to direct costs (construction and land) at P50 is therefore 66% which is in line with WebTAG rail appraisal guidance. The level of contingency is 52% higher than the base cost estimate including indirect costs (£19.0bn in 2011 prices at P50).

3.31. A target price for Phase 2 has not yet been identified due to its relatively early stage of development. However, to ensure that we have assessed the case for HS2 against an appropriately wide range of outcomes we have also considered a scenario in which the entire provision for funding agreed with HM Treasury is needed for construction. This represents total allowances of 89% on top of direct base costs with 10% applied to indirect costs (a total of £21.2bn in 2011 prices at P95).

Rolling Stock Costs

3.32. HS2 Ltd has taken forward detailed work to assess the latest view on the likely cost of HS2 rolling stock. This has involved: reassessing the fleet requirement (including removing 260 metre units as a service offering) given the latest view on service patterns; assessing recent market activity in order to benchmark costs; taking market soundings; making separate provision, (including a 100% risk allowance) for design costs; and considering procurement approaches.

3.33. This latest cost estimation work has led to a revised central estimate for rolling stock costs of £6.9bn (2011 prices) of which £1.35bn is contingency.

Operating Costs

3.34. HS2 Ltd has conducted a technical review of the estimated operating costs of HS2 with the aim being: to update assumptions in line with the latest available benchmarks and to reflect improved information associated with more detailed scheme design and development.

3.35. The most significant operating cost changes in terms of their impact on overall costs have been:

- HS2 rolling stock electricity consumption – Methods used to evaluate this cost have significantly improved; and
- Improvements have been made to the methods used to calculate Train Operating Company overheads and administrative costs.

3.36. HS2 Ltd, in consultation with DfT, has also reviewed the level of optimism bias applied to HS2 operating costs. In carrying out this review, the aim has been to better reflect the maturity of cost estimates, the availability of relevant benchmarks and the quality of the evidence on which they are based. As a result, differing levels of Optimism Bias are applied to different costs ranging from 10% applied to rolling stock electricity costs to 41% applied to infrastructure operations and maintenance costs.

3.37. Unlike previous iterations of the Economic Case for HS2, no optimism bias allowance is applied to classic line savings. Previously, the application of optimism bias to cost savings acted to increase the assumed level of savings. Further details of the changes to operating cost estimates are available in the HS2 Ltd Economic Case[29].

What impact do these changes have on the reference Economic Case for HS2?

3.38. In order to understand the impact of the changes described above on the Benefit Cost Ratio (BCR) of HS2, a 'reference' case has been developed which adheres to the detailed advice provided by the Department for Transport on how to apply Green Book principles to transport investments (WebTAG).[30] This allows for comparison with the benefit cost ratio as presented in the August 2012 Economic Case

[29] HS2 Ltd (2013), 'Economic Case for HS2', http://www.hs2.org.uk/news-resources/economic-documents

[30] Department for Transport, 'Transport Analysis Guidance – WebTAG', https://www.gov.uk/transport-analysis-guidance-webtag

update, and also provides a point estimate against which the Economic Case for each of the alternatives can be compared.

3.39. Further details regarding how each of the changes to the modelling framework noted above have impacted on the BCR of HS2 can be found in the 'PFM V4.3: Summary of Key Changes since August 2012' report[31].

Benefits

3.40. The total net transport benefits (excluding Wider Economic Impacts) of the HS2 Y-Network (including both Phase 1 and Phase 2) are calculated to be £59.9bn (2011 PV and prices) with a net revenue impact of £31.1bn (2011 PV and prices). Overall this represents an increase in benefits of £11.7bn (2011 PV and prices) compared to the August 2012 estimate. Revenue has remained relatively unchanged.

3.41. For Phase 1 total benefits equal £24.6bn (2011 PV and prices) with a net revenue of £13.2bn (2011 PV and prices). As with the Y-network this represents a substantial increase in benefits from £18.8bn in August 2012. Revenue remains broadly unchanged from an estimate of £13.2bn in August 2012. The table below provides a summary of the benefits of Phase 1 and the Full Network.

Table 3 - Breakdown of the benefits from the HS2 proposals

£m (2011 PV)	**Phase One**	**Full Network**
Access/Egress Cost Savings	£1,094	£1,115
Crowded time savings	£4,068	£7,514
Board/Interchange time savings	£810	£4,146
Wait Time Savings	£3,508	£8,081
Walk Time Savings	£404	£1,330
In Vehicle time savings	£14,142	£36,503
Car User Benefits	£568	£1,162
Transport User Benefits	**£24,594**	**£59,852**

Notes: Numbers may not add due to rounding.

3.42. In comparison with the previous appraisals of the scheme, there is an increase in the level of user benefits originating from travel time savings, despite the reduction to the business value of time. One of the primary drivers of this is the updates to the modelling which reflect an improved understanding of why people travel. This indicated that a greater proportion of journeys are undertaken by business travellers between the locations covered by HS2.

3.43. An assessment has also been made of the non-monetised benefits of the scheme, taking account of the impact of HS2 on factors such as

[31] This report can be found at: http://www.hs2.org.uk/news-resources/economic-documents

heritage, biodiversity and journey ambience. Further details of this assessment can be found in Section 6. It concludes that consideration of these additional impacts does not imply conclusively that they improve or worsen the case for the scheme, as there are both adverse and beneficial impacts.

Costs

3.44. Since the assessment made in August 2012 scheme capital costs have increased from £18.8bn to £21.8bn (2011 PV and prices) for Phase 1. For the full Y-Network the increase is from £36.4bn to £40.5bn (2011 PV and prices)[32]. This includes a rolling stock cost estimate of £6.5bn (2011 PV and prices including a full replacement). In contrast, operating costs have remained similar to the August 2012 assessment (although this is largely a coincidental result of changes in both directions). The scheme costs are summarised in the table below:

Table 4 - Breakdown of the net cost to Government from HS2

£bn (2011 PV)	PHASE ONE	FULL NETWORK
Capital Costs	21.8	40.5
Operating Costs	8.2	22.1
Total Costs	**29.9**	**62.6**
Revenues	13.2	31.1
Net Costs	**16.7**	**31.5**

Wider Economic Impacts

3.45. The Wider Economic Impacts (WEIs) resulting from HS2 are valued at £4.3bn for Phase 1 and £13.3bn for the entire Y-Network. In August 2012 these figures were calculated as £4.8bn for Phase 1 and £15.4bn for the Y-Network. The table below describes the Wider Economic Impacts of the scheme:

[32] This assessment differs from the £42.6bn total funding package for HS2 as it takes account of discounting and reflects a lower level of contingency.

Table 5 – Wider Economic Impacts

£m (2011 PV)	Phase One	Full Network
Agglomeration	£2,413	£8,706
Imperfect Competition	£1,692	£4,053
Increased Labour Force Participation	£235	£535
Total	**£4,341**	**£13,293**

3.46. Further details of the impact these changes have had on the benefits and costs of the scheme can be found in the 'The Summary of Key Changes to the Economic Case since August 2012'. This report indicates that the changes which had the most significant impact on the BCR were:

- Improved estimates of base year transport demand and our understanding of why people travel which increased the estimated proportion of business travellers and therefore **increased** scheme benefits;
- The changes to the value of travel time savings for business passengers which **reduced** scheme benefits;
- Incorporating new evidence on the value passengers place on reducing crowding which **reduced** scheme benefits;
- Revisions to capital cost estimates which **increased** scheme costs;
- Updated train service specifications both on HS2 and the classic lines when HS2 is operational which **increased** scheme benefits; and
- Updates to the 'without scheme' case to incorporate all committed rail infrastructure investment which **reduced** scheme benefits.

Benefit Cost Ratio

3.47. The impact of these changes on the benefit cost ratio (BCR) for the reference case is presented in the table below. The resulting BCR (excluding Wider Economic Impacts) is 1.4 for Phase 1 and 1.8 for the entire Y-Network. The equivalent figures presented in August 2012 were 1.4 for phase 1 and 1.9 for the entire network.

3.48. The benefits and costs of proceeding with Phase Two of the scheme once Phase One has been completed have also been analysed. The BCR for Phase Two once Phase One is built is expected to be 2.1 excluding Wider Economic Impacts.

3.49. When Wider Economic Impacts are included the BCR has stayed largely constant for Phase 1 at 1.7 whereas for the Y-Network it has fallen from approximately 2.5 to 2.3. The BCR including Wider Economic Impacts for Phase 2 assuming Phase 1 is in place is 2.7.

Table 6 - Reference Case BCR calculation (60 year appraisal period)

£m (2011 PV)	**PHASE 1**	**Y-NETWORK**	**PHASE 2**
Net Transport Benefits (PVB)	**23.8**	**57.7**	**31.9**
Net Transport Benefits including Wider Economic Impacts (PVB)	**28.1**	**71.0**	**40.7**
Capital Costs	21.8	40.5	18.7
Net Operating Costs	8.2	22.1	13.7
Net Revenues	13.2	31.1	17.3
Net Cost to Government (PVC)	**16.7**	**31.5**	**15.1**
BCR (excluding Wider Economic Impacts)	***1.4***	***1.8***	***2.1***
BCR (including Wider Economic Impacts)	***1.7***	***2.3***	***2.7***

4. The Alternatives to HS2

Introduction

4.1. The Government has considered a wide range of alternative options to a high speed rail network to-date. These include assessing the case for using other modes of transport, building a new conventional speed line and enhancing the existing rail network.

4.2. The latest assessment of alternative options has mainly focussed on enhancements to the existing rail network since these are most likely to deliver capacity and journey time improvements comparable to those of HS2. Given the scale of HS2, few alternative schemes will be able, on their own, to deliver an equivalent level of functionality. It was therefore considered more appropriate to examine packages of interventions.

4.3. The alternatives to HS2 have been reviewed and enhanced for the economic and strategic case documents. Packages of infrastructure works and train service specifications were built up through an iterative and joint process involving experts from the Department for Transport, Network Rail's route teams and technical advisors. The benefits and costs of these schemes have been modelled and are presented below.

4.4. This chapter briefly describes the different packages of alternatives, the extent to which they have the potential to improve capacity and journey times, as well as outlining the costs and benefits of each. It should be read in conjunction with Chapter 6 of the Strategic Case which assesses in more detail how well the alternatives meet the objectives of HS2, which are:

- To provide sufficient capacity to meet long term demand and to improve resilience and reliability across the network;
- To improve connectivity by delivering better journey times and making travel easier;

It is deemed that any solution must:

- Minimise disruption to the existing network;
- Use proven technology that we know can deliver the required results
- Be affordable and represent good value to the taxpayer
- Minimise impacts on local communities and the environment

4.5. Further technical detail on the packages and their assessment can be found in a report published by the Department's technical advisors, Atkins. [33] Despite the alternatives being at an earlier stage of development than HS2 they have been assessed using consistent methods and assumptions wherever appropriate.

Summary of previous work

4.6. Previous reports have considered numerous different packages of rail interventions as alternatives to both HS2 Phase 1 and the Y network.[34] These range from a capital cost of £3 to £23 billion (2009 prices and values) including enhancements such as lengthening trains, providing increased lines of track in busy areas and electrifying some stretches of train line.

