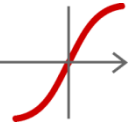


DAVID SIMMONDS CONSULTANCY

URBAN, REGIONAL AND TRANSPORT PLANNING



Modelling a Pan-National UK Network

Final Report

February 2020

Document control

Reference: c95_1 PN2

File 95_1_UK2070_FinalReport_v6.0.docx.

| Version | Date | Main author | Other author(s) | Reviewer(s) |
|---------|----------|----------------|-----------------|----------------|
| 1.0 | 18/11/19 | Alistair Halls | | David Simmonds |
| 2.0 | 19/11/19 | Alistair Halls | | David Simmonds |
| 2.1 | 20/11/19 | Alistair Halls | | |
| 3.0 | 03/12/19 | Alistair Halls | | David Simmonds |
| 4.0 | 09/12/19 | Alistair Halls | | |
| 4.1 | 20/12/19 | Alistair Halls | | |
| 5.0 | 10/02/20 | David Simmonds | Alistair Halls | |
| 6.0 | 24/02/20 | Alistair Halls | | |
| 6.1 | 24/02/20 | Alistair Halls | | |

This document has been prepared by David Simmonds Consultancy Limited as a report on work commissioned for the UK2070 Commission, to model a connectivity revolution in the UK.

Copyright David Simmonds Consultancy Limited 2020. DELTA is a registered trademark of David Simmonds Consultancy.

David Simmonds Consultancy Limited is registered in England and Wales, company registration 04860878. The registered office is 10 Jesus Lane, Cambridge, CB5 8BA England. Offices:

Suite 4, Bishop Bateman Court, 5-7 New Park Street, Cambridge CB5 8AT, England; phone 01223 316098

112 George Street, Edinburgh EH2 4LH, Scotland; phone 0131 226 5908

100, rue d'Aboukir, 75002 Paris

CONTENTS

| | | |
|----------|--|-----------|
| 1 | Introduction and scope | 1 |
| 1.1 | Introduction | 1 |
| 1.2 | Scope | 1 |
| 2 | The Strategic National Model: modelling, scenarios and policies | 2 |
| 2.1 | Introduction | 3 |
| 2.2 | Land-use/transport interaction | 3 |
| 2.3 | Model structure and design | 4 |
| 2.4 | Model outputs | 6 |
| | <i>Economy and employment modelling</i> | 6 |
| | <i>Floorspace development</i> | 6 |
| 2.5 | Model implementation | 6 |
| 2.6 | Transport inputs | 7 |
| 2.7 | Caveats and notes | 7 |
| 3 | Key Concepts and Notes | 8 |
| 3.1 | The base scenario | 8 |
| 3.2 | Accessibility | 9 |
| 3.3 | Frames of reference | 9 |
| | <i>Units</i> | 9 |
| | <i>Geography</i> | 9 |
| 4 | Package A – Improving intercity connectivity | 12 |
| 4.1 | Background | 12 |
| 4.2 | Modelling approach | 12 |
| | <i>Overview of corridors</i> | 12 |
| | <i>Phasing and input processing</i> | 15 |
| 4.3 | Results | 16 |
| | <i>Direct effect – accessibility impact</i> | 16 |
| | <i>Economic indicators</i> | 18 |
| | <i>Demographic indicators</i> | 24 |
| 4.4 | Conclusion | 26 |
| 5 | Package B – Intraurban mobility | 28 |
| 5.1 | Background | 28 |
| 5.2 | Modelling approach | 28 |
| | <i>Area of effect</i> | 29 |
| | <i>Phasing</i> | 29 |
| 5.3 | Results | 31 |
| | <i>Direct effects – accessibility impact</i> | 31 |
| | <i>Economic indicators</i> | 32 |
| | <i>Demographic indicators</i> | 38 |
| 5.4 | Conclusion | 41 |
| 6 | Package C – Reconnecting Marginalised Communities | 43 |
| 6.1 | Background | 43 |
| 6.2 | Modelling approach | 43 |

| | | |
|----------|--|-----------|
| | <i>Phasing and input processing</i> | 44 |
| | <i>Indicative travel time savings by rail</i> | 46 |
| 6.3 | Results..... | 47 |
| | <i>Direct effects – accessibility impact</i> | 47 |
| | <i>Economic indicators</i> | 48 |
| | <i>Demographic indicators</i> | 52 |
| 6.4 | Conclusion | 55 |
| 7 | Connectivity Revolution | 56 |
| 7.1 | Rationale and context..... | 56 |
| 7.2 | Modelling approach | 56 |
| | <i>Improving intercity connectivity</i> | 56 |
| | <i>Improving intraurban mobility</i> | 56 |
| | <i>Reconnecting marginalised communities</i> | 56 |
| | <i>Combining rail packages using hubs</i> | 57 |
| | <i>Indicative travel time savings</i> | 59 |
| 7.3 | Results..... | 60 |
| | <i>Direct effects - accessibility impacts</i> | 60 |
| | <i>Economic indicators</i> | 62 |
| | <i>Demographic indicators</i> | 66 |
| 7.4 | Conclusion | 68 |
| 8 | A Connectivity Revolution with an Enhanced Northern Growth Scenario | 70 |
| 8.1 | Rationale and context..... | 70 |
| 8.2 | Modelling approach | 70 |
| 8.3 | Results..... | 73 |
| | <i>Economic indicators – GVA</i> | 73 |
| | <i>Economic indicators – employment</i> | 75 |
| | <i>Demographic indicators</i> | 77 |
| 8.4 | Conclusion | 79 |
| 9 | Developing an appraisal of the packages..... | 80 |
| 9.1 | Introduction..... | 80 |
| 9.2 | Structure of the chapter | 80 |
| 9.3 | The problem to be addressed | 80 |
| 9.4 | What approach are we taking to these issues? | 82 |
| 9.5 | Benefits to households | 84 |
| 9.6 | Benefits to firms..... | 86 |
| 9.7 | Benefits to property owners and developers | 87 |
| 9.8 | Benefits to the public sector..... | 87 |
| 9.9 | “Other” sector benefits: environmental | 88 |
| 9.10 | “Other” sector benefits: rebalancing and regeneration | 88 |
| | <i>Background from the “3Rs” Book</i> | 89 |
| | <i>Measures for Rebalancing Benefits</i> | 89 |
| | <i>Higher marginal utility Income</i> | 90 |
| | <i>Shadow value of relocating</i> | 91 |
| | <i>Social Infrastructure Savings</i> | 92 |
| | <i>Conclusions: approach for the UK2070 project</i> | 92 |
| 9.11 | Implementation of the shadow value of a job in a deprived area | 92 |

| | | |
|-------------------|--|------------|
| | <i>Most deprived zones</i> | 92 |
| | <i>Gross cost per net additional job</i> | 94 |
| 9.12 | Implementation of infrastructure savings | 95 |
| 9.13 | Structure and content of the summary benefits table | 96 |
| 9.14 | Results | 98 |
| 10 | Discussion | 104 |
| 10.1 | Notes on the results | 104 |
| 10.2 | Limitations | 104 |
| | <i>Zone size and coverage</i> | 104 |
| | <i>Corridor choice</i> | 105 |
| 11 | Summary and Conclusion | 106 |
| 11.2 | Areas for further exploration | 107 |
| | <i>Outline</i> | 107 |
| | <i>The impact of change in non-transport markets</i> | 107 |
| | References | 109 |
| Appendix A | Transport inputs to SNM | 110 |
| A.1 | Car | 110 |
| A.2 | Rail | 110 |
| A.3 | Air | 113 |
| A.4 | Bus | 113 |
| A.5 | Walk | 114 |

LIST OF TABLES

| | |
|---|-----|
| Table 4-1 Rail improvement corridors, Package A | 13 |
| Table 4-2 Package A employment impact | 19 |
| Table 4-3 Package A GVA impact (values expressed in £mn) | 22 |
| Table 4-4 Package A population impact..... | 25 |
| Table 5-1 Package B impact on employment | 33 |
| Table 5-2 Impact of Package B on GVA (values expressed in £mn) | 36 |
| Table 5-3 Impact of Package B on population..... | 39 |
| Table 6-1 Impact of reconnecting marginalised communities on employment..... | 48 |
| Table 6-2 Impact of reconnecting marginalised communities on GVA | 51 |
| Table 6-3 Impact of reconnecting marginalised communities on population..... | 53 |
| Table 7-1 Impact of Connectivity Revolution on employment | 62 |
| Table 7-2 Impact of Connectivity Revolution on GVA..... | 65 |
| Table 7-3 Impact of Connectivity Revolution on population | 67 |
| Table 8-1 Impact of Connectivity Revolution and Enhanced Northern Growth on GVA (£mn)..... | 73 |
| Table 8-2 Impact of Connectivity Revolution and Enhanced Northern Growth on employment..... | 75 |
| Table 8-3 Impact of Connectivity Revolution and Enhanced Northern Growth on population | 77 |
| Table 9-1 3Rs Guidance on local employment effects | 89 |
| Table 9-2 HM Treasury Green Book advice on marginal utility of income..... | 90 |
| Table 9-3 Summary benefits:costs table: definitions..... | 97 |
| Table 9-4 Benefits of Package A | 99 |
| Table 9-5 Benefits of Package B | 101 |
| Table 9-6 Benefits of Package C | 101 |
| Table 9-7 Benefits of the Combined Package (A+B+C) | 102 |
| Table 9-8 Comparison of total (GB) benefits | 102 |
| Table A-1 Rail distance, speed and frequency by category in SNM..... | 112 |
| Table A-2 Rail fares in SNM..... | 112 |

LIST OF FIGURES

| | |
|--|----|
| Figure 1-1 Illustration of a UK-wide Transport Network..... | 2 |
| Figure 2-1 Scenarios, policies and models – full LUTI modelling..... | 3 |
| Figure 2-2 Scenarios, policies and models - LUMIT modelling, as used in SNM/UK2070 study | 4 |
| Figure 2-3: Time-marching structure of the model..... | 5 |
| Figure 2-4 Model structure | 5 |
| Figure 3-1 Northern and Southern Britain | 10 |
| Figure 3-2 Illustrative UK megaregions | 10 |
| Figure 4-1 Rail improvement corridors, Package A | 14 |
| Figure 4-2 Input rail travel time savings for Package A | 16 |
| Figure 4-3 Impact of improved intercity connectivity on active accessibility..... | 18 |
| Figure 4-4 Impact of Improved Intercity Connectivity on employment..... | 19 |
| Figure 4-5 Impact of Improved Intercity Connectivity on employment by sector, 2061 ... | 20 |
| Figure 4-6 Map of impact of improved intercity connectivity on employment in 2061..... | 21 |
| Figure 4-7 Impact of improved intercity connectivity on GVA | 22 |
| Figure 4-8 Map of impact of improved intercity connectivity on GVA in 2061 | 24 |
| Figure 4-9 Impact of improved intercity connectivity on population | 25 |
| Figure 4-10 Map of impact of Package A on population in 2061..... | 26 |
| Figure 5-1 Model zones with bus/walk improvements (intraurban mobility) | 30 |
| Figure 5-2 Maps of impact of improved intraurban mobility on static accessibility | 32 |
| Figure 5-3 Impact of improved intraurban mobility on employment | 34 |
| Figure 5-4 Map of impact of improved intraurban mobility on employment in 2061..... | 35 |
| Figure 5-5 Impact of improved intraurban mobility on GVA | 37 |
| Figure 5-6 Map of impact of improved intraurban mobility on productivity in 2061 | 38 |
| Figure 5-7 Impact of improved intraurban mobility on population | 39 |
| Figure 5-8 Map of impact of improved intraurban mobility on households in 2061..... | 41 |
| Figure 6-1 Unemployment rate by Local Authority | 43 |
| Figure 6-2 Local Authorities (model zones) with corridor improvements | 45 |
| Figure 6-3 Indicative travel time savings by rail from Hull as a result of Package C | 46 |
| Figure 6-4 Maps of impact of reconnecting marginalised communities on accessibility ... | 47 |
| Figure 6-5 Impact of reconnecting marginalised communities on employment..... | 49 |
| Figure 6-6 Map of impact of reconnecting marginalised communities on employment in 2061..... | 50 |

| | |
|---|-----|
| Figure 6-7 Impact of reconnecting marginalised communities on GVA..... | 51 |
| Figure 6-8 Map of impact of reconnecting marginalised communities on GVA in 2061 .. | 52 |
| Figure 6-9 Impact of reconnecting marginalised communities on population | 53 |
| Figure 6-10 Map of impact of reconnecting marginalised communities on households in 2061..... | 54 |
| Figure 7-1 Improvement corridors and areas - UK Network..... | 58 |
| Figure 7-2 Indicative travel time savings by rail from a Connectivity Revolution | 60 |
| Figure 7-3 Maps of impact of connectivity revolution on accessibility | 61 |
| Figure 7-4 Impact of connectivity revolution on employment | 63 |
| Figure 7-5 Map of impact of connectivity revolution on employment in 2061..... | 64 |
| Figure 7-6 Impact of connectivity revolution on GVA | 65 |
| Figure 7-7 Map of impact of connectivity revolution on productivity in 2061 | 66 |
| Figure 7-8 Impact of connectivity revolution on population | 67 |
| Figure 7-9 Map of impact of connectivity revolution on households in 2061..... | 68 |
| Figure 8-1 Main features of UK Innovation Districts..... | 71 |
| Figure 8-2 Additions to exports for each city in Enhanced Northern Growth scenario | 72 |
| Figure 8-3 GVA impact to 2061 of Connectivity Revolution and Enhanced Northern Growth | 73 |
| Figure 8-4 Impact on growth in GVA by 2061 with Connectivity Revolution and Enhanced Northern Growth | 74 |
| Figure 8-5 Employment impact of Connectivity Revolution and Enhanced Northern Growth to 2061 | 75 |
| Figure 8-6 Impact of Connectivity Revolution and Enhanced Northern Growth on employment relative to base, 2061 | 76 |
| Figure 8-7 Impact of Connectivity Revolution and Enhanced Northern Growth..... | 77 |
| Figure 8-8 Impact of Connectivity Revolution and Enhanced Northern Growth on population relative to base scenario, 2061 | 78 |
| Figure 9-1 Conventional TEE: main concept for user benefit calculation | 85 |
| Figure 9-2 ULTrA: main concept for consumer benefit calculation | 85 |
| Figure 9-3 : Most deprived districts in GB (in SNM zone number order) | 93 |
| Figure 9-4 Most deprived districts in Great Britain..... | 94 |
| Figure 10-1 85 major city TTWAs, with rail improvements from this study overlaid..... | 105 |
| Figure A-1 Car speeds in SNM..... | 110 |
| Figure A-2 Low frequency waiting time function for rail | 113 |
| Figure A-3 Bus speeds in SNM | 114 |

ABBREVIATIONS

| Abbreviation | Meaning |
|--------------|---|
| CaMKOx | Cambridge – Milton Keynes – Oxford |
| DELTA | Land-use/economic modelling package developed by DSC |
| DfT | Department for Transport |
| DSC | David Simmonds Consultancy Limited |
| ECML | East Coast Mainline |
| GVA | gross value added |
| GWML | Great Western Mainline |
| LUMIT | Land-Use Model Influenced by Transport |
| LUTI | Land-Use/Transport Interaction [model] |
| NSS | National Spatial Strategy |
| SNM | Strategic National Model (DELTA application developed by DSC) |
| WCML | West Coast Mainline |

1 INTRODUCTION AND SCOPE

1.1 Introduction

- 1.1.1 The UK2070 Commission's second report outlined seven national priorities for action, in order to rebalance the UK economy. Amongst the priorities is one to 'deliver a connectivity revolution' in the UK, which constitutes a pan-national UK Network.
- 1.1.2 Building primarily on the back of work done by Greengauge21 to identify the UK's 2070 transport infrastructure requirement, the Commission has identified three main areas of focus, at three different scales, for a potential UK Network. The first is the national-regional scale, improving links between cities/urban areas within the UK; the second is the regional-intraurban scale, improving links within urban areas; and the third is the regional-local scale, addressing those peripheral, 'left-behind' areas.
- 1.1.3 At any level, the infrastructure required to contribute to rebalancing the economy must necessarily focus on inclusivity – so targeting those on lower incomes and/or those who don't own a car – and on sustainability – so targeting higher vehicle occupancy and lower usage of private cars. These two points are paramount and mean that necessarily the UK Network will look increasingly public transit oriented.
- 1.1.4 DSC has been commissioned by UK2070 to carry out strategic what-if modelling work to forecast the potential impact of transformative changes to the UK's transport network.
- 1.1.5 Our work focuses on modelling shrinking the UK, by way of improving transport links at the three levels described: shrinking East to West as HS2 has done North to South (Package A – '**Improving Intercity Connectivity**'); shrinking urban areas themselves to increase the gravitational pull towards them, from the surrounding area (Package B – '**Improving Intraurban Mobility**'); and moving peripheral areas closer to major centres of business and commerce (Package C – '**Reconnecting Marginalised Communities**'). These three packages are modelled separately to demonstrate the scale of the change brought about by each, and then as a combined package to demonstrate a possible effect of a pan-national UK Network.

1.2 Scope

- 1.2.1 This report gives an overview of the Strategic National Model (SNM), which has been used to model the packages described here. It then outlines some important concepts, including the base scenario (the hypothetical scenario of business as usual within the model's representation), before detailing the packages and their outcomes.
- 1.2.2 For each of the modelled packages, an outline of what has been input will be provided, then some outline results for key variables in the model. For the combined package, more detailed results will be provided.
- 1.2.3 The overarching and guiding principle of this report is to examine the potential impact of the connectivity revolution encapsulated in the UK2070 Commission's vision for a UK Network.



Figure 1-1 Illustration of a UK-wide Transport Network

2 THE STRATEGIC NATIONAL MODEL: MODELLING, SCENARIOS AND POLICIES

2.1 Introduction

2.1.1 This section provides a brief general description of the national land-use/transport/economic model which David Simmonds Consultancy (DSC) has developed, drawing upon some 20 years of experience in such modelling. It concentrates on the modelling approach with some detail of scenarios and inputs.

2.2 Land-use/transport interaction

2.2.1 The standard land-use/transport interaction (LUTI) modelling process is illustrated in Figure 2-1. A full model starts from an input base year and forecasts forward over time, alternatively considering land-use/economic and transport changes, predicting the detailed outcomes resulting from the interaction of the “top-down” scenarios of overall growth and the “bottom-up” policies of land-use and transport planning. The impacts of interventions, singly or in combination, are calculated by comparing the results of model runs with and without those interventions.

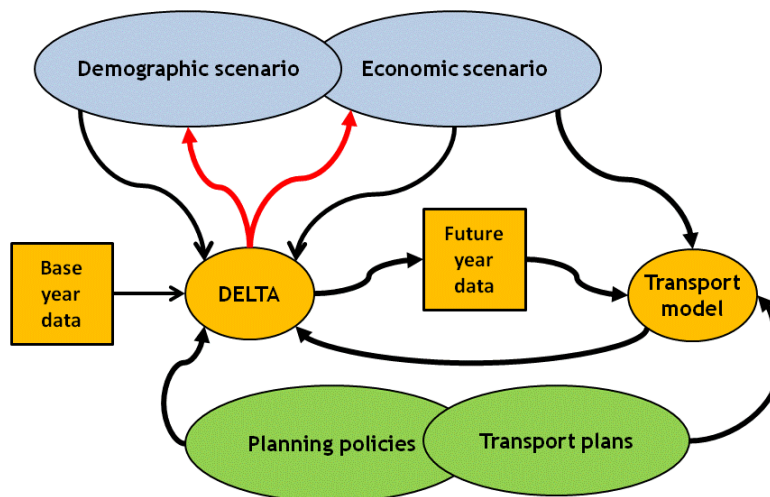


Figure 2-1 Scenarios, policies and models – full LUTI modelling

2.2.2 Transport modelling is typically time-consuming both in staff resources and in elapsed time, and therefore a lot of analysis is done considering the impacts of transport interventions on land-use and the economy without necessarily considering the feedback to transport. This is an approach which we have named ‘LUMIT’ (land-use modelling influenced by transport) to distinguish it from full land-use transport interaction (LUTI) modelling. The LUMIT approach is illustrated in Figure 2-2, which differs from Figure 2-1 only in omitting the linkage from future land-use to the transport model.

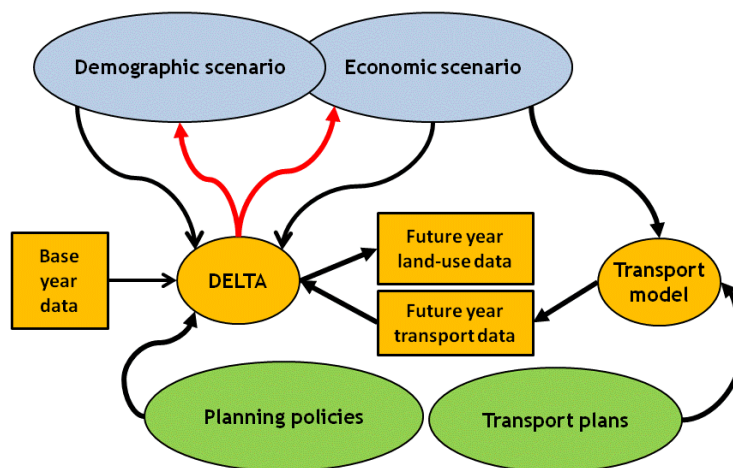


Figure 2-2 Scenarios, policies and models - LUMIT modelling, as used in SNM/UK2070 study

- 2.2.3 An important feature of the model is that whilst it starts from given economic and demographic scenarios (at national and optionally at regional or finer level), the policies that are adopted area can influence the total economy (and possibly the total population) as well as the distribution of activity. This linkage is indicated by the red upward arrows pointing back to the demographic and economic scenarios. the changes in overall economic performance come about through agglomeration and related productivity impacts.
- 2.2.4 The modelling carried out for this report has been done using the LUMIT approach, owing to the relative speed of the approach, and the nature of the transport input data.

2.3 Model structure and design

- 2.3.1 The model is an application of DSC's DELTA package, which has been developed as a land-use modelling package, and increasingly as an economic modelling package, over the past 20+ years. The DELTA design is essentially that of an economic model which reads in a database for one year and outputs a forecast database for the following year, as illustrated in Figure 2-3.
- 2.3.2 The core of the model is a zonal system which is used to forecast the location of households and jobs in their respective property markets, and to deal with many of the related topics such as development, resident population and car ownership. This is linked to
- a higher level economic model, working at the level of macrozones (based on travel-to-work areas (in/around London) or housing market areas (elsewhere))
 - a migration model dealing with longer-distance moves of population between macrozones
 - a productivity model which forecasts how changes in connectivity (themselves calculated from land-use forecasts and from transport inputs) will affect GVA/worker, locally and overall.

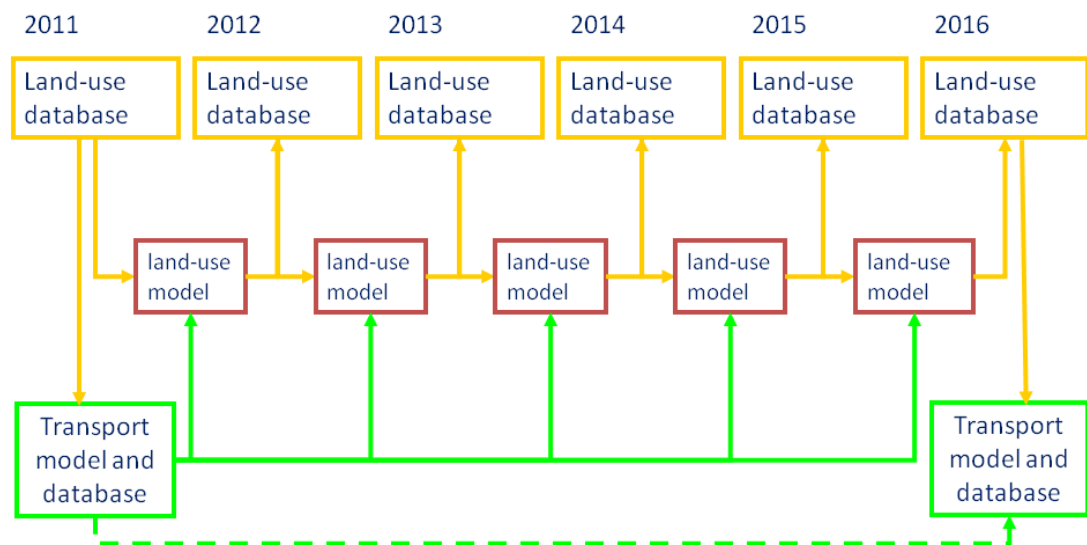


Figure 2-3: Time-marching structure of the model

2.3.3 As already discussed, this system is linked in a one- or two-way relationship with the transport model (see Figure 2-4 Model structure). The following paragraphs very briefly outline what the model forecasts. The behavioural bases for the different parts of the model can be elaborated if required, but in broad terms can be summarised as drawing mainly on different streams of economic research (urban, regional, property market and transport) and on related work in regional science and demographics (e.g. migration research).

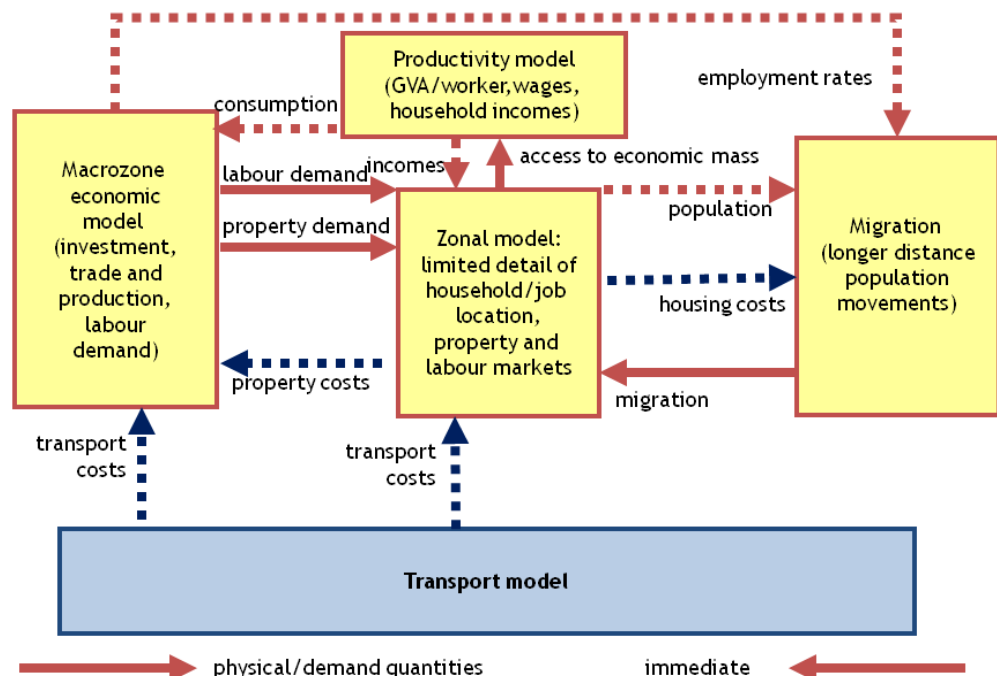


Figure 2-4 Model structure

2.4 **Model outputs**

Economy and employment modelling

2.4.1 The model forecasts

- the distribution of future investment by sectors (macrozone level);
- production by sector and macrozone, and trade between macrozones (including imports and exports);
- employment by zone, broad occupation level (socio-economic level) and sector;
- rent per m² and vacancy rates for major employment floorspace types (retail, office, industrial/warehouse)
- GVA per worker by sector and zone, and hence total GVA
- wages per worker by sector and zone
- accessibility to markets and to the labour force.

2.4.2 An important feature of the model is that it starts from a given database for the base year (observed data or, where necessary, estimates based as far as possible on observed data) and it outputs an equivalent database for each forecast year.

Households and population

2.4.3 The model forecasts

- the future distribution of households in the housing market;
- household incomes and expenditure;
- housing rents and vacancy rates;
- population in households, split into children, working adults, non-working non-retired adults and retired adults;
- car ownership;
- home:work matrices by socio-economic level and car-ownership (i.e. “travel-to-work” matrices, but in terms of persons rather than trips)
- accessibility to work opportunities, retail/service opportunities etc.

Floorspace development

2.4.4 The model forecasts the development of floorspace of each type, subject to planning policy controls.

2.5 **Model implementation**

2.5.1 The starting database for the National Model was built up using standard sources including

- 2011 Census data on households, population and employment;

- Council tax records for housing data;
- Valuation Office Agency data on commercial property (with other estimates for Scotland);
- DfT data on spatial differentials in GVA/worker.

2.6 Transport inputs

- 2.6.1 The National Model uses simple transport cost assumptions which are entirely synthetic in their production and developed by DSC. It incorporates five modes of passenger transport – car, rail, air, bus, walk; two freight modes – light and other goods vehicles; and three passenger purposes – business, commuting and other (including shopping, leisure and education).
- 2.6.2 Transport costs are expressed as generalised costs represented in minutes. The value between each Local Authority District/zone comprises the in-vehicle time, any monetary costs, and any expected waiting, access or egress times/costs. The inputs and the process for creating them are described further in Appendix A.

2.7 Caveats and notes

- 2.7.1 The model is not directly calibrated to reproduce observed data, but to reproduce relationships (such as elasticities) from a variety of research and other sources. The calibration continues to be revised in the light of new information and of feedback from peer review of completed studies.

3 KEY CONCEPTS AND NOTES

3.1 The base scenario

3.1.1 The base scenario in the context of the commissioned work is the reference point from which all comparisons are made. It represents a hypothetical situation where, regarding transport:

- No new transport investment to the strategic network is made, aside from Crossrail, which is input as complete in 2021, and HS2 phase 1 (London to Birmingham) which is input as complete in 2026 (further phases of HS2 have not been given royal assent and so are excluded from the base scenario);
- there is no change in congestion on the road network;
- fares and other non-operating costs are held constant; vehicle operating costs for freight vehicles and cars are subject to forecast change in line with the WebTAG assumptions;
- value of time changes in line with WebTAG¹ assumptions.

3.1.2 With respect to the planning system, there are some further assumptions:

- All floorspace provision is input as permissible – meaning developers are free to build floorspace or not, depending on their estimates of its expected profitability;
- permissions accrue on a year-on-year basis, such that any permissible floorspace not built in one year is added to the available permissions in the following year;
- the level of input over time matches NTEM 7.2 targets of household/employment growth, provided density of occupation remains the same. The model does not allow more development than that, unless the inputs are expressly change.

3.1.3 As such, and as the previous mention outlines, the base scenario does not reproduce observed *data* – instead, it serves to outline outcomes at yearly intervals as a result of observed *relationships* and *elasticities* from a variety of sources. This is clearly not the only possible forecast of the changes to expect given the policy inputs described, but it provides an effective basis for assessing the broad impacts of the UK2070 Commission’s vision for a connectivity revolution.

3.1.4 There are a number of principles of the UK2070’s vision that are not yet modelled here. This work only looks at infrastructure provision considering minimal changes in doing business going forward, and work exploring other elements is to follow.

¹ WebTAG (‘TAG’ for Transport Analysis Guidance’) gives guidance to transport practitioners, with guidelines on how to build and operate models. The data here are derived from these values which are standardised across practitioners.

3.2 Accessibility

- 3.2.1 Accessibility can be regarded as how easy it is to reach opportunities (be they places of work, educational institutions or shops) from a given point – otherwise known as ‘active’ accessibility; or conversely, how easily a given place can be reached by those who may wish to – known as ‘passive’ accessibility. Within the land-use-transport nexus, accessibility is a key determinant of the spatial distribution of activity. This comes about due to the spatial separation of businesses doing business with other businesses; people in households seeking out or travelling to work; and producers shipping goods to consumers or other, secondary producers.
- 3.2.2 An accessibility measure therefore must incorporate the location of activities pertinent to the measure at hand, and the time and cost of travel (or generalised cost) between these activities. In the remainder of this section, accessibility in the base scenario is addressed. The measures considered are national and local business-to-business accessibility, and commuting for workers of different socio-economic levels. Further measures are used within the model, but these are generally representative of the changes arising from improvements in transport infrastructure and services.

3.3 Frames of reference

Units

- 3.3.1 In transport and land-use modelling, we are primarily concerned with the behaviours of different socio-demographic and economic groupings as a result of changes to transport, land-use and economic scenarios. At the broadest level, these groupings of activity can be classified as either employment or household (though there are many, much finer classifications). As such, this paper refers mainly to these two groupings, preferring to use the more tangible indicator of population for the latter. In addition, gross value added (GVA) is used to measure impacts on economic output. This measure encompasses the total value of the goods and services produced within a given area.

Geography

- 3.3.2 The model used for this study is built from the 380 Local Authority Districts that make up Great Britain. All transport inputs have been created or modified at this level of detail, and as such it is used to report direct travel time and accessibility impacts.
- 3.3.3 Economic and demographic indicators are calculated at a zonal level, but given the focus on rebalancing the UK on the whole, significant movements or changes in either are best reported at a more aggregate level. Therefore, mapping of the demographic and economic effects of packages is done at a macro-zonal level, in this model represented by housing market areas within Great Britain. London and its immediate surroundings are an exception; here, travel-to-work areas are used instead.

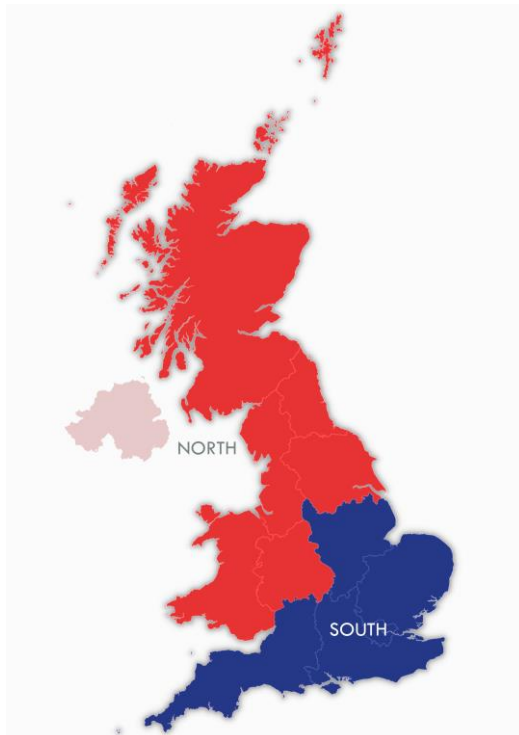


Figure 3-1 Northern and Southern Britain

Contains OS data © Crown copyright and database right 2019.



Figure 3-2 Illustrative UK megaregions

Source: © IPPR Economic Executive Regions for England

- 3.3.4 When reporting the overall impact of the schemes, effects are assessed at a level most appropriate for the package in hand. For example, Package A (Improving Intercity Connectivity) focuses on the two broad areas of Northern and Southern Britain, as defined by Martin *et al.* (2019) at RSA (Figure 3-1) – in this report the terms ‘North’ and ‘South’ have been used for convenience. The combined ‘Connectivity Revolution’ package is also expressed in these terms, to concentrate analysis on the large-scale rebalancing sought by the Commission. Wherever references are made to ‘the North’ or ‘the South’, the Martin *et al.* definition outlined above is used.
- 3.3.5 Package B is analysed at a regional/supra-regional level. The ‘megaregions’ used, outlined in Figure 3-2, aim to represent the impacts on a more logical level than the traditional former Government Office Regions would allow. This reflects an emerging (in some parts, quite well-established) economic geography within the UK which exists in the form of cross-regional bodies and partnerships such as Northern Powerhouse, Midlands Engine, and Great Western Powerhouse.
- 3.3.6 Focussing on the megaregions also helps to concentrate on the bigger picture while avoiding issues over the delicate relationship between London and its surrounding areas, North East and North West, or the East and West Midlands, which all function as units and will do increasingly so over the next 50+ years.
- 3.3.7 When we assess the impacts of reconnecting marginalised communities (Package C), we take the approach that the impacts are felt over parts of multiple regions, so a strict analysis by regions alone would not reflect the aims of the Commission. So,

for this package, we assess the corridor itself, alongside the rest of the North and the rest of the South, as outlined previously.

4 PACKAGE A – IMPROVING INTERCITY CONNECTIVITY

4.1 Background

- 4.1.1 Part of UK2070s proposed approach to rebalancing growth in the UK lies in improving intercity links, in particular by rail. While there are some cities with very good, mainline connections, these routes are heavily patronised, and congested as a result. At a regional level, intercity links are generally poor, barring a few select corridors. HS2 has been planned to provide a strong North-South connection, between cities in the Midlands and North, and London. However, for the scheme to unlock its maximum potential, East-West corridors interchanging with it will need to be improved.