4.7. The January 2012 update of these reports [35] reassessed the three conventional rail alternatives to HS2 which were thought to have the strongest business cases. An alternative proposal put forward by the 51M group of local authorities which built on the Department's previous work was also analysed. Whilst all of these packages represented medium to very high value for money it was considered that they did not deliver benefits on the same scale as HS2.

Rationale for further work on the Strategic Alternatives

4.8. To inform the economic and strategic cases for HS2 it is necessary to review packages of alternative investments in the classic rail network. The analysis underpinning HS2 has progressed significantly since the January 2012 update, particularly in the design and modelling of Phase 2 making it essential to revisit the alternatives. Also, since the previous update, some of the proposed infrastructure interventions have been taken forward by the Department, necessitating their removal from the packages of alternatives.

4.9. The Department took this opportunity to carry out further work on the Phase 1 alternative, changing aspects of the previous package (Rail Package 2) specifically to provide more capacity on commuter train services into London. In addition, alternatives to the HS2 Y network were significantly redeveloped to include more infrastructure spending with the aim of better meeting the objectives of HS2; increasing capacity and

[33] Atkins (2013), 'HS2 Strategic Alternatives: Final Report, 28 October 2013', https://www.gov.uk/government/publications/rail-alternatives-to-hs2
[34] For example: Atkins (2011), 'High Speed 2 Strategic Alternatives Study, London to West Midlands Rail Alternatives – Update of Economic Appraisal', February 2011
[35] Atkins 2012, 'High Speed Rail Strategic Alternatives Study: Update following consultation', January 2012

improving journey times to a larger extent than the previously assessed package (Scenario B). The Y network alternatives were also extended to deal more explicitly with short distance and cross country flows.

4.10. For the first time it has been decided to consider alternatives to Phase 2 of HS2, where it is assumed in the do minimum that Phase 1 has already been built. The analysis of these options can be compared to the HS2 Phase 2 outputs presented in Table 6.

Scope of new work

4.11. The packages of alternatives were derived through a series of workshops with Network Rail. These workshops generated Train Service Specifications (TSS) alongside lists of the additional infrastructure that would be required to run them, forming the proposed packages of alternatives.

4.12. For each route three packages were produced: high, medium and low. The high packages had the greatest increases in infrastructure and rolling stock to support more ambitious TSS whereas the low packages had more modest requirements to support smaller improvements to the TSS. These packages were necessarily produced without the ability to model the package outputs and therefore at this stage did not consider in detail the potential value for money of the schemes. Instead, they were based on Network Rail's knowledge of current asset conditions on the routes and their professional judgement that the proposals would be feasible.

4.13. Following the assembly of these packages, tests were performed in an attempt to maximise the value for money of each. As a result of the modelling, adjustments to the necessary infrastructure and TSS were made, with pieces of infrastructure that appeared to offer low value for money removed. In addition, some additional infrastructure thought necessary to run the desired TSS was included. The results of this optimisation process were then used to generate five packages of infrastructure works and TSSs (described below) that would form the final sets of alternatives.

4.14. In order to ensure that these alternatives were feasible, the five packages were then sense checked, bearing in mind that the level of design and testing is at a very high level and should any of the alternatives be taken forward, more detailed analysis would need to be conducted. Network Rail considered whether the optimised TSS were feasible with the levels of infrastructure proposed and suggested

changes where necessary. The results of this iterative and joint process are presented below.

Short-listed alternatives

4.15. There are five different alternative packages to HS2 covering three hypothetical scenarios:

- Package P1: Alternative to HS2 Phase 1;
- Packages P2A and P2B: Alternatives to HS2 Phase 2 (assuming Phase 1 has been built); and,
- Packages YA and YB: Alternatives to the HS2 full Y network (Phases 1 and 2 combined).

4.16. Package P1 only includes upgrades to the West Coast Main Line (WCML). In the other four packages, a more extensive network is covered, with additions to services and infrastructure on the WCML, East Coast Main Line (ECML), Midland Main Line (MML) and some Cross Country (XC) services.

4.17. All packages look to implement infrastructure and train service changes that provide extra capacity where it is needed, particularly for passengers, as well as securing journey time savings where possible.

Alternative to HS2 Phase 1

4.18. Package P1 considers alternatives to Phase 1 and took previous alternative packages RP2 and 51M (an alternative developed by a group of local authorities) as a starting point before considering the scope for further refinements with the aim of better meeting the objectives of HS2. The primary deliverable of this alternative is to provide additional capacity to the West Cost Mainline (WCML) by addressing:

- Train service frequency on the WCML ‘fast’ lines which would be increased to 16 trains per hour (tph) into London Euston;
- Additional capacity improvements delivered through assuming that all Pendolino trains would be extended to 11 cars, with the reduction of one First Class carriage to Standard to increase the number of seats; and,
- Commuter capacity requirements by assuming all commuter services are extended to 12 cars.

4.19. The table below summarises the outcomes of these improvements in terms of connectivity (measured by journey times) and capacity (measured in all day seats) and compares them to HS2. It should be noted that the journey times have not been subject to detailed modelling or timetabling, and so further work could lead to changes in assumed journey time savings.

Table 7 - Journey Times and Additional Capacity for Package P1 against the do-minimum

TRAIN JOURNEY	PACKAGE P1		HS2 PHASE 1	
	Journey times (mins)	**Journey time saving (mins)**	**Journey times**	**Journey time saving (mins)**
London – Birmingham New Street	73	11	49	35
London – Manchester	122	5	100	27
London – Liverpool	126	5	106	25

	WITHOUT SCHEME ALL DAY SEATS	**PACKAGE P1 ALL DAY SEATS**	**HS2 PHASE 1 MINIMUM ALL DAY SEATS**
Euston services	128,200	216,100	238,600

Notes: This represents the % increase in weekday seated capacity arriving into London, estimated for 2036 weekday timetable.
Source: Atkins (2013), 'HS2 Strategic Alternatives: Final Report, 28 October 2013', https://www.gov.uk/government/publications/rail-alternatives-to-hs2, Appendix D

4.20. Package P1 delivers modest journey time improvements to locations on the WCML. The reductions are due to removing stops and some performance allowances. Additional capacity is also provided in this package on both Long Distance High Speed (LDHS) as well as London Midland services.

4.21. HS2 however, performs better in terms of total seats provided on the west coast corridor with the opportunity to further reduce crowding on the key flows from London Euston particularly on inter-city services. It also results in significantly greater improvements in journey times between London and key conurbations than the packages of alternatives thus performing better in meeting both the connectivity and capacity objectives.

4.22. Furthermore, HS2 is not subject to the same operational constraints as upgrades to the existing network. The question of the quality of the

infrastructure capacity provided is reflected in its resilience and this is crucially affected by the intensity of use of the railway. While HS2 reduces usage of the fast tracks on the West Coast Main Line, the P1 alternative intensifies usage. This means that under the upgrade options, service reliability is unlikely to be better and may well be worse in comparison to the situation today.

4.23. The P1 upgrade alternative to Phase 1 entails a lot of disruption to the existing network. Indicative estimates suggest that while HS2 Phase 1 results in 223 weekend closures the Phase 1 alternative leads to 410 weekend closures which is almost double that for HS2.

Alternatives to HS2 Phase 2

4.24. The following two packages are considered as alternatives to HS2 Phase 2, assuming HS2 Phase 1 has already been built and is in the do minimum:

- Package P2A: HS2 Phase 1 is built; interventions on ECML, MML, WCML and XC; trains to Nottingham are routed via HS2; and,
- Package P2B: HS2 Phase 1 is built; interventions on ECML, MML, WCML and XC; trains to Nottingham are routed via ECML.

4.25. In these packages, where HS2 Phase 1 is built, there is a reduced level of investment in the WCML compared to Package P1, restricted to works north of where HS2 re-joins the classic network. In addition to HS2 Phase 1 these packages would deliver:

Package P2A

- A 9 train per hour timetable for long-distance ECML services, with all rolling stock assumed to be operated by 140mph capable IEP sets and Leeds and Newcastle both having a 4tph service from Kings Cross (the former with 2tph extending to Bradford and the latter with 3tph continuing to Edinburgh);
- Retaining a 6 train per hour long-distance service pattern on the MML;
- Additional HS2 trains from London to Birmingham and Manchester, with a link enabling services from Euston to Sheffield, Derby and Nottingham;
- Additional classic line services on the WCML;

- Improvements to commuter services in particular frequency improvements at the bottom end of the MML and frequency and journey time improvements to Cambridge; and,

- Additional Cross-Country services through Birmingham, including making use of Curzon Street and a short section of HS2 for conventional IEP services to the East Midlands and beyond.

Package P2B

4.26. Identical to Package P2A except for:

- An 11 train per hour timetable for long-distance ECML services; and,

- Additional HS2 trains from London to Birmingham and Manchester, with a link enabling services from Euston to Sheffield and Derby but not Nottingham.

4.27. The journey time savings and additional capacity in these packages are summarised in the table below.

Table 8: Journey Times and Journey Time Savings for Package P2A, Package P2B and HS2 Phase 2

TRAIN JOURNEY	PACKAGE P2A		PACKAGE P2B		HS2 PHASE 2	
	Journey times (mins)	Journey time savings (mins)	Journey times (mins)	Journey time savings (mins)	Journey times (mins)	Journey time savings (mins)
London – Nottingham	67	26	70	23	51[1]	42
London – Leeds	96	30	96	30	82	44
London – Newcastle	141	14	141	14	138	17
London – Edinburgh	220	25	220	25	222	23
Birmingham – Nottingham	27	45	27	45	19[1]	53
Birmingham – Leeds	73	49	73	49	55	67
Birmingham – Newcastle	129	70	129	70	127	72

[1]Journey time is to Toton Interchange station

Table 9: Additional Capacity for Package P2A, Package P2B and HS2 Phase 1+ 2

TRAIN LINE	WITHOUT SCHEME ALL DAY SEATS	P2A ALL DAY SEATS	P2B ALL DAY SEATS	HS2 PHASE 1 + 2 MINMUM ALL DAY SEATS
Total	544,500	611,700	608,100	652,600

Notes: The 'without scheme' comparator in this case includes HS2 Phase 1
Source: Atkins (2013), 'HS2 Strategic Alternatives: Final Report, 28 October 2013', https://www.gov.uk/government/publications/rail-alternatives-to-hs2, Appendix D

4.28. Journey times are roughly the same to all destinations in both Packages P2A and P2B. The fact that HS2 Phase 1 is built in these packages removes any journey time savings on the WCML.

4.29. The greater quantity of trains running across the network increases seated capacity, particularly on long distance services. This is expected to result in corresponding reductions in crowding on most train services despite significant increases in demand from the improved journey times. Capacity is also increased on HS2 in Package P2A as more trains use Phase 1 as a quicker way to get to Nottingham.

4.30. HS2 performs better in terms of total seats particularly on long distance inter-city services. It also results in significantly greater improvements in journey times between London and key conurbations than the packages of alternatives.