4.2 Modelling approach

- 4.2.1 In addition to HS2, the UK2070 Commission has identified 7 rail corridors where connectivity could be improved, although these are not exclusive of other East-West improvements (e.g. between Bristol and Birmingham, and further South West to Plymouth and Exeter). Improvements to connections in these main corridors have been modelled, such that the standards are on the level of the best present intercity routes (i.e. West or East Coast Main Lines, rather than HS1/2).
- 4.2.2 This has been done using the same approach as has been used in building base transport inputs to the Strategic National Model (SNM). It involves grouping pairs of Local Authorities (model zones) by the characteristics of the rail network within and between them. This could be, for instance, high-speed/intercity, dense network, or low-density network, among others.
- 4.2.3 The zone pairs which benefit from new rail links have been upgraded to the high-speed categorisation, apart from Gosport, as part of the Wider Solent, which has been joined into the network within the Solent region with ‘intense’ rail network links.
- 4.2.4 The new links have been integrated into a base model which already has HS2 (all phases) and Crossrail 1 (Reading to Shenfield) modelled, following the currently planned phasing as closely as possible.

Overview of corridors

- 4.2.5 Figure 4-1 shows the rail improvement corridors in Package A (including, for reference, HS2 phase 1 and Crossrail, which are already included in the base scenario). The stations and lines chosen (summarised in Table 4-1) go some way in reflecting the schemes which they are approximating, though they are not intended to be exact representations. Instead, the corridors reflect an interpretation of the aims of the schemes – for instance:
- The Thames Estuary improvement is intended to improve connectivity with a possible future growth hub in the estuary, enhancing accessibility to other cities;
 - The Midlands Connect rail corridor is intended to cover cross-Midlands improvements, positioned as part of the ‘Midlands Engine’, specifically the

idea of an East Midlands Rail Hub² to connect cities and urban areas between Hereford and Lincoln;

- The Bristol-Cardiff-Swindon corridor is intended to reflect in some way ideas around a ‘Great Western Powerhouse’ centred on southeast Wales and West England³ or alternatively, long-term aspirations for improved connectivity and capacity along the GWML⁴;
- The Northern Powerhouse Rail corridor intends to reflect similar aspirations in the North – a ‘Crossrail for the North’ with new lines and improved existing routes between cities and urban areas, as well as enhanced access to HS2 and therefore other parts of the country;
- The Edinburgh-Tay Cities-Aberdeen corridor reflects potential connectivity improvements to links between Edinburgh, Aberdeen and the major urban areas of Dundee, Perth, alongside the wider areas of Perth and Kinross, Angus and North East Fife. This corridor was chosen as an example of relatively poor connectivity compared with, say, the Central Belt corridor, which links Edinburgh and Glasgow. There, connectivity is largely good for intercity travel; the nuance is arguably too fine for the detail of this model.
- The Oxford-Milton Keynes-Cambridge corridor (or ‘CaMKOx’) links together the important university cities of Oxford and Cambridge, via Milton Keynes and Bedford. North-South connectivity is *greatly* enhanced here, with interchange with multiple routes along the corridor providing improvements to most parts of the country, via connections with London, GWML, Midlands Connect and ECML;
- The Wider Solent corridor reflects aspects of Transport for South Hampshire’s Transport Delivery Plan⁵, which include better connectivity between the urban areas of Southampton and Portsmouth. It also brings Gosport into the rail network, and enhances connectivity with Southampton Airport. The corridor enhances the connectivity of Portsmouth west towards the GWML, and Greater Southampton east towards Sussex and Kent.

Table 4-1 Rail improvement corridors, Package A

| Rail corridor | New category | Approximate scheme(s) |
|-------------------------------|-----------------------------|--|
| Thames Estuary | London-to-London | Crossrail to Ebbsfleet |
| Midlands Connect | Intercity | East Midlands Rail Hub, wider connectivity |
| Bristol-Cardiff-Swindon | Intercity+ | Enhancements to increase frequency and speed |
| Northern Powerhouse Rail | Intercity | Northern Powerhouse Rail |
| Edinburgh-Tay Cities-Aberdeen | Intercity | Linking Tay Cities, Aberdeen to Central Belt |
| Oxford-MK-Cambridge | Intercity | East-West Rail |
| Wider Solent | Regional express Intense | Improved link between Southampton/Portsmouth Rail link to Gosport |

² https://www.midlandsconnect.uk/media/1204/midlands-connect-ar-v18_final_web.pdf

³ <https://www.apowerhouseforthewest.org.uk/wp-content/uploads/2019/07/A-Powerhouse-for-the-West-Metro-Dynamics-July-2019.pdf>

⁴ <http://www.greengauge21.net/wp-content/uploads/GWP-COS.pdf>

⁵ <https://documents.hants.gov.uk/transport-for-south-hampshire/TransportDeliveryPlan.pdf>

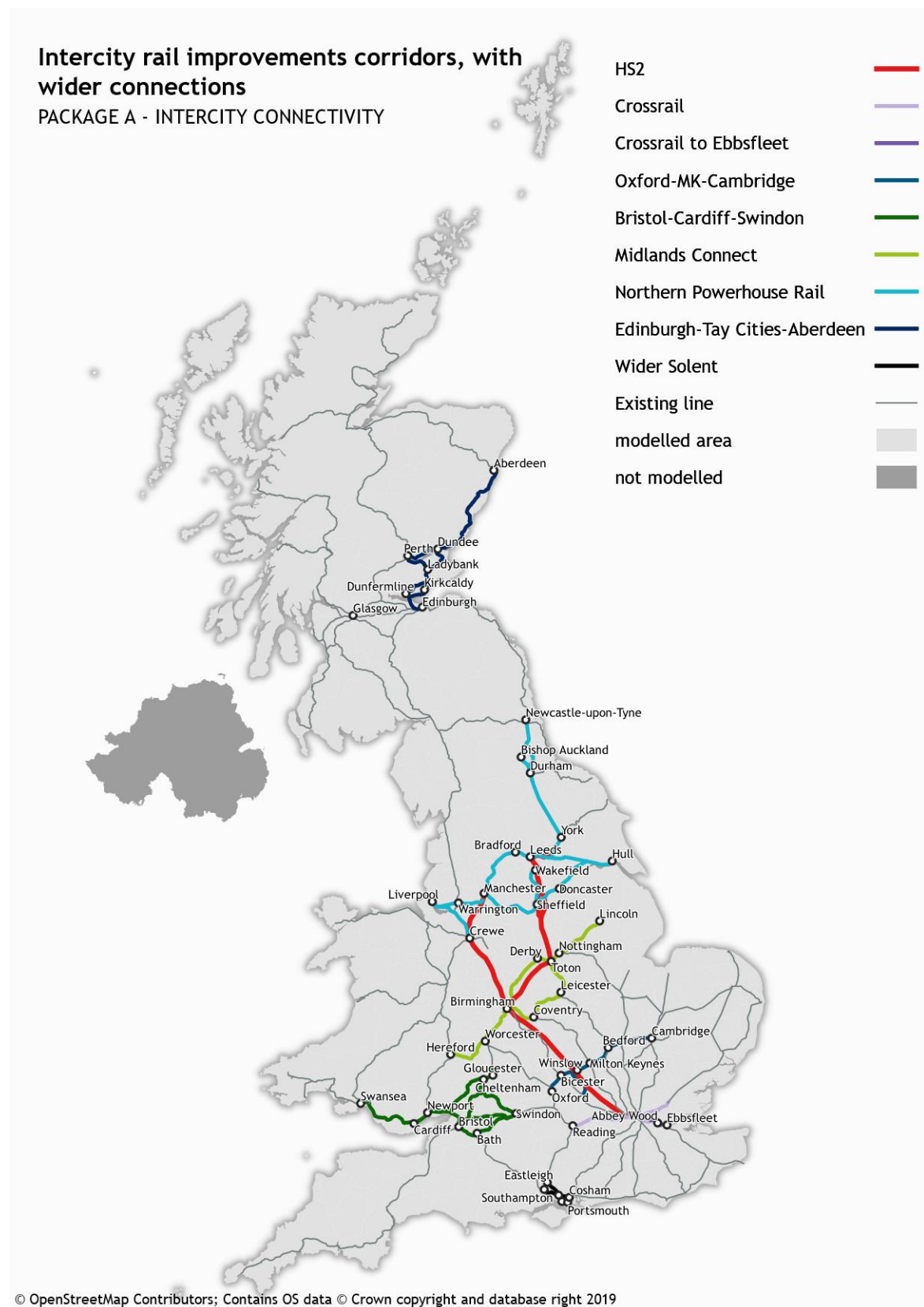


Figure 4-1 Rail improvement corridors, Package A

Phasing and input processing

- 4.2.6 The package has been compiled using a ‘hubs’ process to link all of the new/improved connections into the existing network (with HS2 phase 1 and Crossrail included). This process finds the best path through a sequence of zones, rather than explicitly modelling the network in terms of links and nodes as in a fully-detailed transport model. It is effective at finding key connections: for example, Hull, with improved accessibility from the ‘Northern Powerhouse Rail’ corridor improvement, has had its connection to Birmingham improved via interchange at Sheffield.
- 4.2.7 The hubs process has been undertaken such that gains can be seen over a maximum of two interchanges. The shortest/cheapest route should therefore be shown in the matrix, though some interregional links may see lower accessibility gains than if each scheme was linked to the others in turn.
- 4.2.8 All the improvements have been modelled as being fully developed in 2036, the year HS2 Phase 2b is modelled as completed. Although the simulated packages are likely to occur over a period of 20 years or more, this approach allows for simpler analysis. It largely removes the complexity of analysing the phasing of schemes and allows for more strategic conclusions to be made. Ideally, each scheme would be modelled in isolation before being modelled as part of a wider package, as is being done here – this is beyond the scope of the exercise.

Indicative travel time savings by rail

- 4.2.9 Figure 4-2 shows potential rail travel time changes resulting from Package A compared with the base scenario. The changes are shown from each of eight different urban areas to all other zones in the model. Reading is used as an example of a hub without direct improvement. Since these are changes in rail travel time, negative changes represent improvements.
- 4.2.10 Of the cities shown, Hull could see by far the most significant impacts. Travel time savings of up to 250 minutes are expected to almost all zones in the model (barring a corridor of poor rail connectivity running along the East Coast). The possible gains stem from better access to the main interchange at Doncaster, which itself sees improvements across the North and to HS2. The package would clearly transform the city’s national accessibility.
- 4.2.11 Oxford (and by extension, likely the rest of the CaMKOx corridor) could see significant improvements via its connectivity in all directions, but appears to gain especially from its links with Birmingham (interchanging to the North) and Reading (interchanging to the West).
- 4.2.12 The other cities see broadly similar potential time savings to other parts of the country. It appears the most beneficial improvements are to the Edinburgh-Tay Cities-Aberdeen axis, and to South and West Wales.

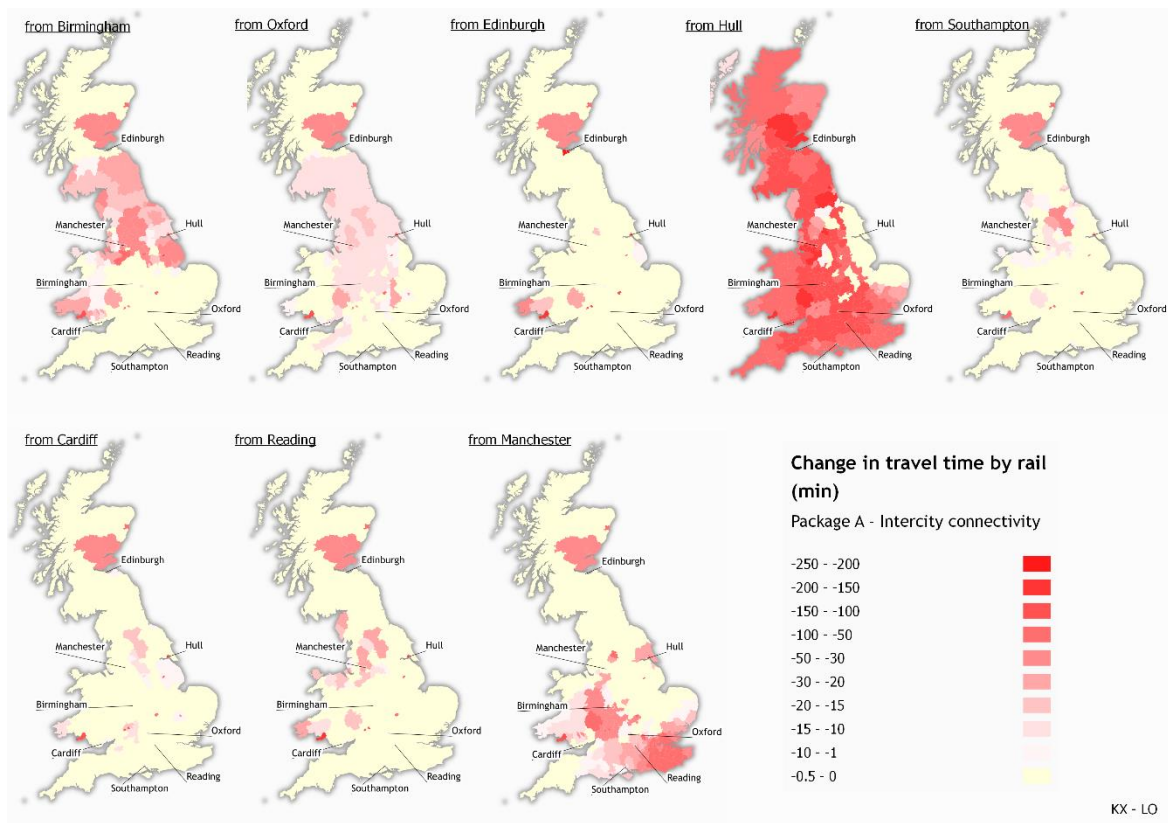


Figure 4-2 Input rail travel time savings for Package A

4.3 Results

Direct effect – accessibility impact

- 4.3.1 Accessibility can be regarded as how easy it is to reach opportunities (be they places of work, educational institutions or shops) from a given zone – otherwise known as ‘active’ accessibility; or conversely, how easily a given place can be reached by those who may wish to – also known as ‘passive’ accessibility. Within the land-use-transport nexus, accessibility is a key determinant of the spatial distribution of activity. This comes about due to the spatial separation of businesses doing business with other businesses; people in households seeking out or travelling to work; and producers shipping goods to consumers or other, secondary producers.
- 4.3.2 Figure 4-3 shows the static impact on accessibility of the rail corridor improvements in Package A at three different scales. ‘Static,’ because accessibility is measured as the ease of certain activities reaching or being reached by other activities. As such, and because over time activities move in response to various factors, accessibility is a dynamic indicator. The maps show the impact *in the opening year* of the scheme – in other words, how accessibility/connectivity for business and households is impacted, without the various redistributive and demand-supply related effects caused by the enhanced accessibility in turn.
- 4.3.3 The three maps show how accessibility for business would be impacted at a local and national scale, as well as for consumers. Business accessibility impacts are

shown for car-owners; commuting accessibility impacts are shown for the group of low-earners who also own no car.

- 4.3.4 Businesses that are generally dispersed and/or rely on local producers/intermediate consumers are more sensitive to local changes in transport cost, yet changes over greater distances are not as important, if at all. On the other hand, businesses which are generally concentrated (whether this is due to locational qualities, or regional specialisms, like finance in London) tend to be more sensitive to changes in travel time and cost over greater distances.
- 4.3.5 The maps show that the intercity connectivity improvements are likely to have the greatest effect on the North of England, as the Northern Powerhouse connections with the HS2 links allow for a joining up of city regions across the North. Otherwise, accessibility would improve to a lesser degree across wide swathes of Britain.
- 4.3.6 London/South East is also notable as having minimal direct improvements to connectivity, yet it sees some modest potential accessibility improvements – likely due to the interchange effect coupled with the sheer number of opportunities (the wider area accounts for between a fifth and a third of the UK’s population, depending on which definition is used).
- 4.3.7 Despite access via the GWML, the far southwestern reaches of Britain see limited to no potential accessibility improvements, suggesting limited indirect effects and therefore more scope for improvements along the Plymouth-Exeter-Bristol-Birmingham axis.
- 4.3.8 The potential local business accessibility impacts are most significant in the areas directly affected by connectivity improvements, and the gains do not extend much further from them. This pattern is expected given that the most significant impacts to local business will be along the lines, from station to station, rather than over a wider area.
- 4.3.9 The potential commuting impacts show more concentrated effects, due to generally shorter commuting distances than those that are intercity. Most marked, however, are the expected impacts in the CaMKOx corridor, the Northern Powerhouse corridor and most significantly the Tay Cities corridor. In Perth and Kinross and Angus in particular, poorer PT service means owning a car is almost a necessity. Improving PT will always have the biggest effect on those without access to a car, and especially in areas where the rail mode is highly uncompetitive at present.
- 4.3.10 The commuting impacts are expected to be smaller and less widespread for non-car-owners than the impacts for car-owners for business purposes. The exceptions outlined above – CaMKOx and Northern Powerhouse – show that decreasing headways and increasing speeds so that services are more evenly-spaced stand to benefit commuters directly. Otherwise, the impacts would be mainly beneficial to businesses, for business travel, over all others.