4.31. As with the Phase 1 alternatives, the quality and resilience of the rail network is likely to be worse under the alternatives than for HS2 while the levels of disruption during construction are significantly higher. Indicative estimates suggest that while HS2 Phase 2 by itself results in 163 weekend closures the Phase 2 alternatives lead to between 2380 and 2430 weekend closures which is more than ten times that for HS2.

Alternatives to the Y Network

4.32. The Y network alternatives have been significantly redeveloped for this update to the economic case to improve the extent to which they meet the objectives of HS2. The alternatives address short-comings across the West Coast, Midland and East Coast Mainline and aspects of the Cross Country Routes.

4.33. The following two packages are considered as alternatives to the Y network:

- Package YA: No HS2 Phase 1; ECML high level of intervention; MML medium level of intervention; other interventions on WCML and XC; and,
- Package YB: No HS2 Phase 1; ECML medium level of intervention; MML high level of intervention; other interventions on WCML and XC.

4.34. Packages YA and YB differ mainly in the level of investment in the ECML versus the MML. In package YA there is a greater level of

investment in the ECML and lower level on the MML while in package YB the situation is reversed. In addition to the Phase 1 alternative these packages would deliver:

Package YA

- An 11 train per hour timetable for long-distance ECML services, with all rolling stock assumed to be operated by 140mph capable IEP sets and with Nottingham and Sheffield served from Kings Cross, and Leeds and Newcastle both having a 4tph service from Kings Cross (the former with 2tph extending to Bradford and the latter with 3tph continuing to Edinburgh);
- Retaining a 6 train per hour long-distance service pattern on the MML;
- Improvements on the WCML as per alternative Package P1;
- Significant journey time and frequency improvements from Birmingham to Derby, Nottingham, Sheffield, Leeds, York and Newcastle; and,
- Enhancements to commuter services.

Package YB

4.35. Identical to Package YA except for:

- A 10 train per hour timetable for long-distance ECML services; and,
- An 8 train per hour long-distance service pattern on the MML

4.36. The journey time savings and additional capacity obtained from these packages are summarised in the table below.

Table 10: Journey Times and Journey Time Savings for Package YA, Package YB and HS2 Phase 2

TRAIN JOURNEY	PACKAGE YA		PACKAGE YB		HS2 Y NETWORK	
	Journey times (mins)	Journey time savings	Journey times (mins)	Journey time savings	Journey times (mins)	Journey time savings
London – Birmingham	73	11	73	11	45	39
London – Manchester	122	5	122	5	68	59
London – Nottingham	70	23	73	20	51[1]	42
London – Leeds	96	30	99	27	82	44
London - York	94	10	97	7	81	23
London – Newcastle	141	14	144	11	138	17
London – Edinburgh	220	25	223	22	222	23
Birmingham – Leeds	78	44	84	38	55	67

[1]Journey time is to Toton Interchange Station

Table 11: Additional Capacity for Package YA, Package YB and HS2 Y-Network

	WITHOUT SCHEME ALL DAY SEATS	PACKAGE YA ALL DAY SEATS	PACKAGE YB ALL DAY SEATS	HS2 Y-NETWORK
Total	434,100	578,800	569,900	652,600

Source: Atkins (2013), 'HS2 Strategic Alternatives: Final Report, 28 October 2013', https://www.gov.uk/government/publications/rail-alternatives-to-hs2, Appendix D

4.37. In Packages YA and YB, WCML destinations generally see journey time savings of 5-10 minutes, with destinations on the northern end of the ECML observing journey time savings of 20-30 minutes. Journey times to ECML destinations as well as Nottingham are most improved in Package YA, some journey times to locations in the East Midlands are lower in Package YB but others are higher (e.g. Derby and Leicester).

4.38. The difference in infrastructure enhancements across the two packages can clearly be seen in the additional seated capacity. Overall Package YA delivers the bigger increase in capacity which subsequently result in reductions in expected load factors except on London Midland services.

4.39. HS2 however, performs better against the connectivity and capacity objectives. It results in greater increases in the number of total seats, especially on long distance inter-city services, which is unsurprising given the cities which HS2 serves directly. The same is true of journey times with HS2 leading to higher journey time savings particularly

between London and the key cities. For destinations not directly served by HS2 the journey time improvements are smaller, however in many cases they are still higher than for the alternatives.

4.40. The quality and resilience of the rail network will suffer significantly more under the alternatives than under HS2 due to greater strain being placed on the existing rail network, while the levels of disruption caused are significantly higher. Indicative estimates suggest that while HS2 Phase 2 by itself results in 386 weekend closures the Y network alternatives lead to between 2770 and 2790 weekend closures which is significantly higher than that for HS2.

Summary of Benefits

4.41. Breakdowns of the present value benefits (PVB) from the five tested packages are presented in the table below.

Table 12: Net Present Benefits of the Alternatives

£bn (2011 PV)	**HS2 PHASE 1 ALTERNATIVE**	**HS2 PHASE 2 ALTERNATIVES**		**HS2 Y NETWORK ALTERNATIVES**	
Benefit	**Package P1**	**Package P2A**	**Package P2B**	**Package YA**	**Package YB**
In Vehicle Time*	2.7	12.1	12.0	14.3	12.2
Access / Walk	0.1	0.2	0.0	-0.1	-0.1
Wait	2.4	2.9	3.1	6.2	6.4
Interchange	-0.4	0.8	0.6	-0.6	-0.5
Crowding	2.8	2.6	2.6	6.0	5.7
Car User Benefits	0.3	0.7	0.7	1.0	0.8
Loss of indirect tax	-0.5	-1.2	-1.2	-1.7	-1.6
Present Value Benefits	**7.4**	**18.1**	**18.0**	**25.3**	**23.1**

*No reliability benefits are being claimed as part of journey time benefits

Benefits of Alternative to HS2 Phase 1

4.42. The benefits delivered by Package P1 are split almost equally between journey time savings, crowding benefits and reductions in waiting times. Despite the package including additional pieces of infrastructure it delivers slightly less passenger benefits than a previous package termed RP2 which was considered as an alternative in January 2012.

Benefits of Alternatives to HS2 Phase 2

4.43. Packages P2A and P2B deliver roughly the same journey time benefits (around £12bn) but there are differences in the locations that these benefits accrue to across the two packages. The greater quantum of trains running across the network has significant wait time and crowding benefits in both packages and there are some interchange benefits.

Benefits of Alternatives to the HS2 Y Network

4.44. Packages YA and YB deliver journey time benefits within the same order of magnitude (£12-14bn) but again there are differences in the locations these benefits accrue to, with YA further benefiting ECML destinations, Nottingham and Sheffield, whereas YB generates more benefits for other MML destinations. There are significant wait time and crowding benefits in both packages as well as slight interchange disbenefits.

Summary of Costs

4.45. Each package of alternatives to HS2 has an estimated cost made up of a capital cost covering the infrastructure and rolling stock (trains), and an operating cost of running and maintaining the rolling stock and railway.

4.46. Estimates of the construction cost of the packages were developed by Network Rail in collaboration with industry experts. The costs were estimated using a series of high level unit rates representing the early stage of development these schemes are in.

4.47. The construction cost of each scheme includes allowances for: scheme design, contractor preliminaries and project management, loss of revenue from disruption to the rail network and land costs. To reflect the relatively low level of design and development of these costs optimism bias has been included at a rate of 66% as advised by the Departments WebTAG guidance for projects at this stage of development.

4.48. The additional rolling stock required for each of these schemes can be purchased and treated as capital costs, or leased to form a component of the operating costs. In order to provide the greatest consistency with HS2 rolling stock is assumed to be purchased in all packages. However, a sensitivity test has been conducted where rolling stock is leased as this is the standard approach for UK railways. This increases the total

cost of the schemes by roughly 10-20% overall. Further sensitivity tests can be seen in the Atkins report.[36]

4.49. Operating costs have been estimated for each scheme. The Department has reviewed the level of optimism bias applied to classic line operating costs. In carrying out this review, the aim has been to better reflect the quality of the evidence on which they are based. As a result, differing levels of optimism bias are applied to different elements of operating costs ranging from 1.6% to 30%. The overall level of optimism bias is lower than for high speed trains, reflecting the better relative understanding of aspects of conventional rolling stock in the UK.

4.50. There are two main cost items which have not been included for the strategic alternatives packages but are included in HS2's costs: infrastructure maintenance and station costs. However, these omissions are expected to be small in relation to the overall package cost.

Table 13: Cost of the Alternatives

£bn (2011 PV)	**HS2 PHASE 1 ALTERNATIVE**	**HS2 PHASE 2 ALTERNATIVES**		**HS2 Y NETWORK ALTERNATIVES**	
Cost	**Package P1**	**Package P2A**	**Package P2B**	**Package YA**	**Package YB**
Construction Costs	1.9	10.2	10.5	12.3	10.7
Rolling Stock Purchase Costs	1.4	1.9	1.8	2.7	2.7
Operating Costs	6.2	8.9	8.3	11.7	11.3
Total Cost	**9.5**	**21.0**	**20.6**	**26.7**	**24.7**

4.51. Operating costs make up two thirds of the total cost of Package P1, this is unsurprising given the greater frequency of train services and lengthened trains included in the package. The total costs are not directly comparable with the latest estimate of RP2 since rolling stock was assumed to be leased not purchased as is shown above.

4.52. In the remaining four packages costs are split almost equally between construction and operation. This corresponds to a higher number of schemes included in these packages as well as some larger infrastructure enhancements. The scheme with the highest cost is Package YA. This is in part driven by an extensive package of upgrades on the ECML.

[36] Atkins (2013), 'HS2 Strategic Alternatives: Final Report, 28 October 2013', https://www.gov.uk/government/publications/rail-alternatives-to-hs2

Benefit Cost Ratio

4.53. The table below brings together the costs and benefits of the five packages and presents their benefit cost ratios.

Table 14: Costs and Benefits of Alternatives and resulting initial BCR

£bn (2011 PV)	HS2 PHASE 1 ALTERNATIVE	HS2 PHASE 2 ALTERNATIVES		HS2 Y NETWORK ALTERNATIVES	
	Package P1	Package P2A	Package P2B	Package YA	Package YB
Net Transport Benefits (PVB) (£bn)	**7.4**	**18.1**	**18.0**	**25.3**	**23.1**
Total Cost (£bn)	9.5	21.0	20.6	26.7	24.7
Revenue (£bn)	5.3	12.0	12.1	16.9	16.1
Net Costs to Government (PVC) (£bn)	**4.3**	**9.0**	**8.5**	**9.8**	**8.6**
Benefit Cost Ratio	**1.7**	**2.0**	**2.1**	**2.6**	**2.7**
Wider Economic Impacts (£bn)	1.1	4.1	4.0	5.4	5.1
Benefit Cost Ratio with WEIs	**2.0**	**2.5**	**2.6**	**3.1**	**3.3**

4.54. All of the packages have a benefit cost ratio (including WEIs) higher than 2. The Phase 1 alternative is categorised as providing medium value for money whilst all other packages provide high value for money[37]. Packages YA and YB both have benefit cost ratios greater than 3 when including WEIs.