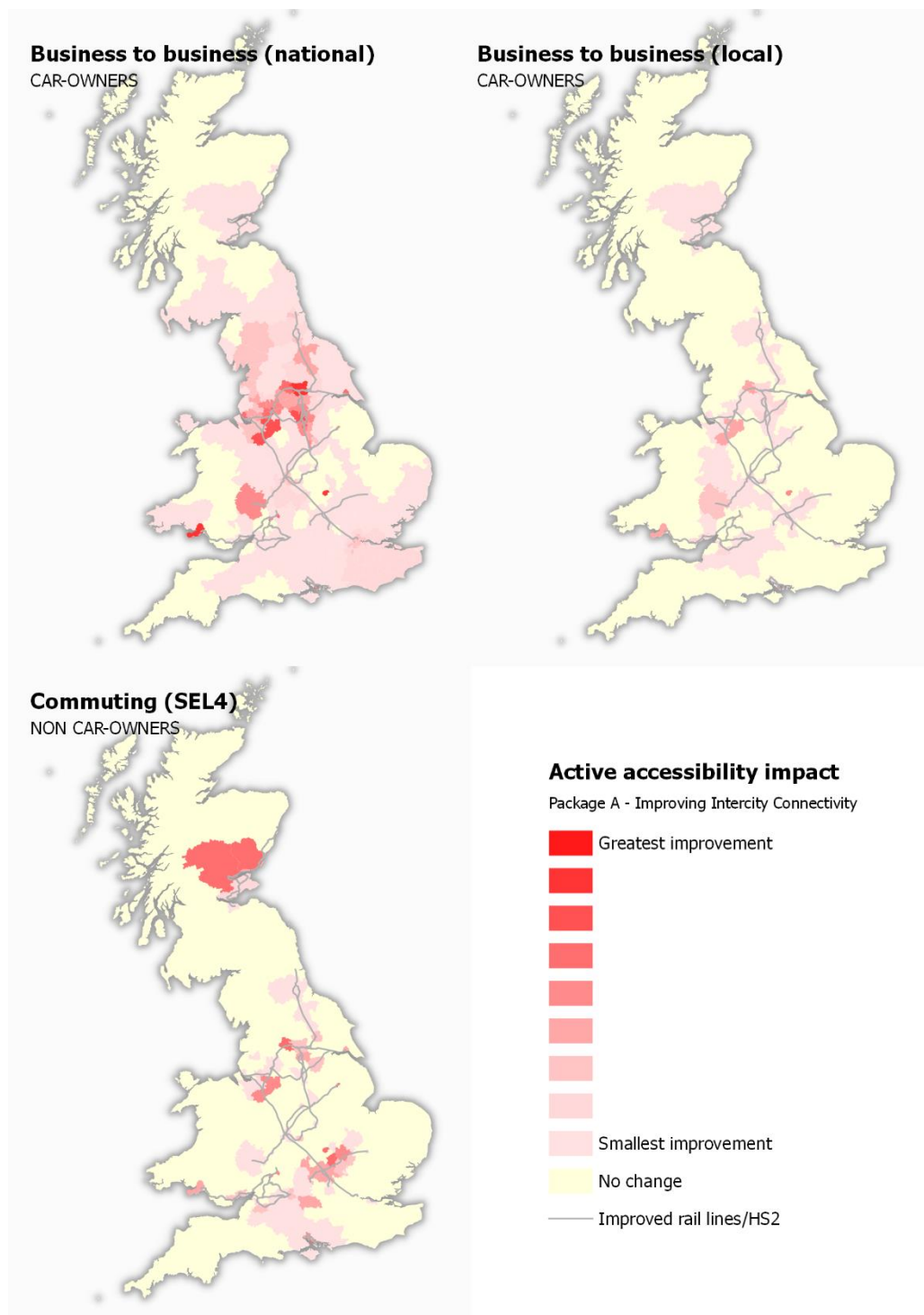


Figure 4-3 Impact of improved intercity connectivity on active accessibility

Economic indicators

- 4.3.11 The Commission views intercity links as fundamentally important in aiding the rebalancing of the economy between North and South. Enhanced connectivity (more links between cities) and improved connectivity (*better* links between cities) should connect more people with more jobs, and give a boost to the residual linkages.

4.3.12 To these ends, we assess the potential impacts of the scheme in terms of the difference, between Southern Britain and the Rest of Britain, between the base scenario and the scenario modelled with the package. The employment impact is shown in Figure 4-4, with key figures in Table 4-2.

Table 4-2 Package A employment impact

| Region | Scenario | 2011 | 2036 | 2061 | Change 2036 to 2061 | CAGR 2036 to 2061 |
|---------------|----------|------------|------------|------------|---------------------|-------------------|
| North | Base | 12,660,730 | 14,057,665 | 15,073,614 | 1,015,950 | 0.27% |
| | A | | | 15,105,987 | 1,048,322 | 0.28% |
| | Impact | | | 32,372 | | |
| South | Base | 15,228,278 | 17,628,725 | 19,112,810 | 1,484,085 | 0.31% |
| | A | | | 19,085,489 | 1,456,765 | 0.31% |
| | Impact | | | -27,320 | | |
| Great Britain | Base | 27,889,008 | 31,686,390 | 34,186,424 | 2,500,034 | 0.29% |
| | A | | | 34,191,476 | 2,505,087 | 0.29% |
| | Impact | | | 5,052 | | |

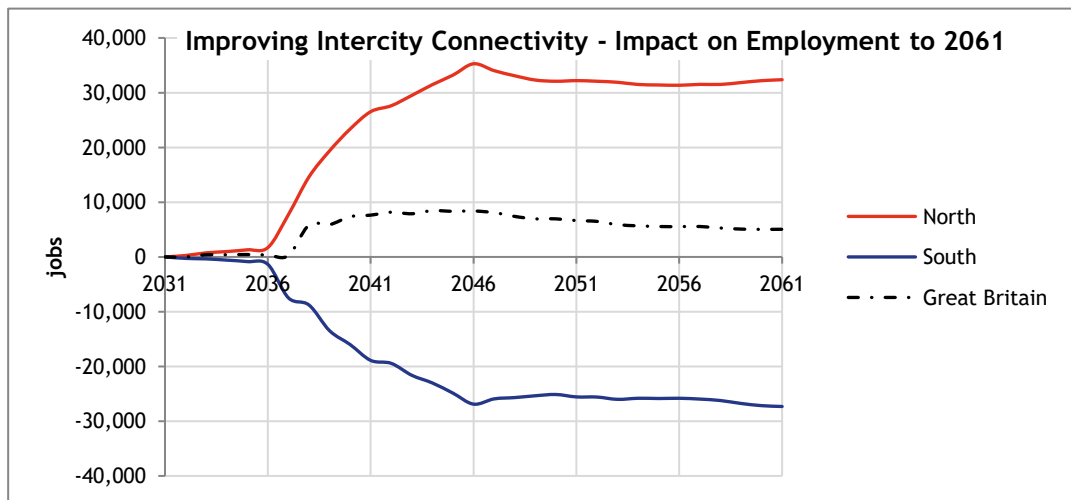


Figure 4-4 Impact of Improved Intercity Connectivity on employment

4.3.13 Some key takeaways are that:

- Great Britain could see a sustained net increase in total employment of about 5,000;
- Employment rebalances: with the overall rebalancing in growth by the end of the forecast for Northern Britain standing at over 30,000 jobs;
- The South sees less pressure on growth by 2061: over 25,000 jobs lower than without the better GB-wide intercity connectivity.
- This rebalancing of growth in the Rest of Britain represents a 0.01% change to the compound annual growth rate between 2036 and 2061;

4.3.14 Figure 4-5 shows the employment impact of the scheme (additional or attenuated growth) by broad sector. All types of employment increase overall; Retail- and Office-type employment both see a rebalancing in growth between Southern Britain

and the rest of Britain, whereas Industry shows the reverse effect. Other employment – modelled here as a range of sectors which includes education, healthcare and construction and many others – plays the most significant role. In the aggregate, we see the jobs rebalancing between the South and North of Britain.

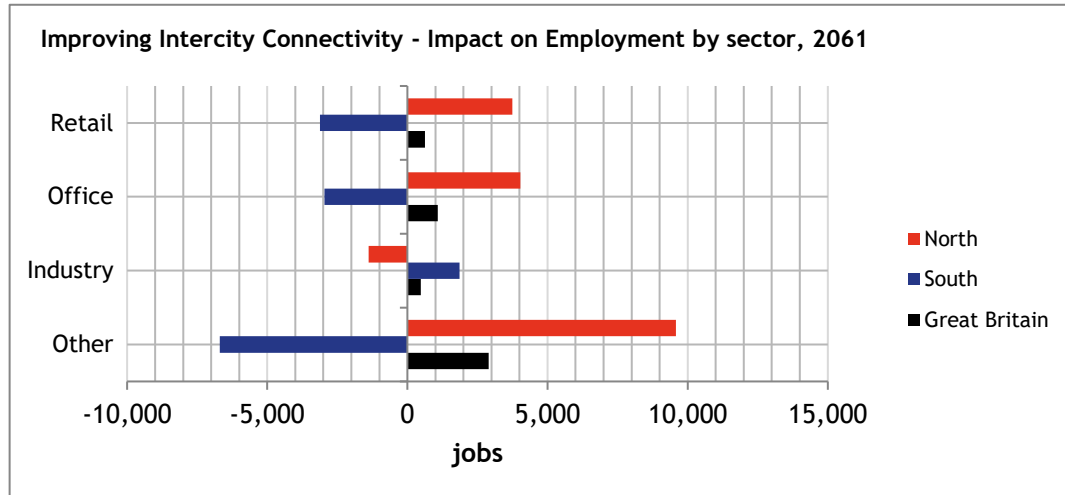


Figure 4-5 Impact of Improved Intercity Connectivity on employment by sector, 2061

- 4.3.15 Figure 4-6 shows the spatial impact by the end of the forecast. Scotland sees a redistribution of employment into the more accessible Tay Cities region, with the largest percentage impact on Perth and Kinross, Angus and Dundee. In Lothian, there is minimal impact. At the opposite end of Britain, in the Solent region, employment appears to grow in the wider area though is almost certainly clustered in the Southampton-Portsmouth area. This shows a similar redistributive effect to that in Scotland.
- 4.3.16 What is particularly interesting in the pattern of employment impacts is that gains to growth appear to be in more centrally located areas. For instance, Hull sees little employment impact, with the northern impacts being clustered primarily in the Leeds City Region, and along the Liverpool-Crewe axis. Similarly, the East-West rail improvement has a significant impact between Bicester and Bedford (i.e. along the central/western part of the corridor, as opposed to at the extremities). In Wales, impacts are clustered within the Greater Cardiff area; in the South West, impacts are very firmly clustered around the Bristol-Cheltenham-Gloucester-Swindon areas.
- 4.3.17 The Midlands region sees the rebalancing in jobs growth chiefly at its southern end – Hereford and Worcester in the West, Birmingham, Coventry and Northampton towards the centre, and Derby to the North. Elsewhere in the region, growth is attenuated somewhat, which is likely a result of the pull towards the centre, as well as the highly competitive schemes with entirely new connectivity which border the region (the East-West and Northern Powerhouse improvements, specifically).

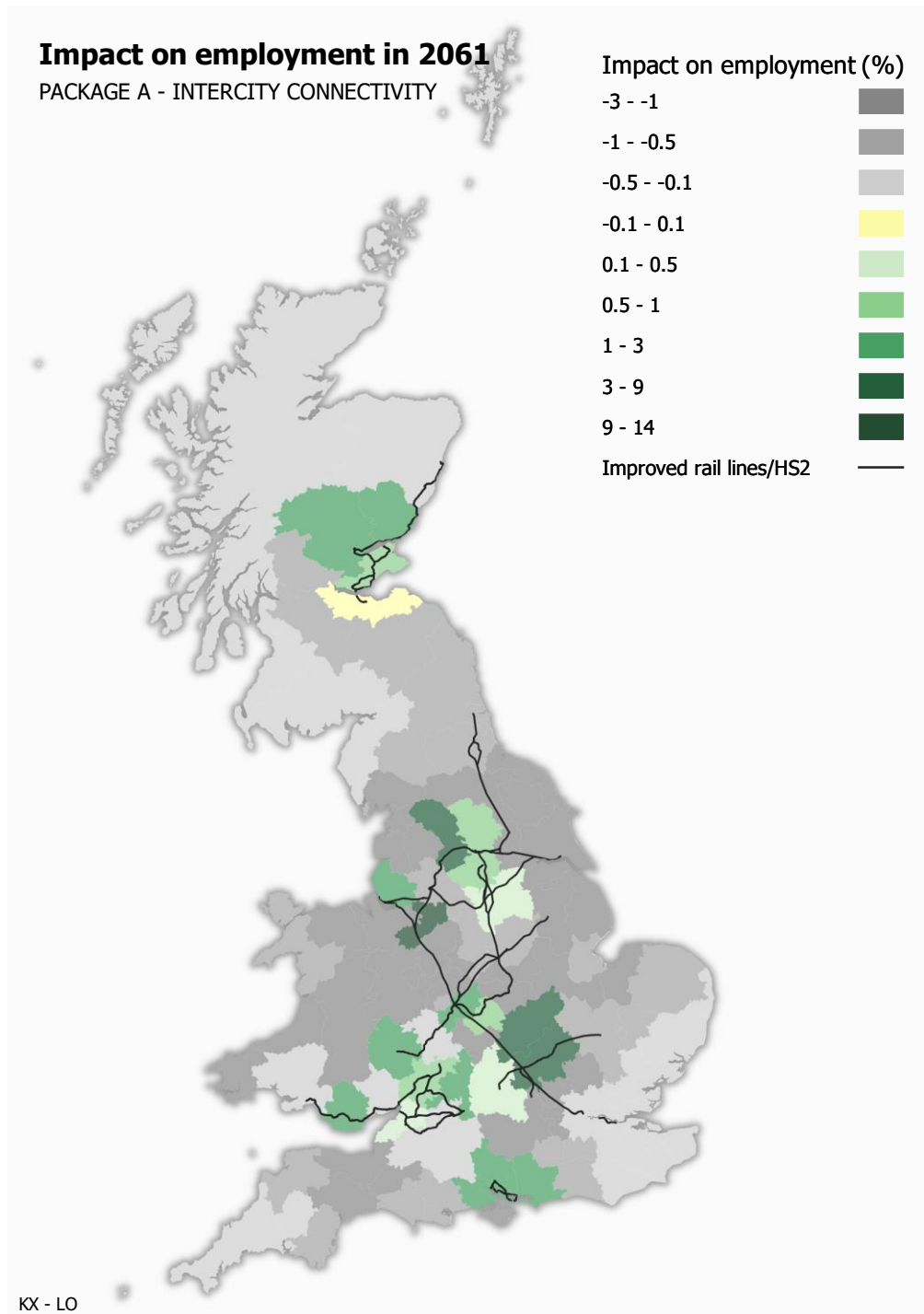


Figure 4-6 Map of impact of improved intercity connectivity on employment in 2061

4.3.18 Compared with the employment impacts, the total output, measured in gross value added (GVA), shows a more muted impact for the North than what one might expect, largely because of the current low levels of productivity. The impacts in terms of Looking to Table 4-3 and Figure 4-7, we see that:

- Overall output across Britain could increase by £5.4B by 2061;
- Southern Britain could see a net increase of £2.5B to its overall growth figure in 2061, compared with the base scenario;

- The rest of Britain could see £2.8B extra growth by the end of the forecast;
- Compound annual growth not significantly impacted in any region;
- Compared with the overall size of the economy in 2061, the impact to growth is significant, though not overwhelming (+0.20% in the North, +0.10% in the South; +0.15% overall).

4.3.19 The graph shows that the possible additions to the economy relative to the base scenario are mainly introduced in the 5 years after 2036; after this, growth is likely to be more gradual. The package could boost total output in both parts of the country by similar amounts (with a slight bias towards the North). This finding is curious, given the rebalancing of total jobs towards the North. The suggestion of the data is that the South's boosted growth would make it more highly competitive for the most productive of labour. So, although the South might lose employment, it would likely gain in GVA, reflecting a shift in the economic structure towards more productive sectors employment. For one reason or another, the capacity requirements for higher GVA growth in the North are not there in this scenario.

Table 4-3 Package A GVA impact (values expressed in £mn)

| Region | Scenario | 2011 | 2036 | 2061 | Change 2036 to 2061 | CAGR 2036 to 2061 |
|---------------|----------|-----------|-----------|-----------|---------------------|-------------------|
| North | Base | 514,493 | 800,112 | 1,287,117 | 487,005 | 1.85% |
| | A | | | 1,289,999 | 489,887 | 1.85% |
| | Impact | | | 2,882 | | |
| South | Base | 775,392 | 1,314,462 | 2,192,770 | 878,308 | 1.99% |
| | A | | | 2,195,331 | 880,870 | 1.99% |
| | Impact | | | 2,562 | | |
| Great Britain | Base | 1,289,884 | 2,114,574 | 3,479,887 | 1,365,313 | 1.93% |
| | A | | | 3,485,330 | 1,370,757 | 1.94% |
| | Impact | | | 5,444 | | |

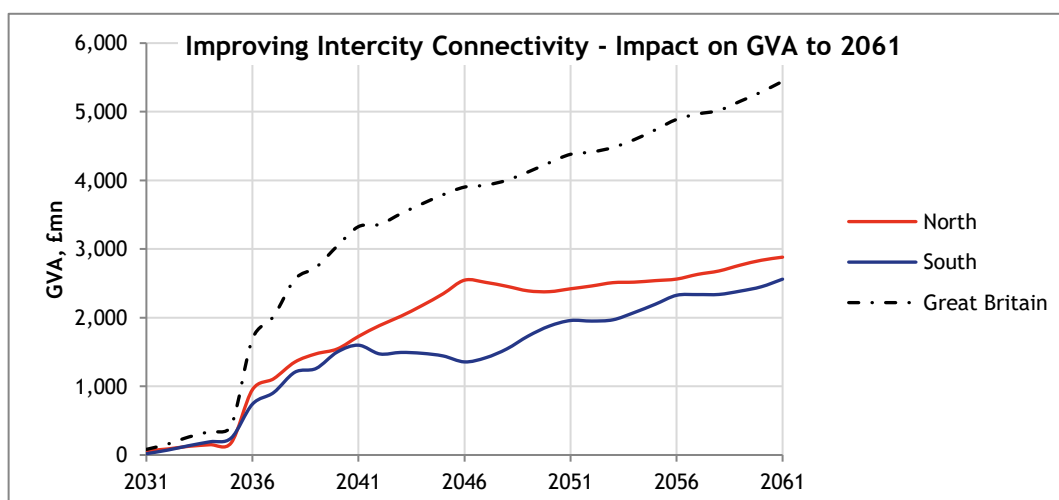


Figure 4-7 Impact of improved intercity connectivity on GVA

- 4.3.20 Looking at the spatial distribution of GVA impacts in Figure 4-8, we see that large swathes of the modelled area would increase in output relative to the base scenario, and the pattern tends to follow that seen for employment. At this level, much of the change in regional GVA is due to the regional rebalancing of jobs, rather than to productivity effects.
- 4.3.21 There are some areas where potential GVA growth is higher overall but employment growth is lower. This suggests a shift in economic structure towards higher skills. This occurs mainly in the area between the Solent and the Great Western Powerhouse region. Elsewhere, in East Anglia, Kent, the North East and Borders regions, there are areas with minimal change in output but slightly reduced jobs growth. London sees a large possible gain in overall output, despite lower employment growth than base, which is a key indicator that its importance as an economic centre allows for the most nationally-focused activities to thrive and even grow under better connectivity elsewhere.

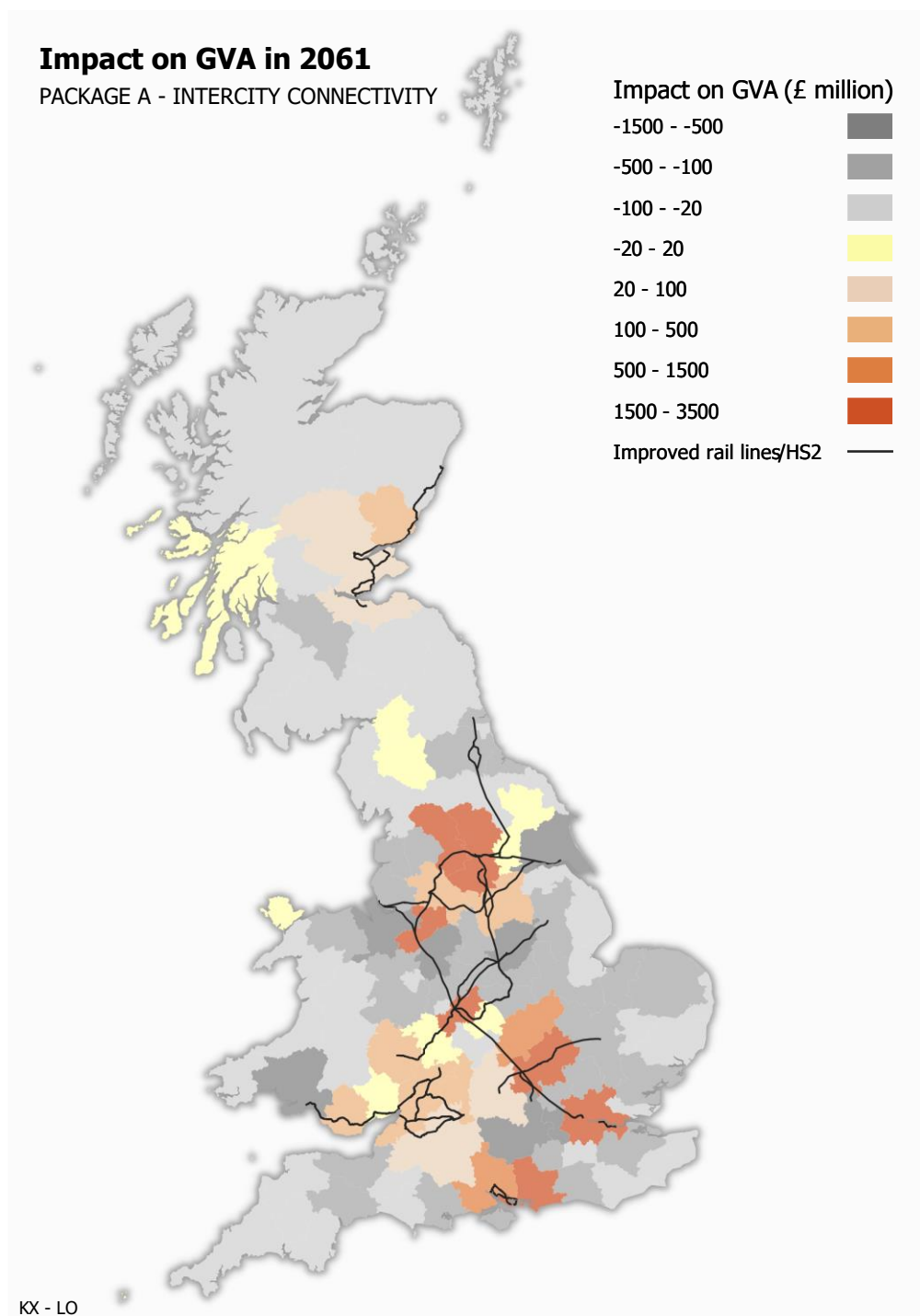


Figure 4-8 Map of impact of improved intercity connectivity on GVA in 2061

Demographic indicators

- 4.3.22 The North/South impacts on population are shown in Table 4-4 and Figure 4-9. Note that the net impact on Great Britain should be viewed as a rounding error: rest-of-world migration is fixed between scenarios, as are projections for household transition, formation and dissolution. As such, all changes to the overall growth are the result of relocation.

4.3.23 The net addition to the North's population growth over time is 30,000 – likewise the South loses the same amount. There is no discernible impact on the compound annual growth rate in either region, and the difference to the North constitutes an additional 0.02% population. The differences are largely insignificant on such a level.

Table 4-4 Package A population impact

| Region | Scenario | 2011 | 2036 | 2061 | Change 2036 to 2061 | CAGR 2036 to 2061 |
|--------|----------|------------|------------|----------------|---------------------|-------------------|
| North | Base | 28,380,907 | 32,663,381 | 36,002,917 | 3,339,536 | 0.38% |
| | A | | | 36,034,597 | 3,371,217 | 0.38% |
| | Impact | | | 31,680 | | |
| South | Base | 31,885,061 | 36,516,415 | 39,989,129 | 3,472,713 | 0.35% |
| | A | | | 39,957,852 | 3,441,437 | 0.35% |
| | Impact | | | -31,277 | | |

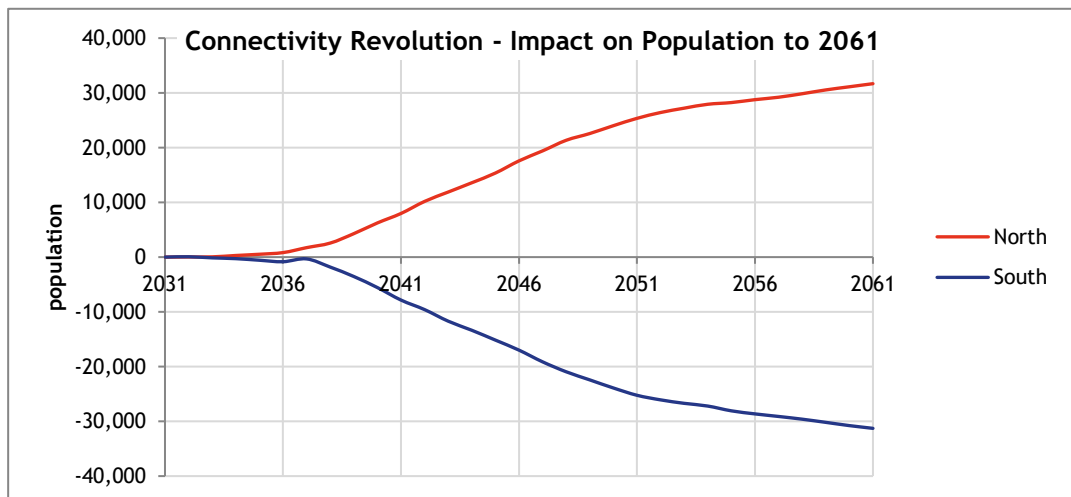


Figure 4-9 Impact of improved intercity connectivity on population

4.3.24 The rebalancing of households and population to regions gaining most from accessibility improvements (and away from oversubscribed London) is an expected result of improving intercity connections (see Figure 4-10). The household impacts are slightly more dispersed than those in employment – for example, Hull and the Humber region gains households, where it lost employees; the same goes for Swansea and the wider region there; elsewhere, Liverpool's household growth is greater than its employment growth. This is broadly intuitive: by and large the factors driving residential location (cost, proximity to family, proximity to a place of work or education) are different to those driving employment location (yes, cost – but also proximity to the greatest number of workers; proximity to a multitude of suppliers and consumers).

4.3.25 One locale that runs counter to the argument above is in the CaMKOx corridor. Here, household location *as well as* employment location centres on the middle of the corridor. This could be a reflection of the cities on the extremities – Cambridge and Oxford – which are renowned as expensive and relatively crowded.

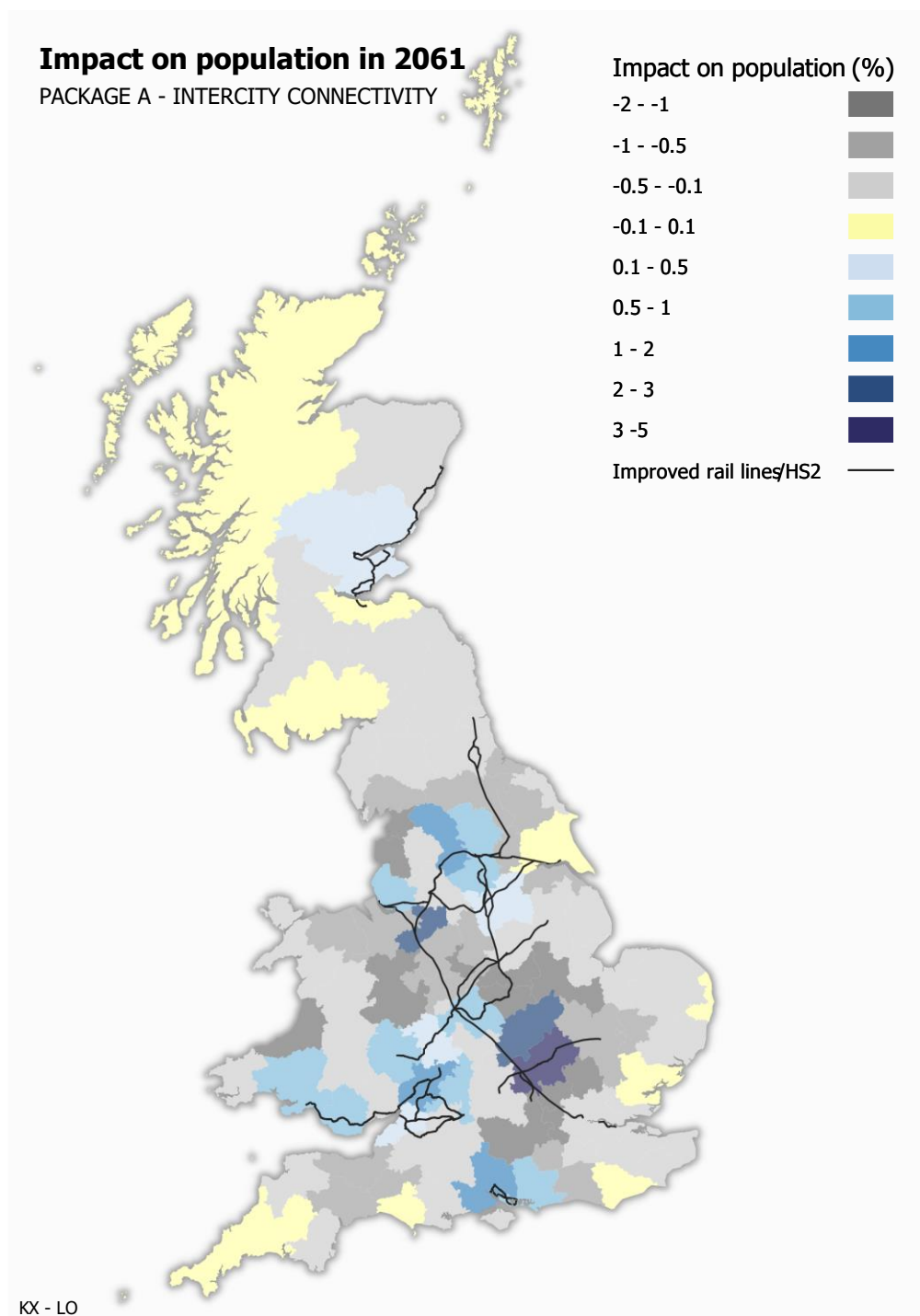


Figure 4-10 Map of impact of Package A on population in 2061

4.4 Conclusion

- 4.4.1 Improving intercity connectivity along and between corridors within the UK rail network provides nationwide economic gains: both employment and output increase over time with the package of schemes. Proportional changes in are employment greater than those for households, which signifies that the improvements affect businesses more than they do households.

- 4.4.2 Although employment increases reasonably substantially in northern Britain, the current lower levels of productivity (which are assumed remain unchanged for the purposes of this modelling) lead to relatively more marginal gains to GVA. Southern Britain, on the other hand – well placed for productive work and with the skills and existing labour force participation to facilitate growth, would be expected to see lower employment gains but more productivity gains unless there is a change. It demonstrates that connecting a large centre of employment with a smaller one likely has a greater effect on the larger area – especially when that larger area is also benefiting from other improved linkages.
- 4.4.3 Improving intercity connectivity has the effect of increasing the efficiency and therefore productive capacity of firms. Across multiple firms in a given place, agglomeration impacts the area of influence a centre of employment imparts. It causes households to move towards employment opportunities, but this may be driven more by the demand for labour than because of other positive impacts to individual households. Possible effects of this could therefore be increases to commute distances or higher occupied densities for residences (less floorspace per household).
- 4.4.4 The challenge that emerges from the pure intercity approach is how to drive productivity and efficiency in a more decentralised (in national terms) way – to boost regional economies from beneath, rather than from the top down.

5 PACKAGE B – INTRAURBAN MOBILITY

5.1 Background

- 5.1.1 Alongside improving connectivity between urban areas in the UK, the UK2070 Commission argues – and we agree – it is important to improve the connectivity *within* them. This should serve to enhance the accessibility of jobs and services to households, and more broadly enhance accessibility by improving door-to-door connectivity and access to transport hubs.
- 5.1.2 Successes in recent years have been achieved through forward-looking strategic planning by public authorities, facilitated by the devolution of ever more powers and responsibilities to combined authorities and passenger transport executives. Most notably, organisations like TfL in London, TfGM in the North West and SPT in Glasgow have been able to successfully guide local transport strategy with multiple objectives in mind.
- 5.1.3 It is expected that intraurban mobility improvements should usher accessibility improvements on a local scale, as opposed to the regional-national scale gains as a result of rail improvement.

5.2 Modelling approach

- 5.2.1 The UK2070 Commission argues that the long-term vision for intra-urban mobility should focus on three areas: reducing congestion and diverting journeys onto other modes; promoting active travel; and improving bypasses, roundabouts, railway junctions and stations.
- 5.2.2 Improvements to bus services seemed most appropriate to model for this package, in light of the capability of the SNM. The bus mode within SNM can indeed be seen as an analogue of other urban mass transit systems, owing to its simple representation.
- 5.2.3 Some accounting for the improvement of public spaces to encourage/speed-up walking has also been made; due to the need to encourage mode shift from private car usage, car inputs remain static, to reflect static congestion and potential road-user charging to offset induced demand from speed gains.
- 5.2.4 Therefore an approach has been taken to reduce bus wait times from a mean of 15 minutes to 10 minutes, with speeds improved by 20% within and between improvement zones. This incorporates representations of some or all of the following:
- higher-capacity vehicles, with better physical accessibility
 - improved spacing of halts
 - dedicated running ways
 - uptake of advance/cashless technologies for payment
 - incorporation of ITS/vehicle-to-infrastructure
- 5.2.5 Additionally, walk speed has been increased from an average of 5km/h to 6km/h within the same urban areas. This is to reflect the incentive effect of public realm

and air quality improvements, alongside efficiency gains from intelligent transport systems (e.g. variable signalling at junctions to allow for enhanced flows) and/or decreased intraurban vehicle flows.

Area of effect

- 5.2.6 As the Commission's vision of a UK Network for transport involves extending access between places at multiple scales, and Package A achieves this through inter- and intra-regional connections, Package B focuses on the complementary *local* scale, at each of the points outlined previously. This means that those same zones which saw intercity rail improvements have been modelled as only seeing bus/walk improvements. See Figure 5-1 for a representation of these zones.

Phasing

- 5.2.7 The changes have been modelled as applying from 2036 onwards, in alignment with the stated aims of simplifying analysis and viewing results on a strategic, end-of-forecast basis. This removes complexity arising from phasing of changes over time.

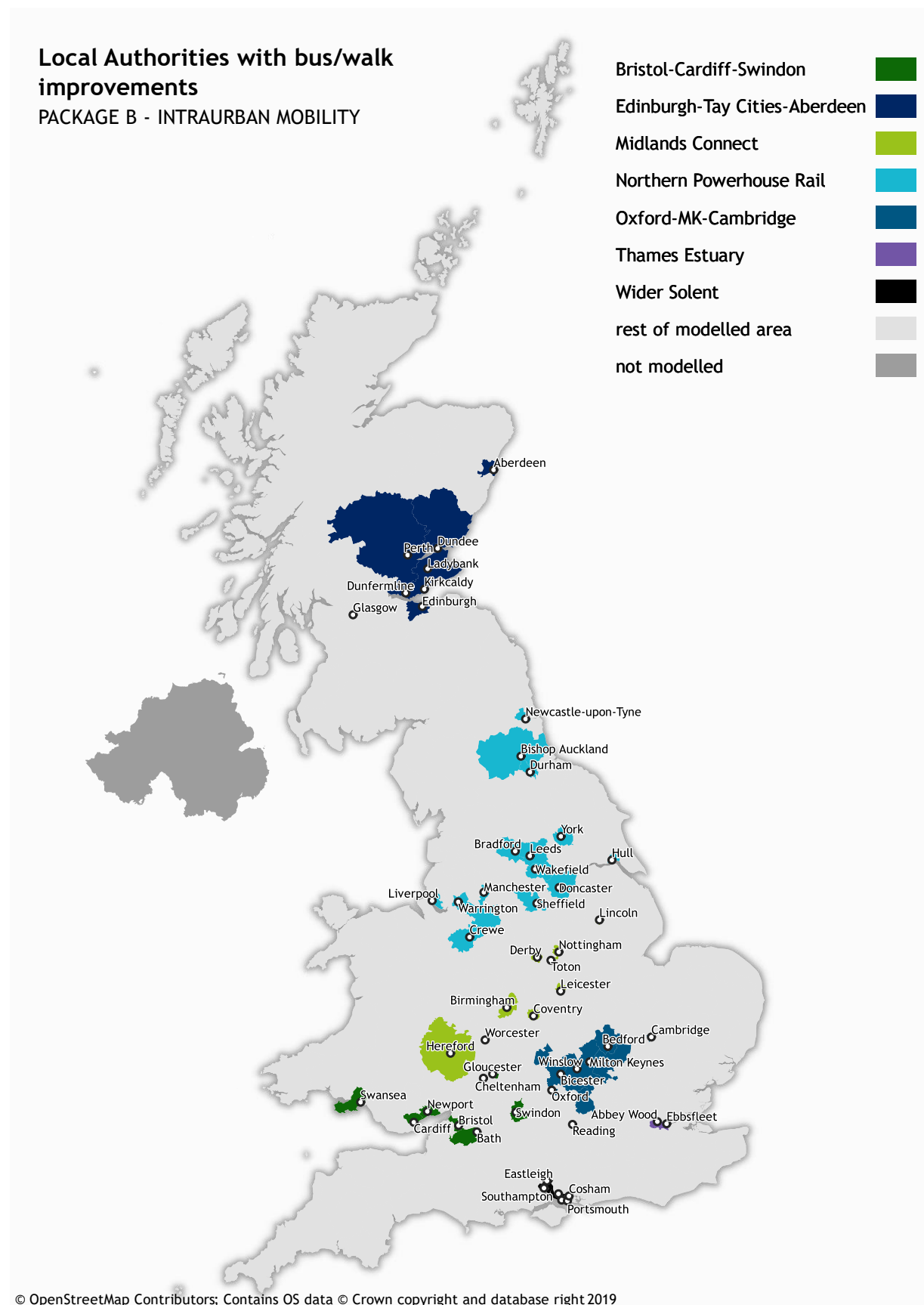


Figure 5-1 Model zones with bus/walk improvements (intraurban mobility)

5.3 **Results**

Direct effects – accessibility impact

- 5.3.1 Assessing accessibility change as a result of implementing a scheme package allows us to look at the expected impact on demographic and economic indicators, owing to its relationship with the separation between land-uses over space mentioned in the last chapter. Figure 5-2 shows the direct, static effect on accessibility from each zone to all others shown as a composite, for national and local business activities, and for the lowest-earning commuters. This static impact doesn't show the change in accessibility coming about as a result of redistribution of households and employment in the forecast, only the direct change impacting these responses. For businesses, accessibility to car-owners is shown; for commuters, accessibility for the group with the lowest earnings and no car ownership is shown.
- 5.3.2 There is very minimal impact on national business-to-business accessibility: the marginal gains of improving 'last mile' accessibility have minimal impact on those travelling for business, whose preferences largely would be on 'who is where' as opposed to 'who is easiest to access'. Distribution of opportunities matters more than the ease of reaching alternatives.
- 5.3.3 Locally, businesses see slightly greater gains, and these tend to be in those areas where there is not already a good rail link – most notably in the Edinburgh-Tay Cities corridor in East Scotland, as well as in the Wider Solent, and in the North of England.
- 5.3.4 The greatest impacts are seen for commuters, and within Great Britain, the areas with potentially the highest impact are those where bus and walk would be the most important modes – for instance, in the Tay Cities region, where improved suburban-rural bus services are highly depended-upon, and whose improvement is a key aim in the region. Similarly, the Durham-Tyneside, North and East Yorkshire, and Newport areas are highly dependent upon bus services, so gain significantly.