4.55. Package P1 has a lower benefit cost ratio than RP2 (4.01 when assessed in January 2012). This has been driven by changes to both the estimated costs and benefits. On the cost side, a more robust approach to estimating rolling-stock capital costs and additional service provision in Package P1 have increased the costs. The updated modelling framework (PfM v4.3) suggests less mode shift results from the intervention, leading to lower estimates of transport user benefits and revenue generation.

4.56. There are only minor differences between the benefit cost ratios of Packages P2A and P2B as well as Packages YA and YB. However, it is important to point out that there are differences in the locations that these benefits accrue to across the packages. Other considerations such as deliverability could differ between YA and YB.

[37] BCR for Package 1 is 1.99 so is formally classified as offering medium value for money.

Sensitivities

4.57. Estimating the future costs of infrastructure schemes, rolling stock and operations is challenging. It is important to acknowledge uncertainty around what might happen in the future and to understand the impact this could have on the results of the appraisal. Nevertheless, the earlier stage of development of the alternative options justifies a less detailed approach to considering uncertainty than that of HS2. Focus is therefore on the key sensitivities likely to influence the results and justifications for those which have been conducted are provided below.

4.58. The following four sensitivities have been carried out to investigate the robustness of the value for money conclusions:

- Sensitivity 1 – rolling stock is assumed to be leased

  Rolling stock was assumed to be purchased in the appraisal to be consistent with HS2, allowing the benefits, costs and BCRs to be compared. However, were these schemes to be implemented, it is highly likely that additional rolling stock would be leased, not purchased. We therefore need to understand the implications this would have on the value for money.

- Sensitivity 2 – a 25% increase in the schemes capital costs

  The infrastructure schemes which make up the packages of alternatives are at a very early stage of development. It is therefore possible that once further design and development work is carried out the cost of these schemes could increase. This sensitivity is intended to assess whether the packages of alternatives still represent value for money in this scenario.

- Sensitivity 3 – higher rates of optimism bias equal to those applied to high speed trains are applied to operating costs.[38]

  To assess whether the alternatives represent value for money if there is more uncertainty surrounding operating costs than is currently applied.

- Sensitivity 4 – combines sensitivities 2 and 3 above

4.59. The table below shows the central case BCRs and how these change in each of the sensitivity tests.

[38] The exact rates and a comparison to those used in the central case can be found in the Atkins report.

Table 15: Benefit Cost Ratios for Sensitivity Tests

	HS2 PHASE 1 ALTERNATIVE	HS2 PHASE 2 ALTERNATIVES		HS2 Y NETWORK ALTERNATIVES	
	Package P1	Package P2A	Package P2B	Package YA	Package YB
Central Case	1.7	2.0	2.1	2.6	2.7
Sensitivity 1	1.2	1.6	1.6	1.8	1.9
Sensitivity 2	1.6	1.6	1.6	2.0	2.0
Sensitivity 3	1.5	1.9	1.9	2.3	2.3
Sensitivity 4	1.4	1.5	1.5	1.8	1.8

4.60. In all of the sensitivity tests the benefit cost ratios remain above 1, that is, the benefits of the schemes remain higher than the costs.

4.61. In sensitivity 1 where rolling stock is assumed to be leased both YA and YB are categorised as medium rather than high value for money. The BCRs of the remaining packages are also lower than in the central case. Sensitivities 2 and 3 result in small changes to the BCRs of all packages but these do not change the value for money conclusions. It is only when higher than expected capital costs are combined with a higher uncertainty around operating costs that there are significant implications for the value for money of the schemes.

Conclusion

4.62. The alternatives to HS2 offer means of providing more capacity on the rail network while also generating high value for money, particularly the Y-Network alternatives which generate BCRs above 3.0. While there are alternatives to HS2 worth considering, they are not as effective at meeting the objectives of the scheme, and are likely to be particularly disruptive. The analysis indicates they are likely to:

- Be unable to provide as much extra capacity for passengers;
- Lead to significant levels of disruption to passengers during construction;
- Are likely to worsen resilience or performance reliability; and,
- Be unable to offer the same level of journey time savings as HS2.

4.63. HS2 in contrast is likely to result in a substantial improvement in the resilience and performance reliability of the network by relieving the pressure on the WCML of the fastest intercity services. It will result in substantially larger journey time savings on key inter-city routes while minimising the level of disruption to rail users during construction and providing a greater uplift in capacity than the alternatives.

5. HS2 – robustness of Economic Case

Introduction

5.1. The reference case specifies the costs and benefits of HS2, assuming one particular future state of the world. This state of the world contains assumptions about external factors such as: GDP, population, energy costs and the relationship between these variables and levels of rail patronage decades into the future, as well as variables currently within our control such as scheme costs and train timetabling.

5.2. The 'reference case' is based on the standard assumptions and approaches specified in WebTAG guidance which provides advice on best practice for conducting analysis of the impacts of transport infrastructure investment. The guidance has been developed over many years and has benefited greatly from the UK's long tradition of applying cost benefit analysis to transport infrastructure investment proposals. Nevertheless, the 'reference case' presents one potential outcome from many possibilities.

5.3. Forecasting such a long way into the future is inherently challenging, it is particularly important to understand the uncertainty attached to those factors which will have the greatest impact on the appraisal. In the case of HS2, as with many transport investments, this means understanding in particular the impact of a range of different assumptions about economic growth, growth in demand for rail travel, construction costs and the valuation of time savings.

5.4. An assessment of the resilience of the economic case to a range of different assumptions associated with these factors has been conducted, using the standard assumptions underpinning the 'reference case' outlined in Table 6 as the starting point. This analysis captures the range of benefit cost ratios that could result from combinations of different assumptions and is based on an understanding of the probability of different events occurring. While it cannot capture all possible outcomes because there are some events which cannot be described in terms of probabilities in this way, it does provide a systematic way of assessing the range of different outcomes that could occur.

5.5. The analysis focuses on the key variables which influence the Economic Case for HS2, identified as having the largest potential impact and those

which are subject to the greatest levels of uncertainty. The variables which meet this criteria are:

- Future GDP;
- Values of Time;
- Approach to capping demand[39];
- Competition and regulation on HS2;
- Capital Costs;
- Responsiveness of Rail Demand to changes in GDP and the cost of rail travel;
- Reliability benefits;
- Future cost of travelling by alternative modes of transport;
- Rail Fares;

5.6. Analysing the uncertainty within each of these variables requires different approaches. This may be because certain techniques are more suitable for some variables than others or because the information does not exist to adopt certain methods in particular cases.

5.7. The techniques for assessing risk and uncertainty can be distinguished into two main approaches. Risk analysis allows us to quantify the combined impact of a number of different risks at the same time giving us the probability of different overall outcomes. Sensitivity tests are used to obtain an appreciation of the likely impact of individual events compared to the reference case and are particularly useful for binary events or variables about which we have limited information on the likely distribution of outcomes.

Risk Analysis

5.8. Risk analysis lends itself towards variables which can take a range of different values and for which the possible values can each be judged to have a specific probability of occurring. For example, future GDP growth can take a range of values and statistical techniques can be used to identify the expected probability of different values occurring based on historic information and the past performance of the forecasting tools

[39] The HS2 reference case assumes that there is no demand growth beyond 2036, demand is essentially capped in this year.

used. Uncertainty around the precise values for important parameters, such as the impact of GDP on travel demand, has also been reflected.

5.9. The key factors considered within the risk analysis are[40]:

- Short-term GDP growth (2012-2017);
- Long-term GDP growth (2017 onwards);
- The responsiveness of rail demand to changes in GDP;
- The responsiveness of rail demand to changes in the cost of rail travel;
- Construction costs;
- The non-work value of time[41];

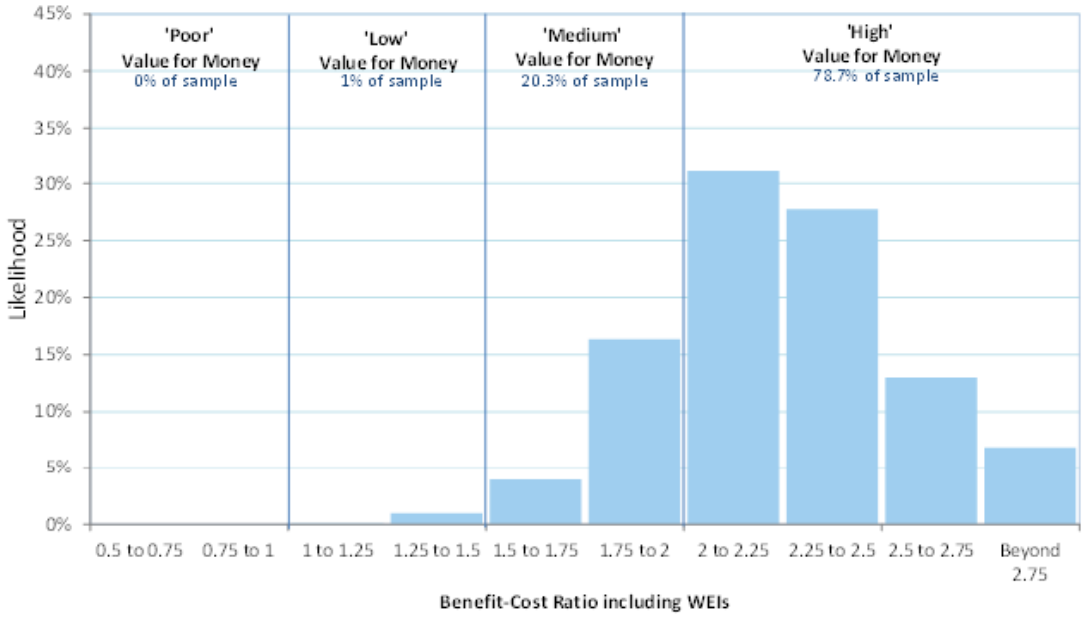
5.10. The chart below presents the results of the risk analysis for the appraisal of the Y-Network. The distribution of outcomes has been mapped against the Department's value-for-money categories enabling comparison against other schemes. It clearly indicates that, taking account of the sources of uncertainty which have been represented here (as listed above) there is very little chance of the Benefit Cost ratio falling below 1.5 with the expected outcome being a BCR between 2.0 and 2.5. In other words, even in an unlikely scenario where construction costs are at their upper limit, and long-term GDP growth is the low end of the range, the BCR remains above unity.

5.11. The BCR is most sensitive to the GDP growth rate forecast. The more optimistic the economic outlook is, the greater probability of a larger BCR. The BCR is resilient to even extremely low forecast rates of long-term GDP growth of between 1.25% and 2.00% per annum; in the majority of cases where GDP growth is between 1.25% and 2.00% per annum the BCR remains greater than 1.75.

[40] Further details of the risk analysis undertaken here can be found at: http://www.hs2.org.uk/news-resources/economic-documents

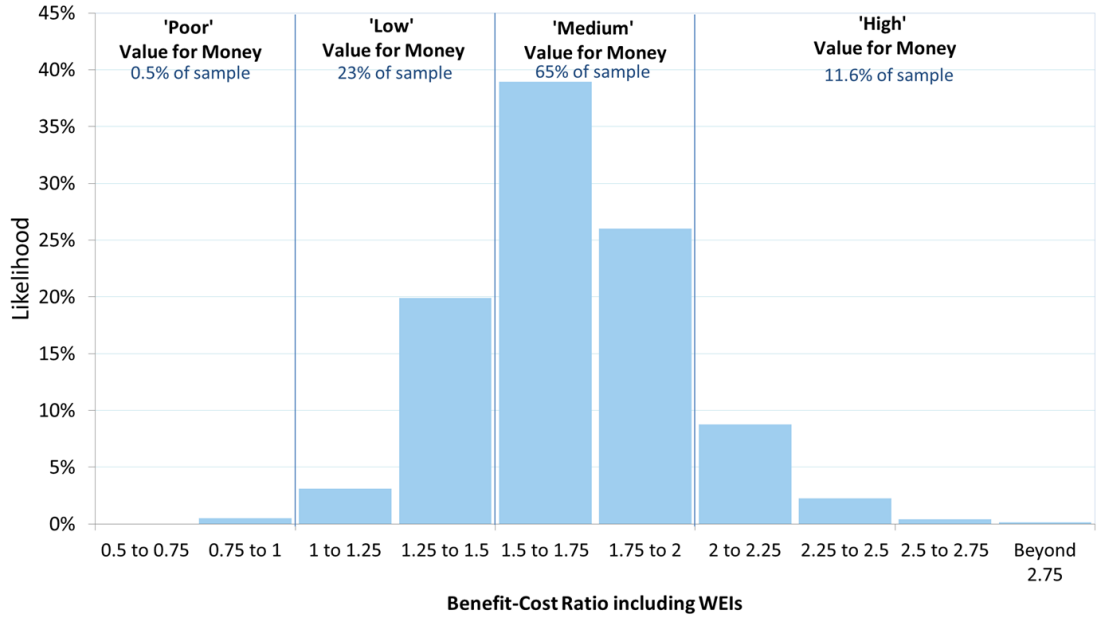
[41] Testing the resilience of the Economic Case to different assumptions regarding the Business Value of Time is considered elsewhere.

Figure 7 – Y-Network distribution of Benefit-Cost Ratios



5.12. This analysis has also been applied to Phase 1 of the scheme separately as shown in the diagram below. While the distribution of potential outcomes has shifted somewhat to the left (reflecting the lower reference case BCR) this aspect of the scheme is still robust to a wide range of outcomes. In more than 75% of cases the BCR of Phase 1 represents medium value for money or better.

Figure 8 – Phase 1 distribution of Benefit-Cost Ratios



Extensions to standard assessment

5.13. HS2 is unlike most other transport schemes. It is a project with high up-front capital investment producing benefits over a very long life-span. There are therefore certain standardised assumptions used in the standard economic assessment that have a substantial impact on the BCR, for which alternative and potentially reasonable approaches exist.

5.14. To understand this further, specific tests were undertaken on the impact of different assumptions, most notably levels of demand forecasts, construction costs and different valuations of time savings. This shows how alternate, but reasonable assumptions, which have been tailored to the unique characteristics of high speed rail, could alter the results.

Business Value of Time

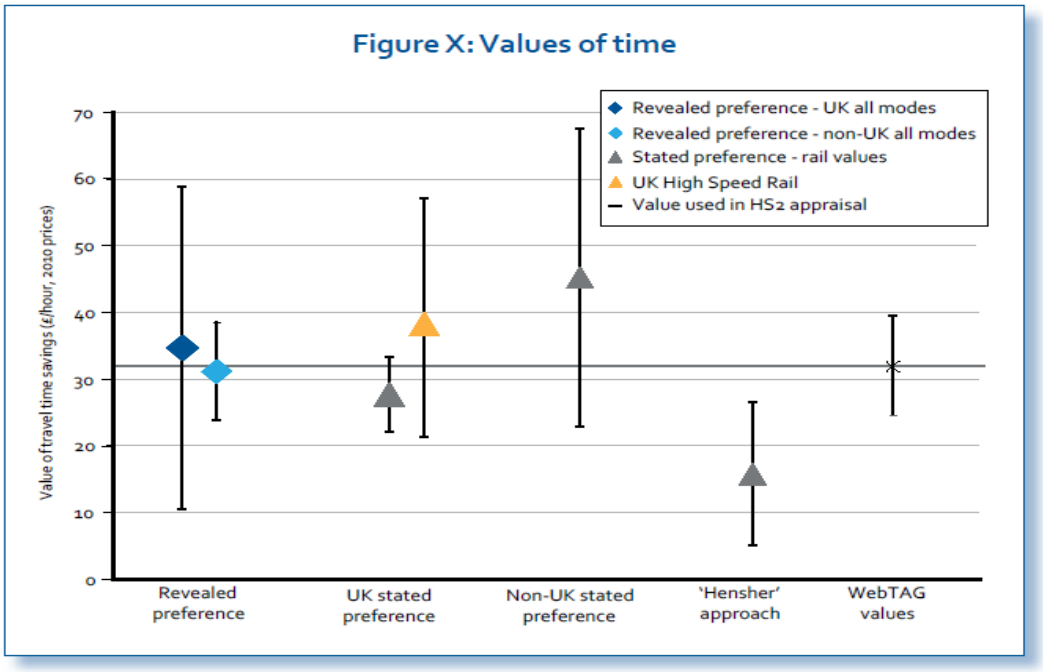
5.15. Business Travel Time Savings contribute a significant proportion of the transport user benefits of the scheme. As noted previously the values used to estimate the benefits to business travellers from travel time savings have been altered in this appraisal to reflect more recent data on the incomes of business passengers.

5.16. The valuation of travel time savings should reflect people's willingness-to-pay for quicker journeys. Over the last year, the Department has undertaken a comprehensive review of different approaches for deriving this willingness-to-pay for business travellers. This has included updating the values in WebTAG with the most recent available data and comparing those updated values with the existing evidence base of values from alternative approaches.[42]

5.17. The comparison of values resulting from different approaches is shown in the chart below. While the assumptions and methods vary between approaches, they are all aiming to estimate the same thing: what businesses would be willing to pay for travel time savings. The wide range in the values presented in the chart, both within and between approaches, demonstrates the variability and uncertainty around what businesses would be willing to pay for travel time savings. However, the updated values given in WebTAG of around £32/hour for rail travel are firmly towards the centre of this range and, therefore, the Department has concluded that these values are a suitable representation of businesses' willingness-to-pay.

[42] https://www.gov.uk/government/publications/values-of-travel-time-savings-for-business-travellers

Figure 9 – Business values of time implied by different methodologies



5.18. However, when considering values of time for high speed rail schemes the study concluded that '*the evidence does seem to support a business valuation in excess of the wage rate*'. While there may be good reason to believe that the Business Value of Time applied to high speed rail should be higher than that specified in WebTAG, we have tested the robustness of the Economic Case to values both higher and lower than those in the 'reference case'.

5.19. To create a 'high value of time' scenario, the WebTAG 2013 standard business value of time for rail users has been increased by 40%[43]. This is consistent with the conclusion in the ITS Leeds (2013) report which suggests that across their sample of High Speed rail specific studies, the value of time was on average 50% higher than the wage rate while for UK specific studies this figure was 40%.

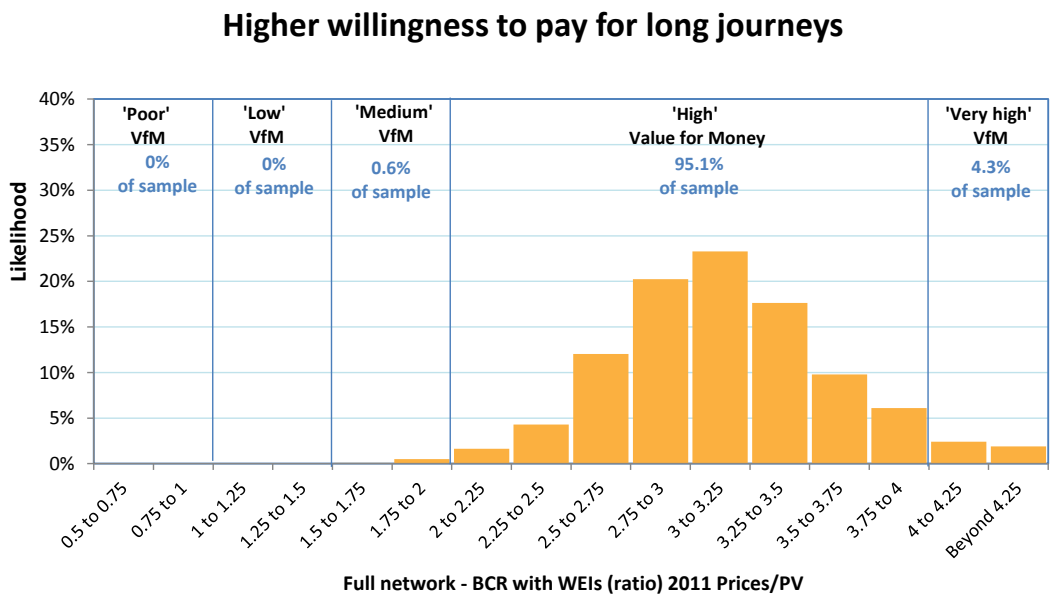
5.20. There are a relatively limited number of High Speed rail specific studies so a low business value of time scenario is also considered which takes account of the wider evidence for the willingness to pay for travel time savings across all rail travel. It therefore assumes that high speed rail passengers have similar values of time to other rail passengers, a conclusion currently at odds with the existing evidence as noted above, and therefore conservative. Evidence presented in the ITS Leeds (2013)

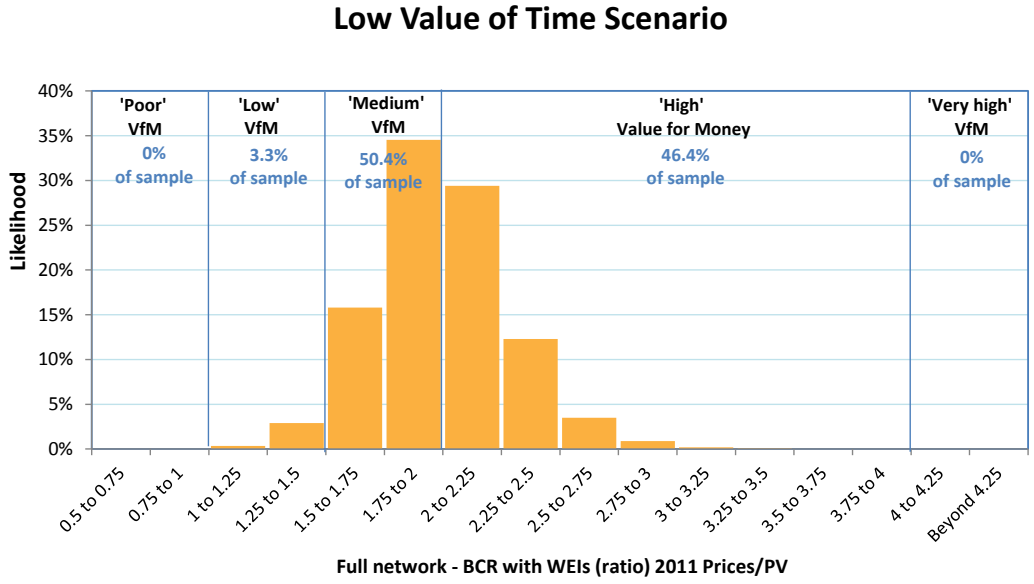
[43] Note this is actually lower than the 25% increase on the WebTAG 2012 values proposed by the study. The non-work values have also been varied according to time savings by trip length (as the standard value is averaged across trip length).

study suggests applying a figure 20% lower than the WebTAG 2013 values of time.