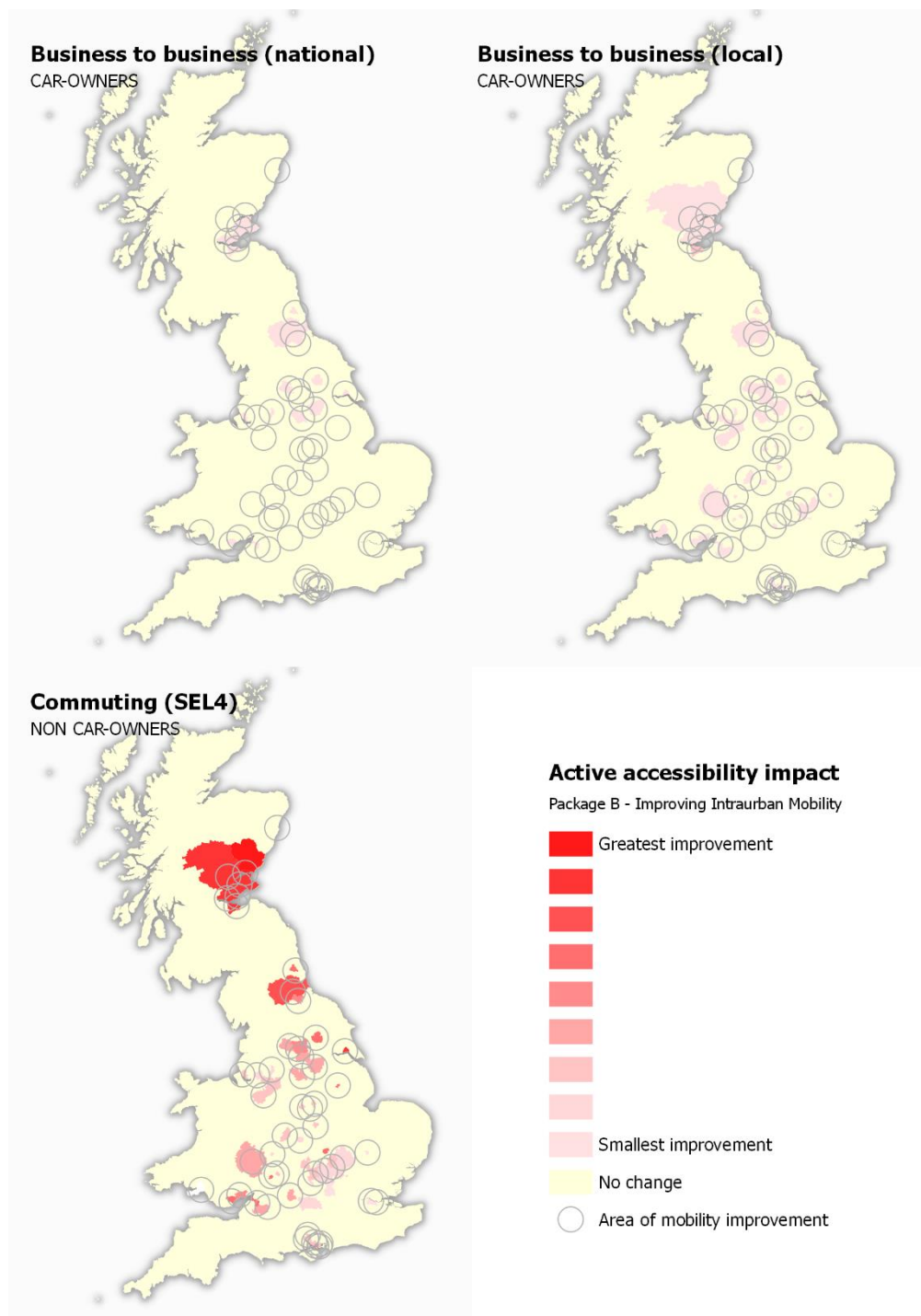


Figure 5-2 Maps of impact of improved intraurban mobility on static accessibility

Economic indicators

- 5.3.5 Whereas Package A, which looked at improving intercity connectivity, was largely an interregional package best viewed through a national lens, Package B requires a focus on the intraregional impacts – as such the analysis looks at each of the megaregions outlined earlier, rather than specifically at the regional rebalancing of the economy.

5.3.6 Table 5-1 gives an overview of the results across the regions. The key findings are that:

- Great Britain as a whole sees an additional 4,200 jobs on top of the base scenario, by 2061;
- Wales, the Midlands and the Wider South East all see reduced growth in employment;
- North England, Scotland and the South West all gain similar absolute amounts;
- Compound annual growth rates on average don't show any significant change;
- The employment impacts appear quite equitable, given the area impacted.

Table 5-1 Package B impact on employment

| Region | Scenario | 2011 | 2036 | 2061 | Change 2036 to 2061 | CAGR 2036 to 2061 |
|------------------|----------|------------|------------|---------------|---------------------------|-------------------------|
| London/ WSE | Base | 10,805,031 | 12,746,067 | 13,976,168 | 1,230,101 | 0.35% |
| | B | | | 13,970,024 | 1,223,957 | 0.35% |
| | Impact | | | -6,144 | | |
| Midlands | Base | 4,406,055 | 4,981,027 | 5,362,009 | 380,982 | 0.28% |
| | B | | | 5,361,181 | 380,154 | 0.28% |
| | Impact | | | -828 | | |
| North England | Base | 6,519,338 | 7,259,237 | 7,827,601 | 568,364 | 0.29% |
| | B | | | 7,832,406 | 573,169 | 0.29% |
| | Impact | | | 4,805 | | |
| Scotland | Base | 2,439,616 | 2,686,235 | 2,872,920 | 186,685 | 0.26% |
| | B | | | 2,876,969 | 190,733 | 0.26% |
| | Impact | | | 4,049 | | |
| South West | Base | 2,441,050 | 2,697,159 | 2,841,492 | 144,333 | 0.20% |
| | B | | | 2,846,013 | 148,854 | 0.21% |
| | Impact | | | 4,521 | | |
| Wales | Base | 1,277,918 | 1,316,665 | 1,306,234 | -10,431 | -0.03% |
| | B | | | 1,303,989 | -12,676 | -0.04% |
| | Impact | | | -2,245 | | |
| Great Britain | Base | 27,889,008 | 31,686,390 | 34,186,424 | 2,500,034 | 0.29% |
| | B | | | 34,190,581 | 2,504,191 | 0.29% |
| | Impact | | | 4,157 | | |

5.3.7 Figure 5-3 shows the regional impact on employment relative to the base scenario, over time.

- 5.3.8 Of the expected net increase of 4,000 jobs compared with the base scenario, over 100% of this goes to each of the North of England, Scotland, and the South West. This means that there is some degree of redistribution – indeed, from London/WSE which sees slightly lower jobs growth compared with the base case by the end of the forecast, and from the Midlands, which also sees a 6,000 lower rate of jobs growth almost immediately, but recoups most of this to end at net -800 (still with an additional 380,000 jobs over 2011);
- 5.3.9 The pattern the Midlands exhibits is possibly due to rent impacts affecting take-up of the floorspace supply. There is also clear interdependence between the Midlands and the North. This runs counter to London/WSE, which sustains lower growth – clearly positive accessibility impacts elsewhere counterweigh the rent impacts.
- 5.3.10 The interdependence between the South West and Wales could result in a net reduction in growth for Wales, although it is also possible that the Midlands rebalancing over time is due to cross-border movements from Wales to Birmingham or Leicester.

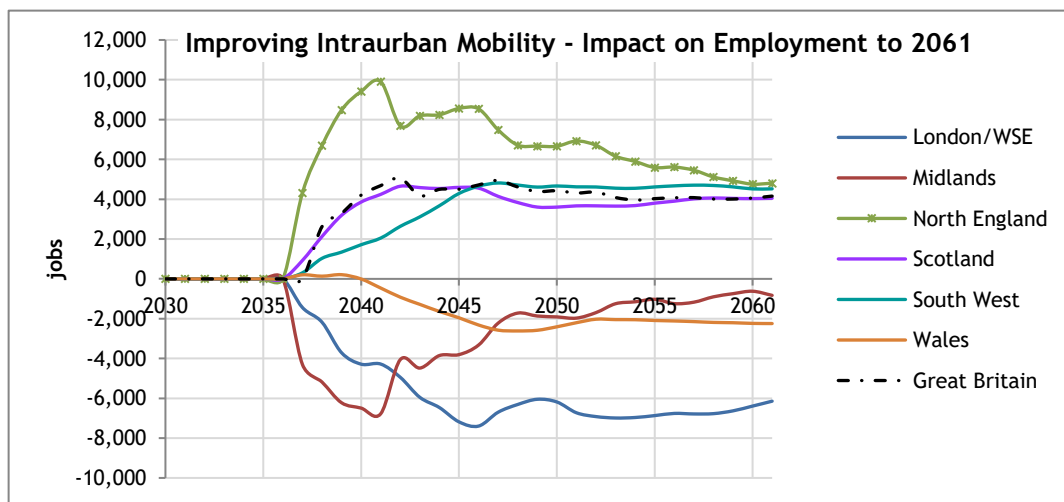


Figure 5-3 Impact of improved intraurban mobility on employment

- 5.3.11 Looking at the overall impact in percentage terms in individual housing market areas (Figure 5-4), the Scottish corridor improvement area would be expected to increase, especially in Lothian. This growth appears to be redistributed from West Central Scotland, however.
- 5.3.12 At a macro-zonal scale, many of the impacts are small, or masked by redistribution to other areas. Those impacts which are big enough to show at the HMA scale are generally focused on larger urban areas with transport improvements. As such, Bristol and Birmingham see large changes, along with Newcastle-upon-Tyne, York-Doncaster, Leeds-Bradford-Wakefield, the Solent, CaMKOx and Cardiff.
- 5.3.13 The Humber region could see a lower rate of growth without any compensatory interventions; so too could Newport, Hereford, Swindon, Bath – all generally smaller urban agglomerations compared with the likes of Birmingham or Leeds.

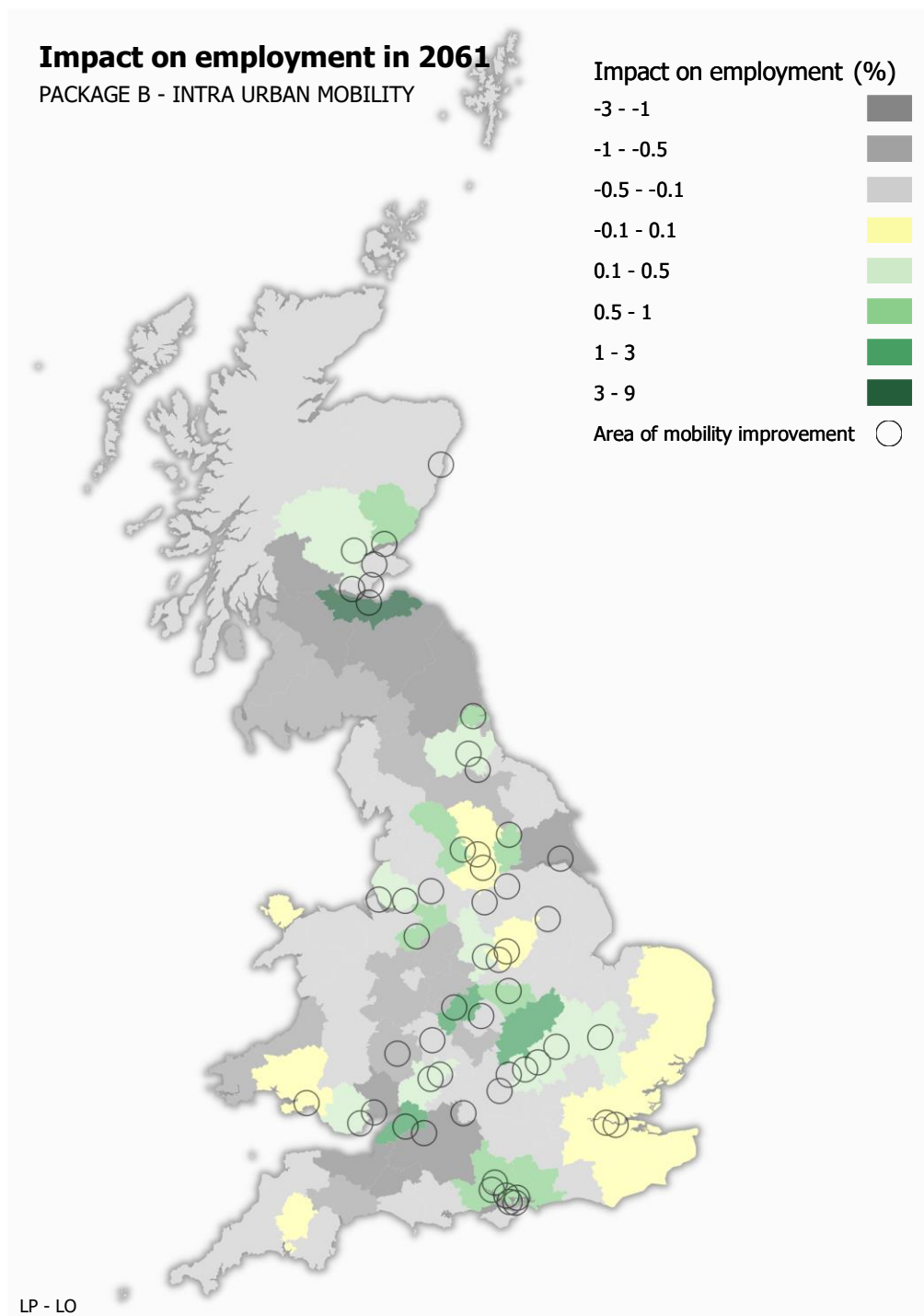


Figure 5-4 Map of impact of improved intraurban mobility on employment in 2061

5.3.14 Output, measured in £million GVA, shows some positive impacts from the package (Table 5-2):

- The net impact on the economy is ~£1.5 billion by 2061;
- The Midlands and Wales see marginally lower rate of growth in output than in the base scenario (-0.05% and -0.50%, respectively);

- The North, Scotland and the South West could all see fair gains of between £400mn and £1.2B;
- CAGR rates between 2036 and 2061 would change very marginally in the regions most affected.

Table 5-2 Impact of Package B on GVA (values expressed in £mn)

| Region | Scenario | 2011 | 2036 | 2061 | Change 2036 to 2061 | CAGR 2036 to 2061 |
|------------------|----------|-----------|-----------|-----------|---------------------------|-------------------------|
| London/ WSE | Base | 590,627 | 1,029,474 | 1,742,474 | 712,999 | 2.04% |
| | B | | | 1,742,417 | 712,942 | 2.04% |
| | Impact | | | -57 | | |
| Midlands | Base | 179,890 | 286,339 | 462,622 | 176,283 | 1.86% |
| | B | | | 462,433 | 176,094 | 1.86% |
| | Impact | | | -189 | | |
| North England | Base | 262,805 | 410,287 | 665,981 | 255,694 | 1.88% |
| | B | | | 666,747 | 256,460 | 1.89% |
| | Impact | | | 766 | | |
| Scotland | Base | 104,958 | 160,258 | 255,448 | 95,190 | 1.81% |
| | B | | | 255,869 | 95,610 | 1.82% |
| | Impact | | | 421 | | |
| South West | Base | 102,989 | 157,751 | 249,867 | 92,116 | 1.78% |
| | B | | | 250,985 | 93,234 | 1.80% |
| | Impact | | | 1,118 | | |
| Wales | Base | 48,616 | 70,464 | 103,495 | 33,030 | 1.49% |
| | B | | | 102,838 | 32,374 | 1.46% |
| | Impact | | | -657 | | |
| Great Britain | Base | 1,289,884 | 2,114,574 | 3,479,887 | 1,365,313 | 1.93% |
| | B | | | 3,481,287 | 1,366,714 | 1.94% |
| | Impact | | | 1,401 | | |

5.3.15 Figure 5-5 shows the impacts on GVA growth over time. The North sees an immediate upturn in output, with a lower rate of growth in the Midlands. However, after five years, the growth picks up in the Midlands, and is steady relative to the base scenario. A similar pattern is seen for the Scotland; and the South West could continue to grow at a faster pace than the base scenario.

5.3.16 Wales could see lower growth over time, highlighting the need for more in the way of equitable solutions here, to prevent (further) decline and marginalisation.

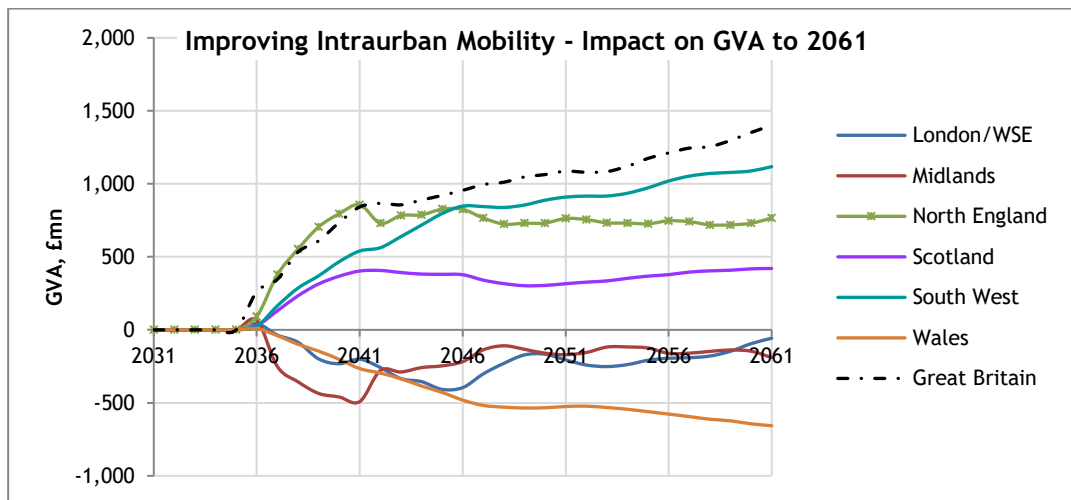


Figure 5-5 Impact of improved intraurban mobility on GVA

- 5.3.17 Figure 5-6 shows the spatial distribution of GVA impacts by the end of the forecast. The gains are broadly intuitive and follow the patterns of employment growth. Bristol, Birmingham, Liverpool, Portsmouth and Lothian all stand out as places with significant positive impacts on GVA. This signifies that the jobs mix has increased in productivity.
- 5.3.18 There are some examples of areas remaining broadly static in employment terms, that could see a lower rate of growth in output relative to the base – for instance, London, Leeds and Wakefield, and Nottingham. This reflects an increase in lower productivity jobs.
- 5.3.19 There are also examples of areas with similar employment compared with the base scenario, but higher GVA. This would suggest an increase in productive work, and it potentially signifies a bigger multiplier as a result of better local accessibility.
- 5.3.20 A notable result is that, with purely intra-regional impacts of the transport package, London does not see an increase in output. Gains are generally within regions, from the wider area towards the centre of city regions, and increases in labour force and output are a result of agglomeration and spillover effects.

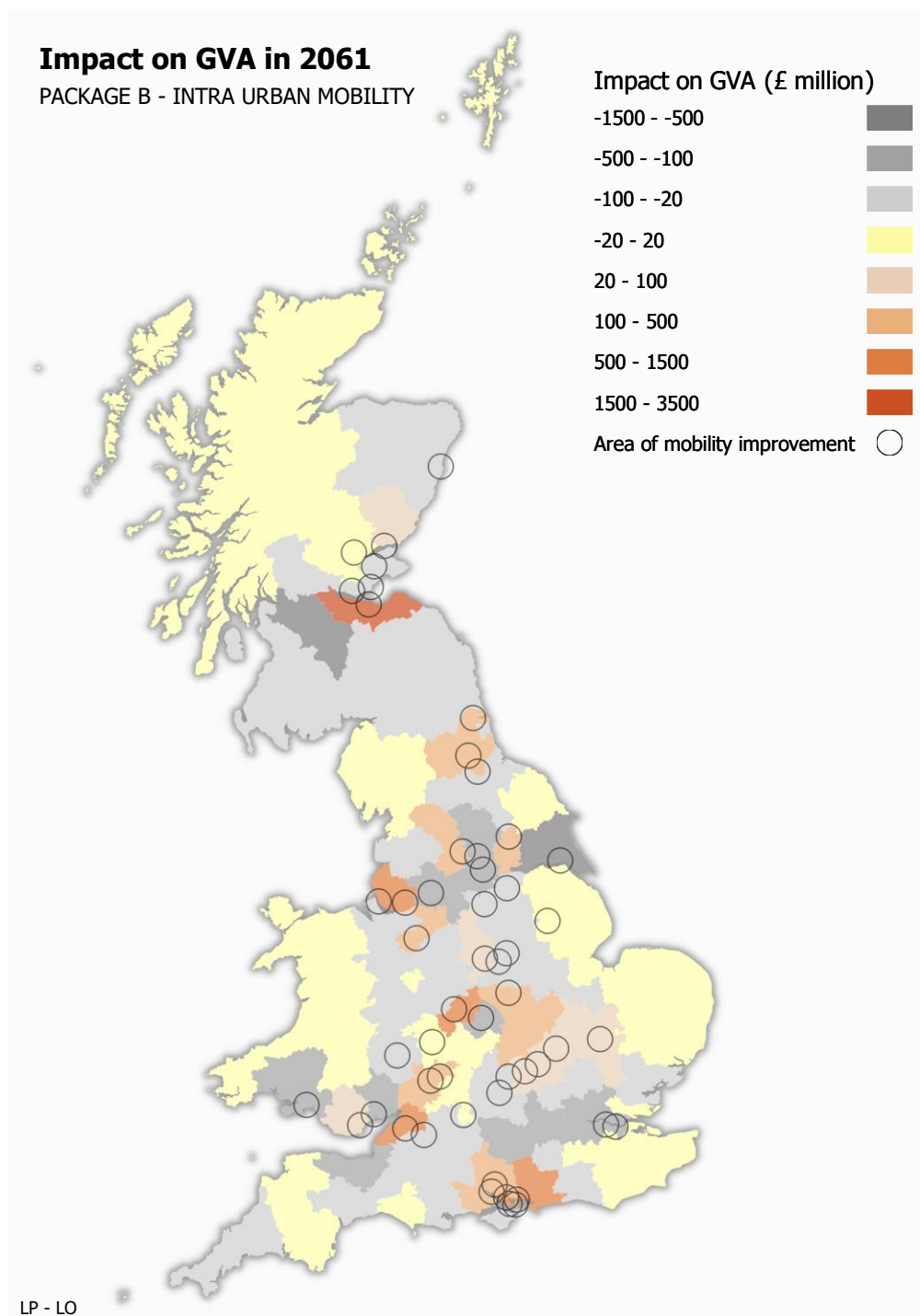


Figure 5-6 Map of impact of improved intraurban mobility on productivity in 2061

Demographic indicators

- 5.3.21 Impacts on household numbers are shown in Table 5-3. Note that demographic growth overall is fixed between scenarios, so a GB total is not shown.
- 5.3.22 The main takeaway from the table is that, as a result of the package, population and households do not grow at the same historic rate in Wider South East and across other regions within Britain. This doesn't have a major impact on compound annual

growth for the South East, but is noticeable at least in Scotland. In general, the boosts to regions are small.

Table 5-3 Impact of Package B on population

| Region | Scenario | 2011 | 2036 | 2061 | Change 2036 to 2061 | CAGR 2036 to 2061 |
|------------------|----------|------------|------------|----------------|---------------------|-------------------|
| London/ WSE | Base | 22,267,962 | 25,109,227 | 27,497,790 | 2,388,562 | 0.35% |
| | B | | | 27,483,215 | 2,373,988 | 0.35% |
| | Impact | | | -14,574 | | |
| Midlands | Base | 9,951,480 | 11,593,759 | 12,923,082 | 1,329,323 | 0.42% |
| | B | | | 12,924,566 | 1,330,807 | 0.42% |
| | Impact | | | 1,484 | | |
| North England | Base | 14,663,972 | 16,871,432 | 18,578,589 | 1,707,158 | 0.37% |
| | B | | | 18,583,954 | 1,712,523 | 0.37% |
| | Impact | | | 5,365 | | |
| Scotland | Base | 5,196,374 | 6,009,631 | 6,588,306 | 578,675 | 0.35% |
| | B | | | 6,590,730 | 581,099 | 0.36% |
| | Impact | | | 2,424 | | |
| South West | Base | 5,175,022 | 6,144,745 | 6,691,108 | 546,363 | 0.33% |
| | B | | | 6,695,554 | 550,809 | 0.33% |
| | Impact | | | 4,446 | | |
| Wales | Base | 3,011,157 | 3,451,002 | 3,713,171 | 262,169 | 0.28% |
| | B | | | 3,714,331 | 263,329 | 0.28% |
| | Impact | | | 1,160 | | |

5.3.23 Figure 5-7 shows the effect over time. Notably, most regions gain growth steadily over time, as the impact of accessibility improvements spreads to more households. The Midlands initially loses growth as the North of England takes off, but the relationship steadies towards the end of the forecast and the Midlands gain growth.

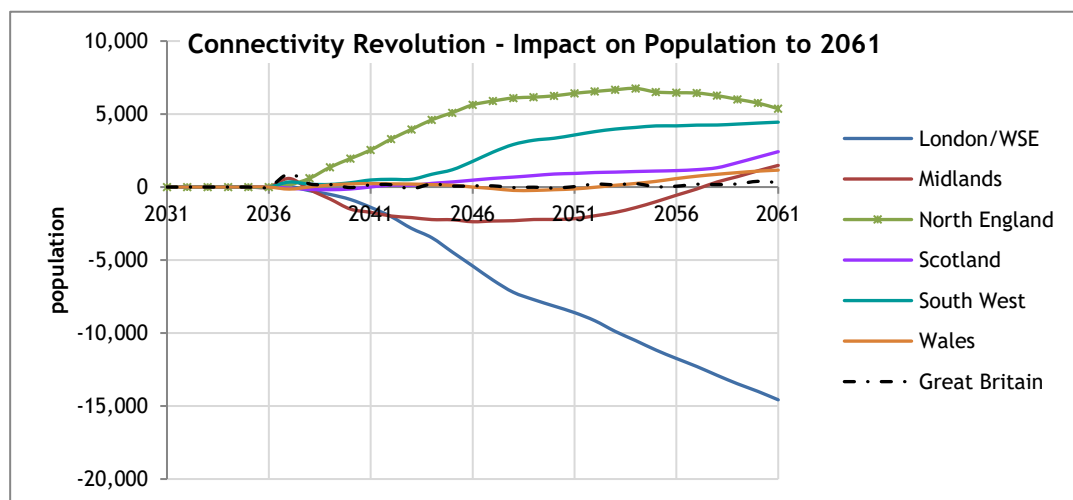


Figure 5-7 Impact of improved intraurban mobility on population

- 5.3.24 The distribution of impacts to population levels by the end of the forecast is shown in Figure 5-8. When compared with the employment map in Figure 5-6 it shows that gains in employment are broadly tied to gains in households and population. This would suggest that households value the increase in ease of access to employment, education and leisure opportunities, and therefore move to be closer to these areas.
- 5.3.25 There are important exceptions: notably in the Humber region, where population growth increases, despite a reduction in employment growth; the same is seen in Leicester, just north of the area of growth around the CaMKOx corridor.
- 5.3.26 Generally, the map suggests population moves as a result of improving intraurban connections are done over shorter distances, if at all: there are significant portions of the modelled area which see no distinguishable effect. Indeed, the relocations that do happen appear to happen between the improvement areas and their bordering areas.

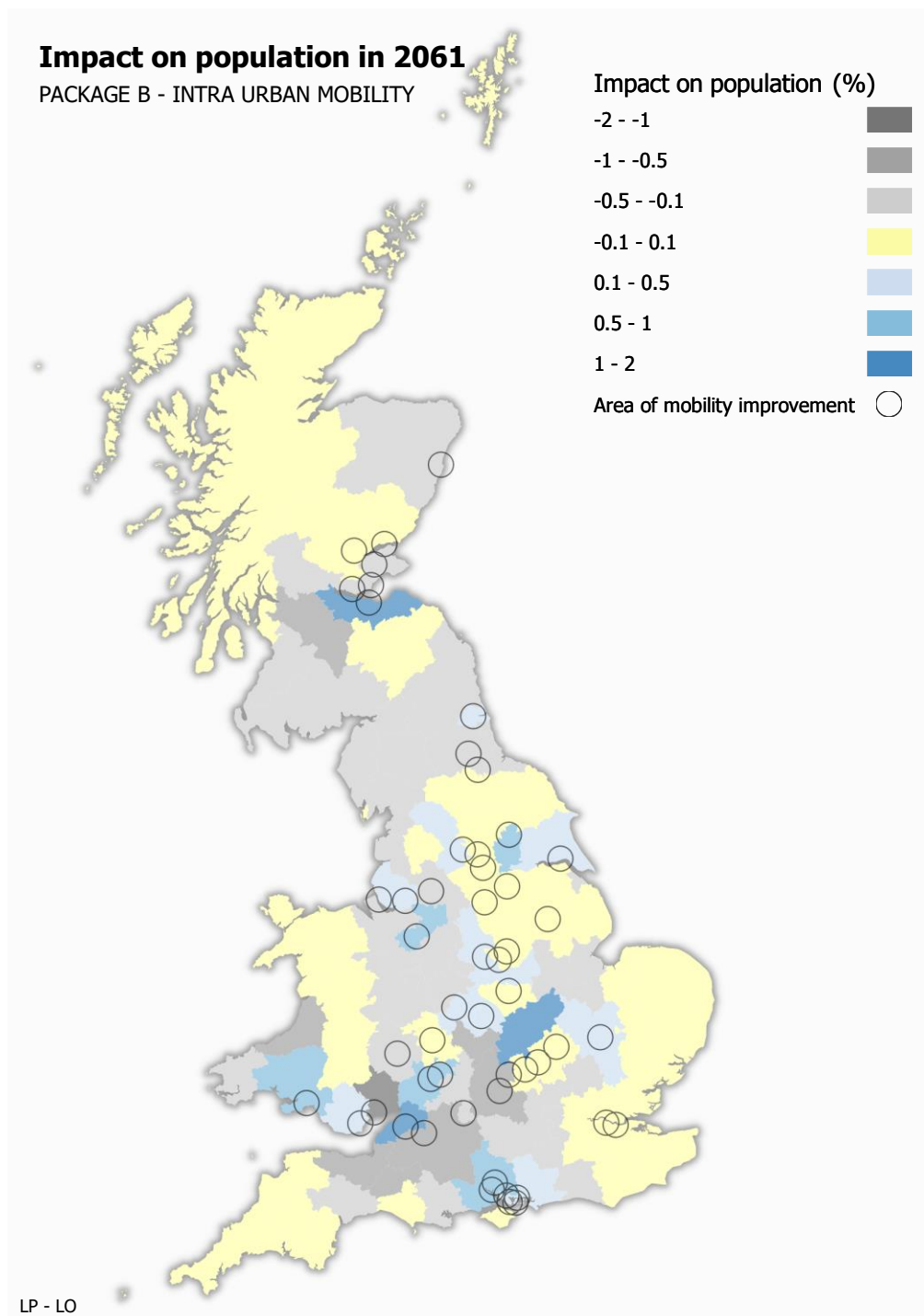


Figure 5-8 Map of impact of improved intraurban mobility on households in 2061

5.4 Conclusion

- 5.4.1 Improving active mode accessibility and intraurban transport links – here modelled as bus improvements, but more generally including LRT and metro services – has a marked effect on local redistribution and growth of households and employment. Better intra-urban mobility tends to benefit those on the lowest economic rungs, who may not own a car, and may live in left-behind or under-served communities within prosperous towns or cities.

- 5.4.2 The modelling has shown that improving local accessibility to a greater extent than national accessibility can serve to improve outcomes for those relatively ‘left-behind’ areas. Output and employment generally increase when an area sees internal mobility improvements. This can be driven by, or itself drive, growth in population, which benefits from the better accessibility. Redistribution of population does occur, but tends to be on a slightly lower, more local scale than when improving accessibility across a wider base.

6 PACKAGE C – RECONNECTING MARGINALISED COMMUNITIES

6.1 Background

6.1.1 Regarding the economic balance between regions, it is important to consider those areas where changes in Packages A and B may have little effect. These are marginalised areas where a historic lack of economic potential coupled with a lack of infrastructure investment has led to what can be described as a ‘spiral of decline’, and limited connectivity at scales beyond the local.

6.1.2 These marginalised communities have great potential, in that investment in infrastructure improvements here can drastically improve outcomes for those worst off.

6.2 Modelling approach

6.2.1 There are many different lenses through which to view regional economic imbalances. One lens through which it has been examined in the Greengauge21 report is in the proportion of benefits claimants to population – shown in Figure 6-1.

6.2.2 The map shows many hotspots where unemployment among those of working age is at or above 5%. A number of these are at the periphery of – or indeed within – larger urban agglomerations. For these, it is implied that urban policy, the type of which explored in Packages A and B, would contribute to their rebalancing. However, there are many where these wouldn’t help. Most notable is the Eastern coastal ‘corridor’ encompassing locales from East Lincolnshire to East Anglia.