5.21. The charts below indicate the robustness of the Economic Case for the Y-Network to the two alternative values of time considered. The Economic Case appears robust to the low scenario with the BCR above one in all cases considered. If the high value of time was adopted then the BCR is most likely to lie above 3 for the full network.

Figure 10 – Y-Network, distribution of Benefit-Cost Ratios across alternative Business Values of Time



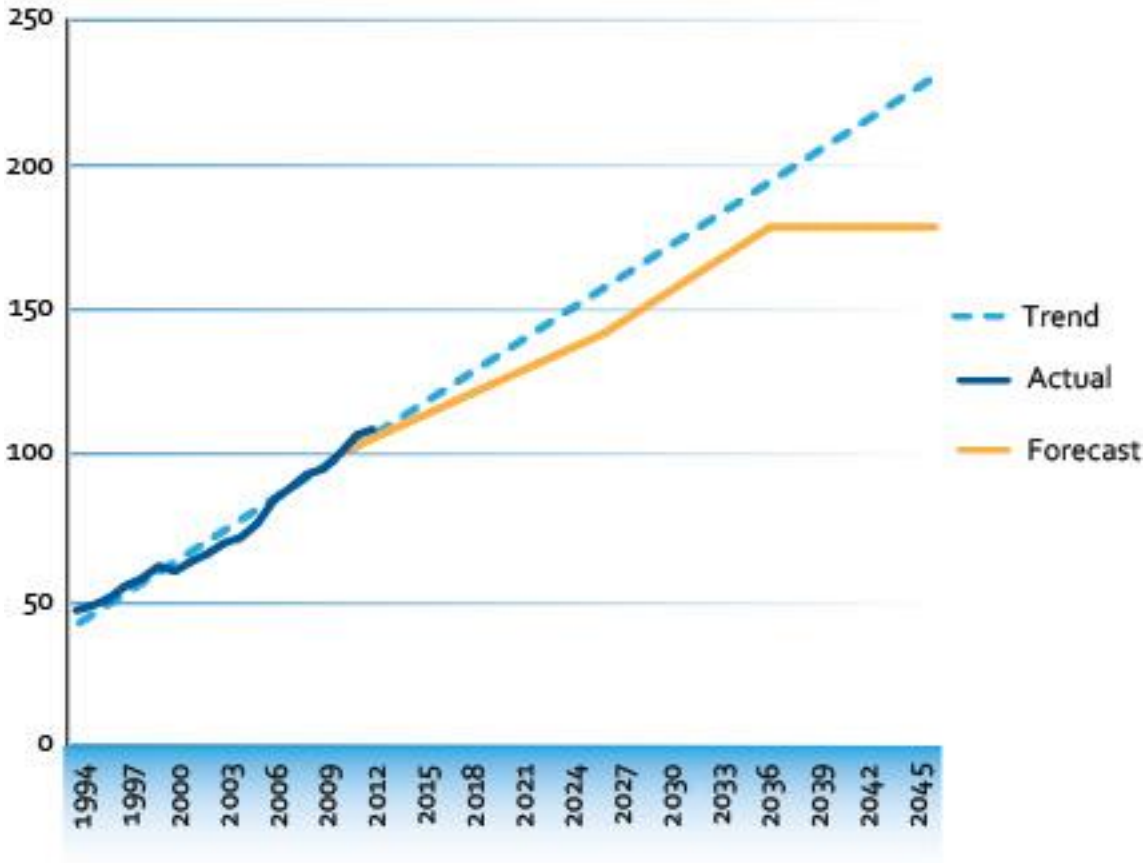


Demand Cap

5.22. The Demand Cap is an important, albeit arbitrary assumption that has a significant influence on the benefits of HS2. Essentially, demand is capped in this appraisal at a specific level which occurs in 2036 in the reference case. Beyond 2036, it is assumed that demand for rail travel whether High Speed or otherwise is constant and fares no longer grow at a rate above inflation. This represents growth of just 47% in long distance rail trip rates per person compared to today's levels.

5.23. Rail demand has in fact grown very strongly over the last 20 years and even during the recession, it has shown little sign of slowing. In the decade from 2002 to 2012 the annual growth in long distance rail travel was 5.2%. The diagram below compares the forecast of long distance rail demand used in this appraisal against a continuation of recent trends, in long distance demand, clearly indicating that relative to recent trends our forecasts are conservative, particularly when also applying a cap on demand in 2036.

Figure 11 – Long distance rail demand forecasts

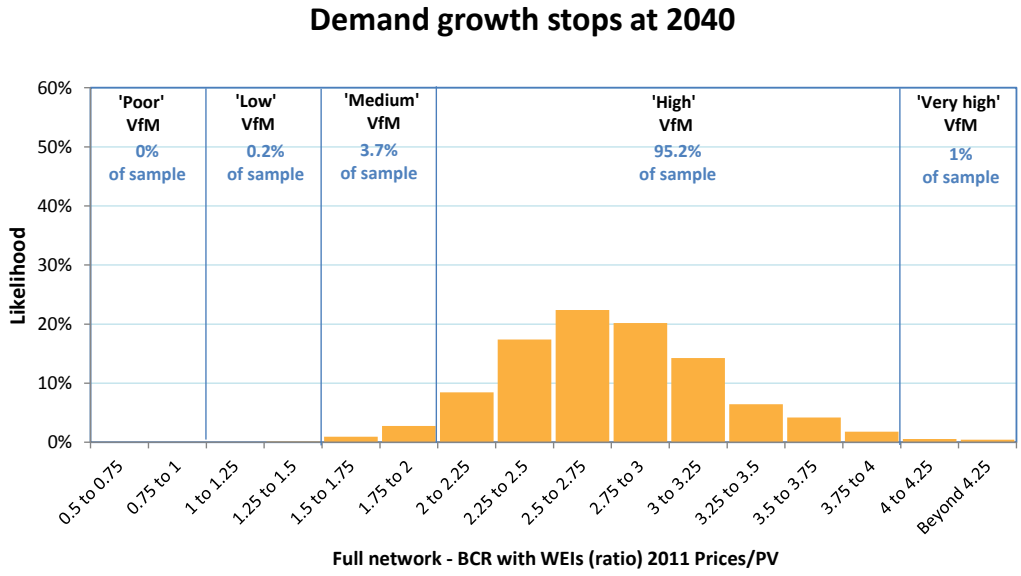


5.24. Subsequent to the last iteration of the HS2 Economic Case, the Department has conducted an external research project into the specification of a demand cap for rail projects titled *'Specifying the Demand Cap for Rail'*[44]. This project emphasised the need for a demand cap to reflect the inherent uncertainty in rail demand forecasting as well as to allow consistency across the appraisal of interventions. However, it uncovered no empirical evidence which could help in determining an appropriate demand cap specification.

5.25. To reflect the nature of the demand cap which is being implemented, its apparent conservatism, particularly when accounting for recent trends in rail demand and to recognise the range of alternative approaches that exist, the Economic Case for HS2 has been tested against alternative options for specifying the demand cap.

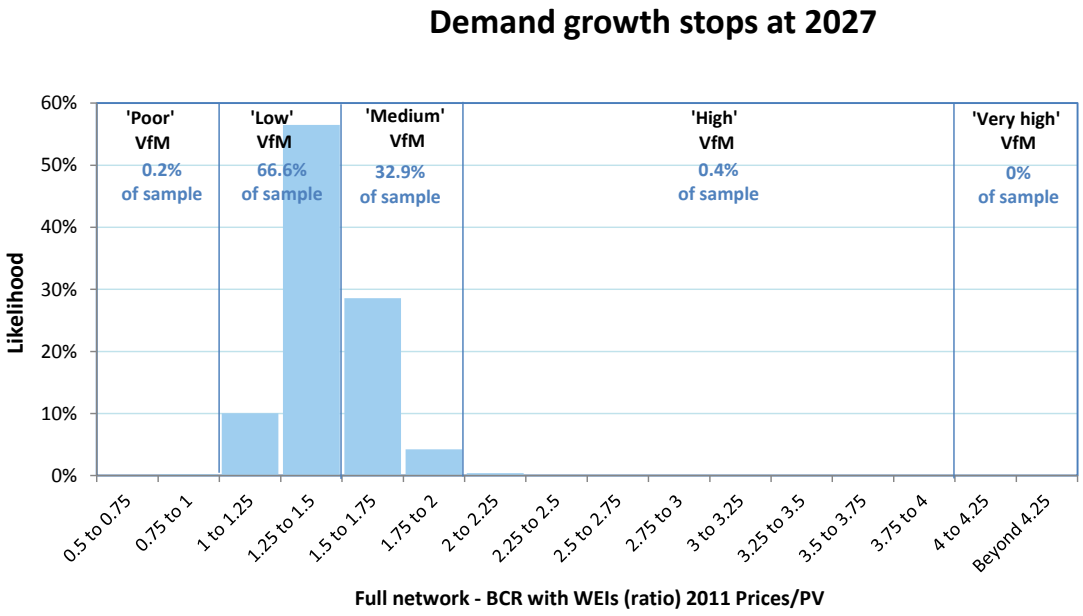
5.26. HS2 Ltd has replicated its risk analysis assuming different levels of demand cap[45] which indicates that the downside risk from reducing the demand cap is smaller than the potential for upside gain if the demand cap were increased (see figure 12 below). This distribution is to be expected since events occurring closer in time are more certain and therefore have lower levels of uncertainty attached to them than events further into the future.

Figure 12 - Y-Network, distribution of Benefit-Cost Ratios across different Demand Cap assumptions



[44] Bates, Worsley, Wardman, Nash & Preston, 2013, Specifying the Demand Cap for Rail https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/251609/specifying-the-demand-cap-for-rail.pdf

[45] The risk analysis assumes that the fares cap which ordinarily is applied at the same year as the demand cap is fixed at 2036.



5.27. These results however should be treated with caution. If demand continued to grow further into the future then higher crowding would result, both in the without scheme scenario against which HS2 and the Strategic Alternatives are compared and the scenario which includes HS2. One would expect that changes to capacity would be considered and that both infrastructure provision and subsequently benefits and costs would change accordingly. Accounting for this in the analysis could alter the BCR both positively or negatively although it is unclear to what extent.

Construction Costs

5.28. Section 3 described a range of cost estimates for the construction of HS2. These range from the HS2 Ltd target price at the lower end, up to the entire provision for funding agreed with HM Treasury.

5.29. The costs used in the reference scenario follow Green Book guidance and include an expected, or average, level of contingency allowances. Because of their influence over the benefit cost ratio, we have also examined what happens if construction costs are adjusted both upwards and downwards.

5.30. We have considered the distribution of cost outcomes alongside other elements within the risk analysis. The impact upon the central BCR for phase 1 is indicated in table 16 below:

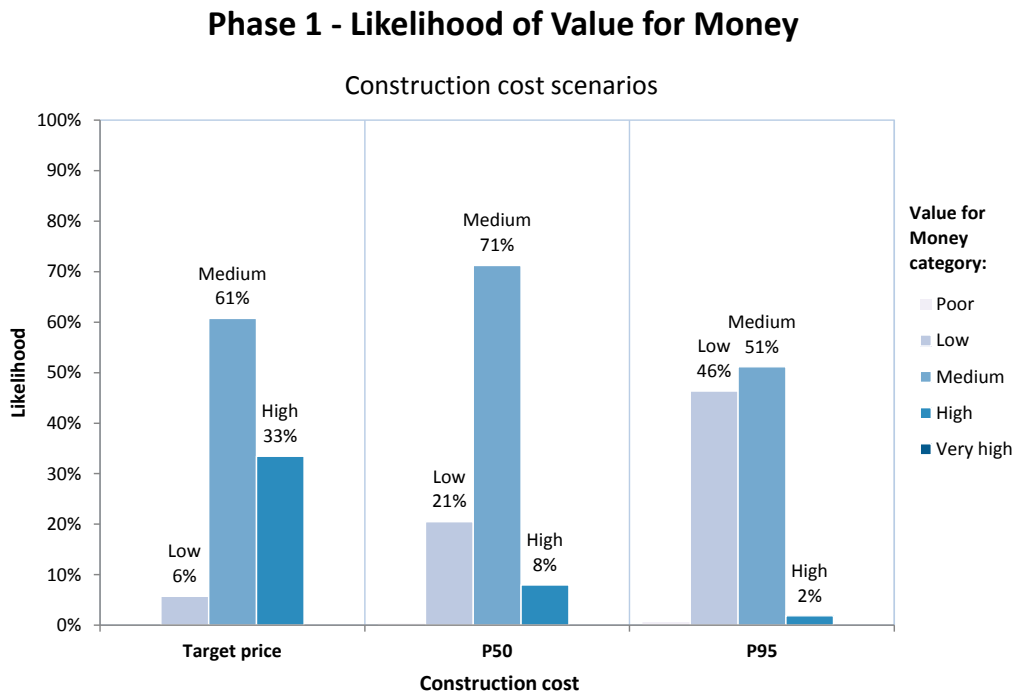
Table 16 – Impact on Phase 1 BCR of differing QRA rates

APPROACH	QRA TARGET PRICE	QRA 'P50'	QRA 'P95'
% contingency	10%	24%	37%
Contingency £bn (2011 PV)	1.6	3.7	5.75
BCR without WEIs	1.6	1.4	1.3
BCR with WEIs	1.9	1.7	1.5

Source: DfT calculations using HS2 Ltd appraisal outputs, Numbers may not add due to rounding.
Monetary values are expressed in £bn (2011 prices)

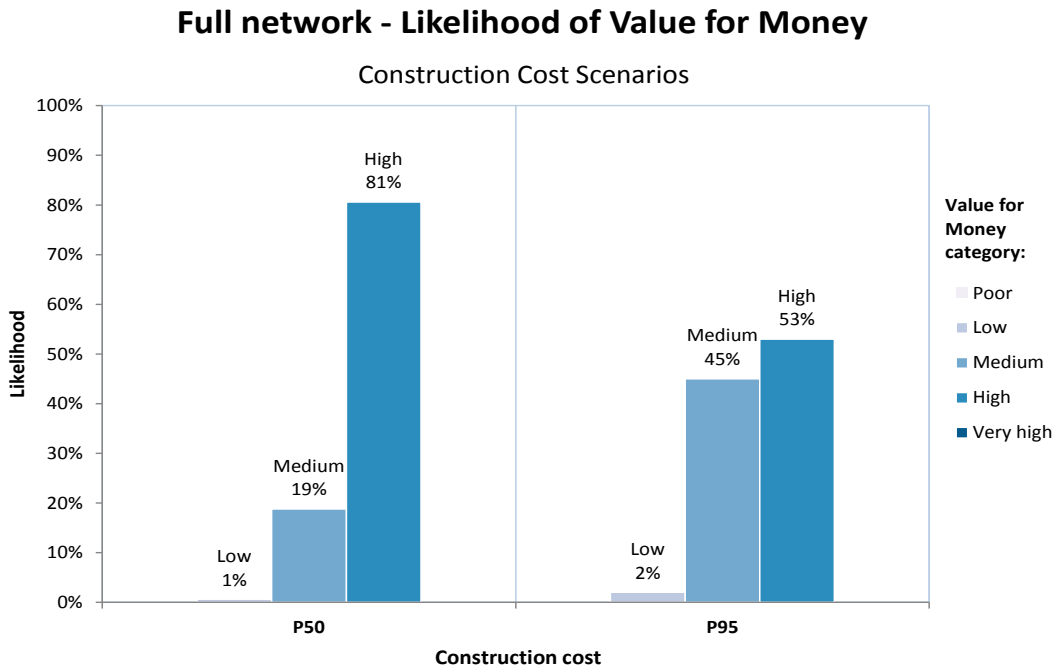
5.31. In addition to these central case estimates, figure 13 below indicates the distribution of benefit cost ratios for phase 1 according to the level of construction costs. It indicates that there are significant opportunities to improve the value for money of HS2 through engineering efficiencies and robust cost controls. At the same time it should be noted that if unexpected events lead to costs reaching the agreed funding provision, alongside a number of other downside risks materialising, the benefit cost ratio would remain above one.

Figure 13 – Distribution of Phase 1 BCR's for differing construction cost estimates



5.32. The equivalent estimates for the entire network are provided in figure 14 below. This represents a worst-case scenario where both phase 1 and phase 2 cost estimates reach their upper bound i.e. £21.4bn (2011 prices) for phase 1 and £21.2bn (2011 prices) for phase 2. In this scenario the BCR of the Y-network would fall by approximately 0.3 to around 2.0 (including wider economic impacts).

Figure 14 - Distribution of Y-Network BCR's for differing construction cost estimates



Sensitivity tests

5.33. In addition to examining the Demand Cap and Business Value of Time, specific sensitivity tests have been employed to assess the robustness of the Economic Case in certain cases where risk analysis is inappropriate. The most relevant tests applied are those testing the impact of different assumptions regarding the cost of other modes, rail fares and the quantification of reliability benefits.

Cost of other modes

5.34. One would expect the cost of alternative modes to alter the attractiveness of travel by rail and therefore HS2. If the costs of road or air travel fall, they become relatively more attractive modes and one would expect travellers to transfer from rail to road or air travel. HS2 Ltd have tested the sensitivity of rail demand to both higher and lower energy costs[46]; with higher energy costs, the cost of fuel rises and therefore the cost of road and air travel also increases.

5.35. These tests have shown that the sensitivity of the BCR for HS2 to changes in energy costs is marginal, with the transport user benefits only increasing by approximately 1% under the high energy cost scenario and falling by just less than 1% in the low energy cost scenario.

[46] These are based on the energy cost scenarios generated by DECC, details of which can be found here: https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/energy-and-emissions-projections

Fares

5.36. Fares tests are difficult to interpret due to the fact that the demand cap is set at a particular level of demand and fares are also capped at this point. Increasing fares reduces demand but, since ultimately the same level of demand is reached, the longer period of higher real revenue growth outweighs the demand impact. In the case of Phase 1, increasing real fares by RPI+2% per annum from 2020 until the demand cap is reached (rather than RPI+1% as used in the reference case) increases the BCR (excluding Wider Economic Impacts) to 1.9 from 1.4 previously, while for Phase 2 this BCR increases to 2.9 from 1.8 previously.

5.37. When the level of fare increases is reduced (to RPI + 0% from 2020 until the demand cap is reached, after which point fares rise at a rate equivalent to the GDP deflator) the effect is the opposite, with the reduction in revenue significantly outweighing any impact on transport user benefits and therefore the BCR falls. For Phase 1, the BCR (excluding Wider Economic Impacts) is now 1.3 compared to 1.4 previously and for the Y-network it falls from 1.8 to 1.6.

Reliability

5.38. Benefits resulting from improvements in reliability are calculated on the basis of the expected reduction in the average minutes of lateness which are then converted into journey time savings in an approach consistent with the Passenger Demand Forecasting Handbook. This improvement in reliability also translates into an increase in the demand for the High Speed services.

5.39. While it is likely that HS2 will deliver significant improvements to reliability, and the assumed forecast delay on HS2 services is consistent with international precedent; until services operate, the level of reliability benefits is somewhat uncertain. Removing reliability benefits from the appraisal reduces the BCR (without Wider Economic Impacts) of Phase 1 to 1.2 and for the Y-Network it falls to 1.5. This however, represents an extreme lower bound of the risk in this area as reliability benefits are expected to exist, the uncertainty relates to their likely scale.

Threats and Opportunities

Competition and Regulation on HS2

5.40. The operational characteristics and regulatory environment in which HS2 might operate are, as would be expected at this stage in scheme development, undetermined. HS2 Ltd has begun to investigate how different operating environments and responses by train operators may impact on the Economic Case. Initial work has considered how

competition between HS2 operators and those on existing networks might influence pricing decisions under the current fare regime.

5.41. The analysis indicates that conventional rail operators may have the incentive to reduce fares to capture market share from HS2 thus potentially limiting the scope for HS2 to set higher fares. Whilst reductions in fares on conventional rail will reduce the revenue on HS2, this will be broadly off-set by an increase in revenue on the existing rail network. The full implications on value for money are uncertain as the models do not attempt to estimate passenger benefits. However, the revenue impacts do not suggest anything which would alter the value for money conclusions.

5.42. It is important to note, that this work is in its early stages and subject to significant further analysis.

Impact of HS2 on Economic Geography

5.43. The standard approach to estimating impacts of transport schemes, as adopted throughout this Economic Case, seeks to capture the impacts on business as well as wider society. This includes, amongst other things, the benefits to business travellers from faster journeys and reduced crowding as well as the value of increased production and the benefits to company efficiency from being closer together. The economic appraisal calculates net national impact, and cannot be used to analyse sub-national impacts.

5.44. With advice from an independent panel of experts, HS2 Ltd has undertaken a programme of work to help us understand the scale of the potential economic benefits of HS2 and how they might be spread across the country.[47] This work complements the standard assessment of economic impacts described.

5.45. This work looks at the potential benefits of HS2 in a different way to this Economic Case, by examining how improvements in connectivity would increase competitiveness of areas outside of London and change the future pattern of growth. The results from this new analysis suggest that HS2 could increase economic output by between £8bn and £15bn per year[48], and that whilst all regions benefit, the city regions in the Midlands and the North do particularly well.

5.46. This is the first attempt to measure economic impact in terms of productivity and location effects, and results should be considered

[47] http://assets.hs2.org.uk/sites/default/files/inserts/High%20Speed%20Rail%2C%20Transport%20Investment%20and%20Economic%20Impact.pdf

[48] Results are modelled for 2037, and reported in 2013 prices.

provisional. HS2 Ltd will continue to refine this work and further develop the evidence in this area, but this study represents a significant development and should be seen as a complement to (not a substitute for) the scheme appraisal presented in this Economic Case. Given fundamental differences in approaches, results are not directly comparable, and are in no way additive, but this work suggests that there may be important economic benefits not captured within the current appraisal of HS2. These are particularly relevant, and have the potential to be significant, in the case of a transformational scheme such as HS2.

Existing Rail Network

5.47. Assumptions about the future of the existing rail network play an important role in assessing the costs and benefits of HS2. There are two key areas of relevance:

- The nature of the classic rail network if HS2 was not constructed 'the without scheme' scenario – this allows comparison between HS2 and a scenario in which HS2 is not built; and,
- The train service specification (TSS) on the existing network if HS2 is built.

5.48. This appraisal uses a 'without scheme' scenario based on 'committed schemes only; largely those described in the Department's 2012 High Level Output Specification.[49] While further improvements to the existing network could be expected throughout the 2020s and 2030s, it would be inappropriate to speculate what these may be; particularly as future investment may complement rather than compete with HS2. The inclusion of further investment could improve or worsen the case for HS2 depending on the extent to which it is complementary or otherwise.

5.49. As long distance services transfer onto HS2, capacity will be created on the existing network to introduce different services. There are many options for making best use of this released capacity, including extra commuter and freight trains, and other regional and local services that would otherwise be impossible to run. The HS2 economic case relies upon assumptions about the train service specification (TSS) on the classic rail network when HS2 opens; however, this represents one possible set of assumptions used for business case modelling purposes. There are many other potential combinations of released capacity.

[49] High Level Output Specification 2012, https://www.gov.uk/government/publications/high-level-output-specification-2012

5.50. Further work will be undertaken to optimise the use of released capacity as the project develops in accordance with the set of principles described in the Strategic Case for HS2.[50] The finalisation of the TSS will be expected to impact on the value-for-money of the scheme and the extent of the upside or downward risk is dependent upon how well the final TSS matches demand for rail services.

Calculation of scheme benefits

5.51. HS2 Ltd has calculated user benefits using the 'rule of a half'[51]. Depending on the nature of demand it is possible for this assumption to lead to either an underestimate or an overestimate of the benefits to passengers. This is not unique to HS2 and this uncertainty around the accuracy of the 'rule of a half' approximation exists in all transport appraisals, particularly on projects which offer large journey time savings. It is to be noted however that alternative methods exist which can generate lower benefits although these are less commonly used, poorly understood and subject to their own uncertainty.

Scheme opening date

5.52. Phase 1 of HS2 is currently scheduled to open during 2026 while Phase 2 of the scheme is scheduled to open in 2033. There remain risks to these delivery dates, which range from passage through a complex Parliamentary approvals process to the engineering work required being delivered on time.

5.53. Were the delivery of HS2 to be delayed, it would likely increase scheme costs and could alter scheme benefits and revenues. The scale of the impact on the Economic Case would depend on the nature of the delay and the implications for the resulting profile of costs, revenues and benefits over time.

5.54. Delay might itself lead to higher costs than would otherwise be the case. Preliminary work suggests that a delay to the Hybrid Bill process (for example for one year), could result in inefficient delivery due to the nature of the HS2 Ltd corporate and indirect cost structure, which could result in perhaps £100m of additional costs above current estimates.

[50] Department for Transport (2013), 'The Strategic Case for HS2', https://www.gov.uk/government/publications/hs2-strategic-case

[51] The rule of half estimates the changes to consumer welfare (in this case the welfare of transport users) resulting from changes in supply assuming a constant demand curve.

6. Value for Money Assessment

Introduction

6.1. The Economic Case needs to reach a conclusion on whether the scheme represents good value for taxpayers' money. This requires comparing HS2 against a "without scheme" reference case, in order to assess the economic, social, environmental and public account impacts that a transport intervention may incur. The analysis presented in Sections 3 and 5 allows such conclusions to be drawn and the Department's WebTAG guidance provides a framework for doing so.

6.2. In order to allow comparison across schemes, WebTAG specifies value for money categories within which schemes can be placed, and the table below describes these categories:

Table 17 – Value for Money Categories

VALUE FOR MONEY CATEGORY	BENEFIT COST RATIO
Poor	Less than 1.0
Low	Between 1.0 and 1.5
Medium	Between 1.5 and 2.0
High	Between 2.0 and 4.0
Very High	Greater than 4.0

6.3. As previously discussed, the long-term forecasting horizon required when considering a project such as HS2 combined with its inherent scale and complexity, limits the ability of a single 'reference case' BCR to generate informative conclusions on the value for money of the scheme. It is appropriate therefore, to consider how robust the Economic Case for HS2 remains across a range of possible future scenarios and therefore draws heavily on the analysis in Section 5.

6.4. Not all potential scheme impacts can be assessed in monetary terms and of those that can; we have more robust evidence for the monetisation of some impacts than others. In assessing value for money, WebTAG recommends using a three stage approach:

- We start with those impacts where the evidence for the monetisation is robust. We call the resulting BCR the "initial" BCR;

- We then add those impacts where monetisation is possible, but where the evidence for doing so may not be as robust. The resulting BCR is called the 'adjusted BCR';

- Finally those impacts for which it is not possible to provide monetary values are accounted for in a qualitative manner, and the potential ability for these impacts to shift the value for money category is assessed.

6.5. The table below presents the categories within which the assessment of differing impacts are ordinarily placed. Even within these categories the robustness of the analysis can vary, for example the quantification of Wider Economic Impacts is considered more robust in this assessment than landscape impacts.

Table 18 - Three stage approach to monetisation of impacts

Initial BCR: robust, monetisable impacts	**Adjusted BCR: less robust, but monetisable impacts**	**Judgement whether non-monetised impacts could shift value for money assessment**
Travel Time Savings Crowding benefits Noise Air Quality Greenhouse Gases Physical Activity Accidents Indirect Tax Revenue Reliability	Wider Economic Impacts Landscape	Townscape Heritage of Historic Resources Biodiversity Water environment Security Access to Services Affordability Severance Option Values

Notes: Note that in the economic case for HS2 the reliability benefits have been recorded in the initial BCR to ensure consistency with previous versions of the economic case. This differs from the treatment recommended in WebTAG. Nevertheless, paragraph 5.39 provides an approximate BCR if reliability benefits are removed.

Does the scheme represent 'value for money'?

6.6. Table 6 presents the 'initial BCR' for the 'reference case' for both Phase 1 and the Y-Network. It indicates that excluding Wider Economic Impacts leads to an initial BCR of 1.4 for Phase 1 and 1.8 for the Y-Network.

6.7. Including WEIs provides a BCR of 1.8 for Phase 1 and 2.3 for the Y-Network. As noted previously, point estimates are unable to demonstrate the uncertainty inherent within consideration of a project such as HS2. It

is therefore imperative to consider how robust these BCR estimates are to changes in both the external and internal environment.

6.8. The economic analysis of HS2 described in Section 5 suggests that taking account of certain key sources of uncertainty, there is a low probability that the BCR for the Y-Network will fall below 1.5. Only in a very limited number of scenarios, where there is an unexpected prolonged series of low economic growth (averaging 1.25% to 2% per annum over the entire appraisal period) combined with the upper range of cost estimates and pessimistic views on other key variables does the BCR drop below 1.5. The most likely outcome taking into account uncertainty that can be quantified is that the **BCR for the Y-Network represents high value for money** with a BCR above 2.0.

6.9. **The Economic Case for Phase 1 has a most likely outcome of medium value for money** with a BCR above 1.5 however; there is a small likelihood that this could fall into low value for money. The conclusions for Phase 1 and the Y-Network are consistent with the BCR implied by the 'reference case'.

6.10. The case for the scheme is strong using the standard tools and methodology as expressed in WebTAG, however, as shown in Section 5, using alternative but plausible assumptions on the values of time and demand capping in particular could make the Economic Case stronger. Furthermore, consideration of other factors such as the impact of HS2 on Economic Geography may improve the case even further.

Landscape impacts

6.11. Landscape impacts consider the effects of a scheme on the visible features of a landmass combined with the physical and cultural aspects of the land itself. Any valuation of something which is intangible such as landscape is challenging, and while the Department has used the best available methods to quantify landscape impacts, the assessment remains sensitive to a key set of underlying assumptions. The monetised assessment should therefore, not be considered a substitute for the detailed landscape assessment conducted in the Environmental Statement[52].

6.12. The Landscape impacts have been estimated at £1.0bn for Phase One and £2.9bn for the Y-Network (Present Value, 2011 Prices) which would reduce the BCR in both cases by 0.1. Whilst these estimates provide a useful indication of the potential scale of landscape impacts, sensitivity

[52] HS2 Phase One Environmental Statement, https://www.gov.uk/government/collections/hs2-phase-one-environmental-statement-documents

tests show that the plausible range on these values is extremely large and therefore we do not believe them to be sufficiently robust to include in the adjusted BCR.

Non-monetised impacts

6.13. There are a range of impacts which we are unable to quantify in monetary terms. These include the effect of HS2 on heritage, biodiversity and the water environment and are therefore assessed qualitatively. The Department's analysts appraise whether these are likely to change the value for money categorisation of the scheme. The table below summarises the Department's view of the affects of the scheme on each of the impacts considered. This represents a judgement of the overall impacts across each Phase of the scheme based on the material contained within the HS2 Environmental Statement for Phase 1 and the Phase 2 Appraisal of Sustainability, which are mapped against the categories of impact outlined in WebTAG. It is recognised that there will be localised effects which may be greater or less than the overall categorisation.

Table 19 – Department's assessment of non-monetised impacts

IMPACT	**ASSESSMENT**	
	Phase 1	**Phase 2**
Townscape	Neutral	Neutral
Heritage	Moderate Adverse	Slight Adverse
Biodiversity	Slight Adverse	Adverse
Water Environment	Moderate Adverse	Moderate Adverse
Accessibility	Slight Beneficial	Slight Beneficial
Personal Affordability	Not assessed	Not assessed
Severance	Slight Adverse	Slight Adverse
Option Values	Slight Beneficial	Slight Beneficial
Physical Fitness	Neutral	Neutral
Journey Ambience	Slight Beneficial	Slight Beneficial
Transport Interchange	Slight Beneficial	Slight Beneficial

6.14. Consideration of these additional impacts does not imply conclusively that there is any change in the case for the scheme, as there are both adverse and beneficial impacts. It is also important to note that mitigation measures to account for these impacts will be implemented. While the adverse impacts are likely to outweigh those that are beneficial, **it is highly unlikely that the effects will be significant enough to change the value for money categorisation of the scheme.**

Conclusion

6.15. The available evidence indicates that the most likely outcome for the Y-Network is **high** value for money while for Phase 1 the most likely outcome is **medium** value for money. Accounting for landscape impacts and impacts which cannot be monetised will generate downside but are unlikely to alter this conclusion.