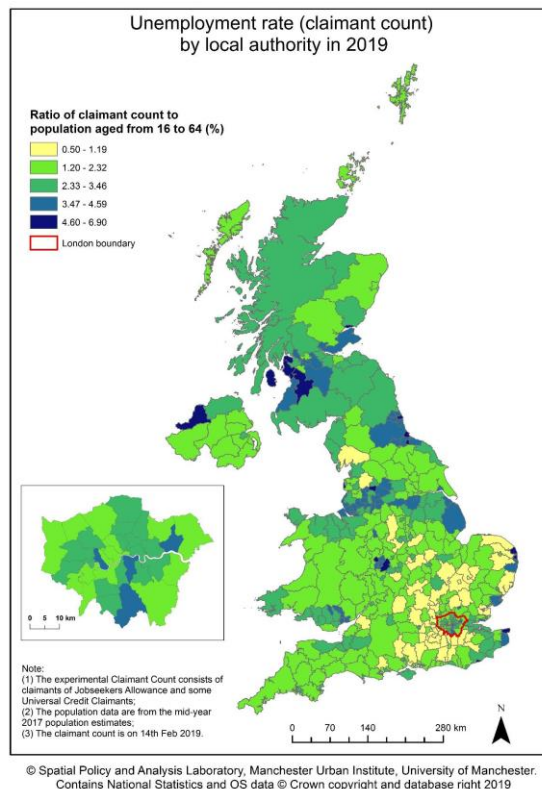


Figure 6-1 Unemployment rate by Local Authority

Source: © Spatial Policy & Analysis Laboratory, Manchester Urban Institute

- 6.2.3 The Greengauge21 report for the Commission notes that, to improve this corridor, a combination of multi-modal hubs, interurban bus services and additional estuarial crossings and rail links (most notably between Boston and Louth) should be developed. Aspects of these recommendations have been modelled in this package. Figure 6-2 outlines the Local Authority model zones where the improvements have been modelled. A coastal belt from Teesside to North Norfolk, it incorporates many aspects of the proposal for the east coast in the Greengauge21 report on the 2070 transport infrastructure requirement.
- 6.2.4 The inputs constitute upgrading the rail connectivity between all zones in the corridor to the equivalent of medium-density rail zones. This means the following:
- Increased frequency, from one train every 3-4 hours, to one train every 2 hours
 - Increased speed, from 50km/h on average, to 60km/h;
 - Decreased access and egress distance, from 20km total, to 10km.
- 6.2.5 Bus and walk generalised costs have been improved to the same degree as those in Package B, over the entire corridor. This provides a good analogue for the multimodal hubs implied within the rail costs, through the halving in access and egress distances – i.e. the total distance to and from stations, via other modes, for rail journeys.

Phasing and input processing

- 6.2.6 The package was compiled using a ‘hubs’ process to link all of the new/improved connections into the existing network (with HS2 phase 1 included). The result of this has been that, for example, East Riding of Yorkshire, with improved accessibility to Hull, has had its connection to London and the South East improved.
- 6.2.7 The improvements have been modelled as being fully developed in 2036, to be fully comparable with the other scenarios that have been modelled. Changes could (and would likely) be brought in earlier or later, and different components of the package arriving at different times. We are not concerned with these (and indeed the differences as a result would be less significant on the broad scale of this modelling, than the nature of the package as a whole).

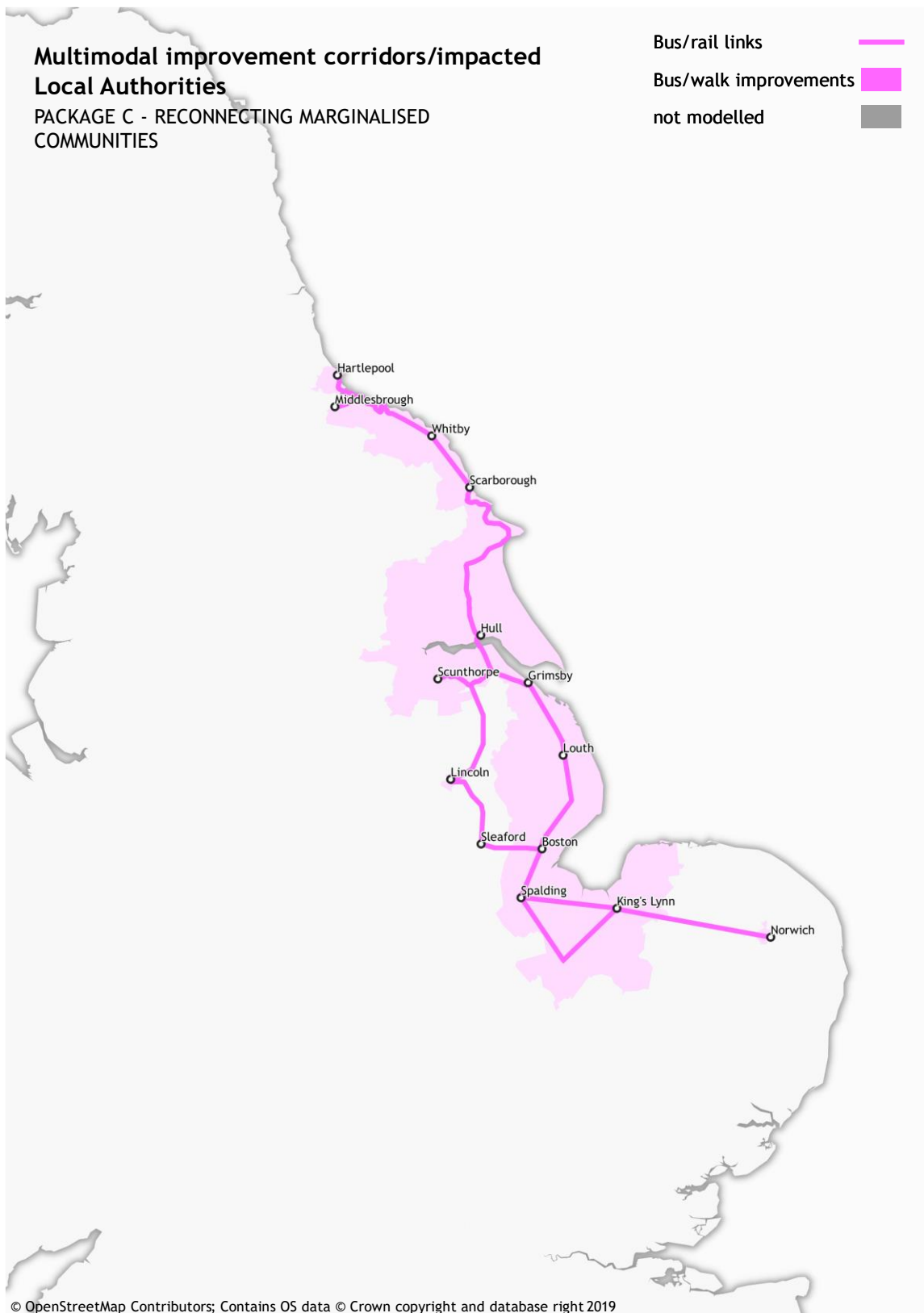


Figure 6-2 Local Authorities (model zones) with corridor improvements

Indicative travel time savings by rail

- 6.2.8 Figure 6-3 shows the travel time savings of improving the eastern corridor outlined above. ‘Rail’ here is intended to be a proxy for combined bus/rail improvements.
- 6.2.9 The map shows that there are large effects on short-distance travel times, transforming North-South connectivity locally. Additionally, we see some more widespread savings southwest.
- 6.2.10 As an example, the biggest improvements in rail times from Hull would be to a range of destinations across a large part of Southern England. These improvements are picked up via the interchange points to the South of Hull. The single biggest factor in this pattern is the opening of a cross-Humber rail link, which has the potential to save hours by opening a direct route south, rather than having to use an interchange with Doncaster, for example. Removing the requirement to travel via Doncaster could serve to improve journey times south by one hour, before any other improvements are considered.
- 6.2.11 The travel time savings are only an indication, as the methodology used here doesn’t account for complex multi-modal cases where one may use other means to cross the Humber.

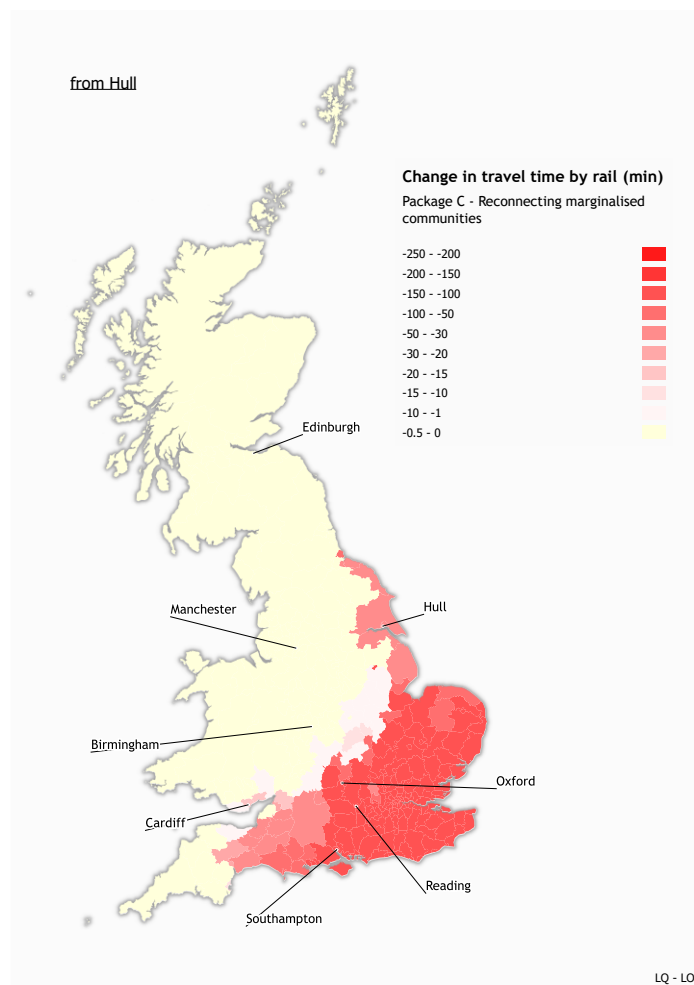


Figure 6-3 Indicative travel time savings by rail from Hull as a result of Package C

6.3 Results

Direct effects – accessibility impact

- 6.3.1 The maps in Figure 6-4 show the static accessibility impact for car-owners' business-to-business travel at national and local scales, and for non-car-owning commuters at the lowest socio-economic level. Like before, these static impacts show the direct, immediate effect of opening the package, and not the redistributive or other supply-demand related effects brought about in the years following. In other words, they give a good representation of what is affecting demographic and economic changes in the forecast.

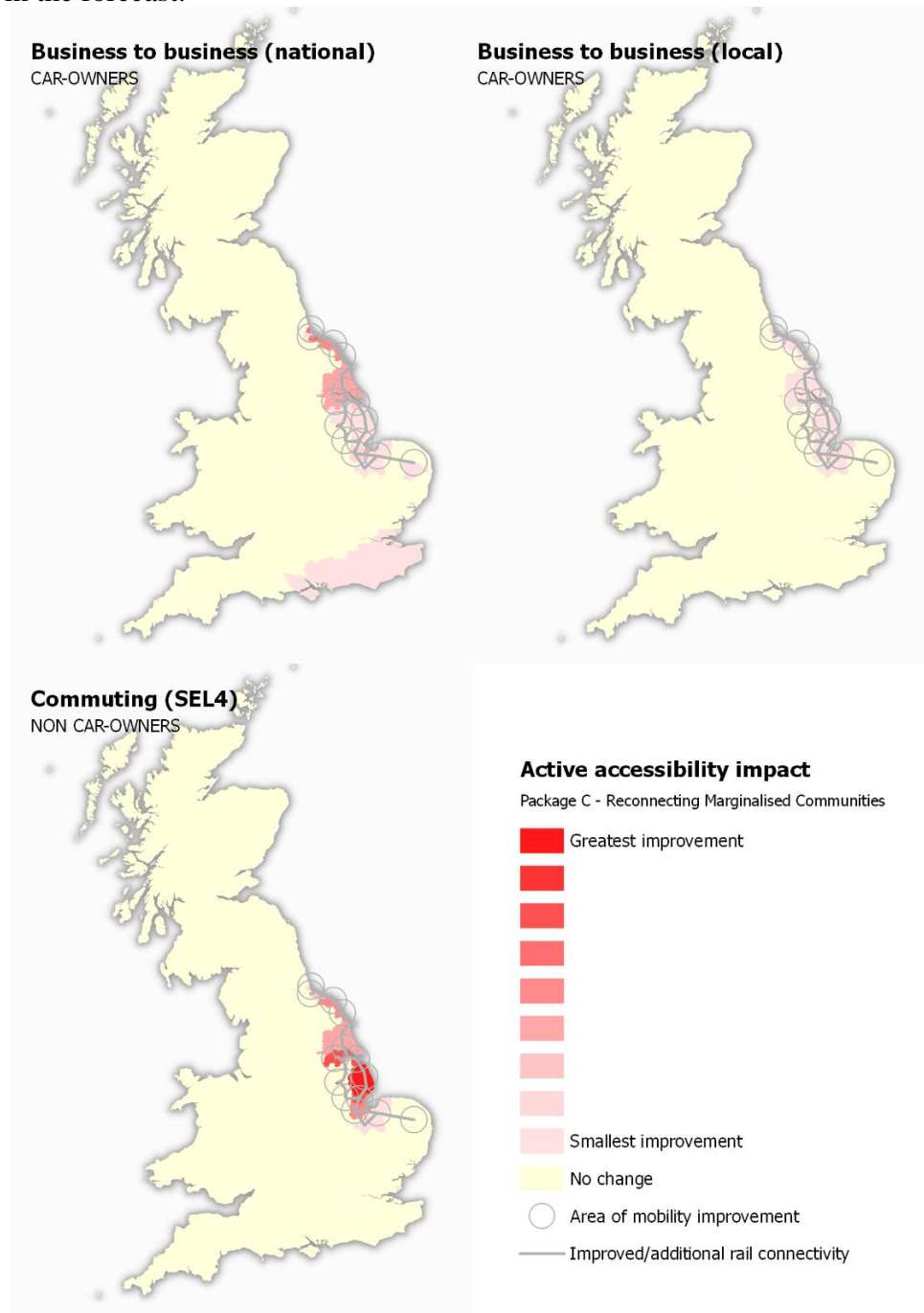


Figure 6-4 Maps of impact of reconnecting marginalised communities on accessibility

- 6.3.2 Looking at the national business-to-business impact, bringing the places along the eastern corridor ‘closer’ into the wider network by virtue of reducing travel times would not only benefit the corridor itself, but it could also have an impact on a band of Southern England stretching from the Solent to the Thames Estuary. The key impacts would be seen north of the Humber, stretching to Tyne and Wear.
- 6.3.3 Local business-to-business accessibility would also be improved, though the gains would be limited to the corridor itself, and relatively small. Improved local rail links only have a marginal local effect on the businesses located there, when rail remains uncompetitive as is the case here (with exceptions – e.g. across the Humber between Hull and North Lincolnshire, where the new rail link may become very significant).
- 6.3.4 On the other hand, commuting accessibility would dramatically improve, especially in the region between the Wash and the Humber. This is likely due to the improved ability of accessing the city of Lincoln and the towns of Boston, Grimsby and Scunthorpe, from Lincolnshire and from across the Humber.

Economic indicators

- 6.3.5 Employment remains broadly static when looked at in the aggregate over Great Britain (Table 6-1), with a modest improvement of around 600 (insignificant at the scale of the model). The improvement corridor gains an extra 30,000 jobs over time, which means that (owing to the minimal net impact) the rest of the North and South see slightly lower growth over time as a result of the package.

Table 6-1 Impact of reconnecting marginalised communities on employment

| Region | Scenario | 2011 | 2036 | 2061 | Change 2036 to 2061 | CAGR 2036 to 2061 |
|-----------------------------|----------|------------|------------|----------------|---------------------------|-------------------------|
| North | Base | 12,087,673 | 13,447,761 | 14,436,782 | 989,021 | 0.27% |
| | C | | | 14,418,580 | 970,818 | 0.27% |
| | Impact | | | -18,203 | | |
| South | Base | 14,874,114 | 17,241,030 | 18,699,795 | 1,458,765 | 0.31% |
| | C | | | 18,688,687 | 1,447,656 | 0.31% |
| | Impact | | | -11,108 | | |
| Improve ment corridor | Base | 927,220 | 997,598 | 1,049,847 | 52,249 | 0.20% |
| | C | | | 1,079,815 | 82,217 | 0.31% |
| | Impact | | | 29,968 | | |
| Great Britain | Base | 27,889,008 | 31,686,390 | 34,186,424 | 2,500,034 | 0.29% |
| | C | | | 34,187,081 | 2,500,691 | 0.29% |
| | Impact | | | 657 | | |

- 6.3.6 Figure 6-5 shows that the impacts to the corridor, and to the rest of Great Britain, are very steady over time, with a ramp from 2036 to 2046, and stability thereafter.
- 6.3.7 Looked at in isolation, the package would do very well for the corridor impacted.

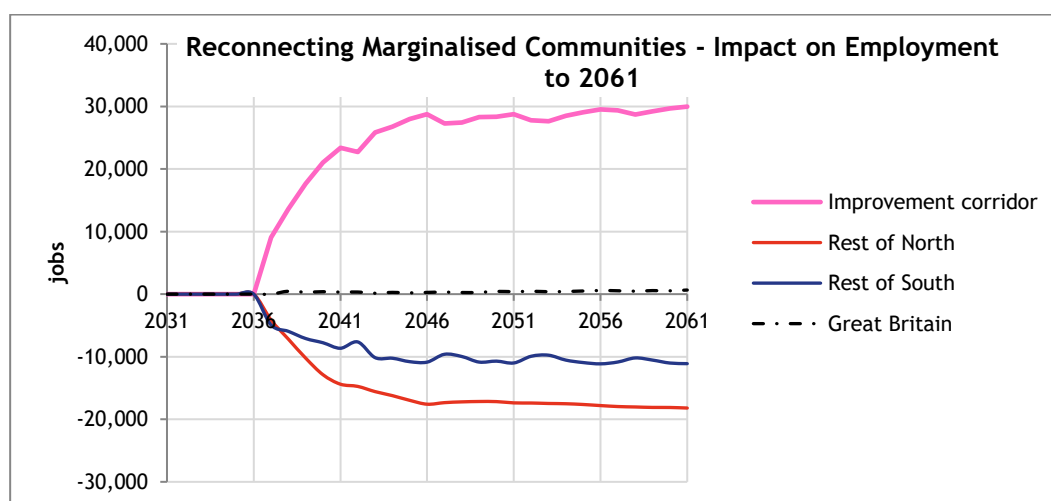


Figure 6-5 Impact of reconnecting marginalised communities on employment

- 6.3.8 The bulk of the redistribution of employment would be from areas bordering the corridor (Figure 6-6). Here, we see that by 2061, employment has increased by up to 9% along the corridor, where neighbouring areas see up to 0.5-1.0% reductions. The proportional changes mask the fact that included in the areas losing employment are other cities in the East Midlands, the built-up areas of the North East, and parts of South and West Yorkshire.
- 6.3.9 The map shows that there would be minimal redistribution within the Wider South East, and indeed, it appears as though employment rebalancing would take place, from areas to the West of the corridor and Norfolk, at the south/south-eastern extremity of the corridor. Gains are significant to the corridor.

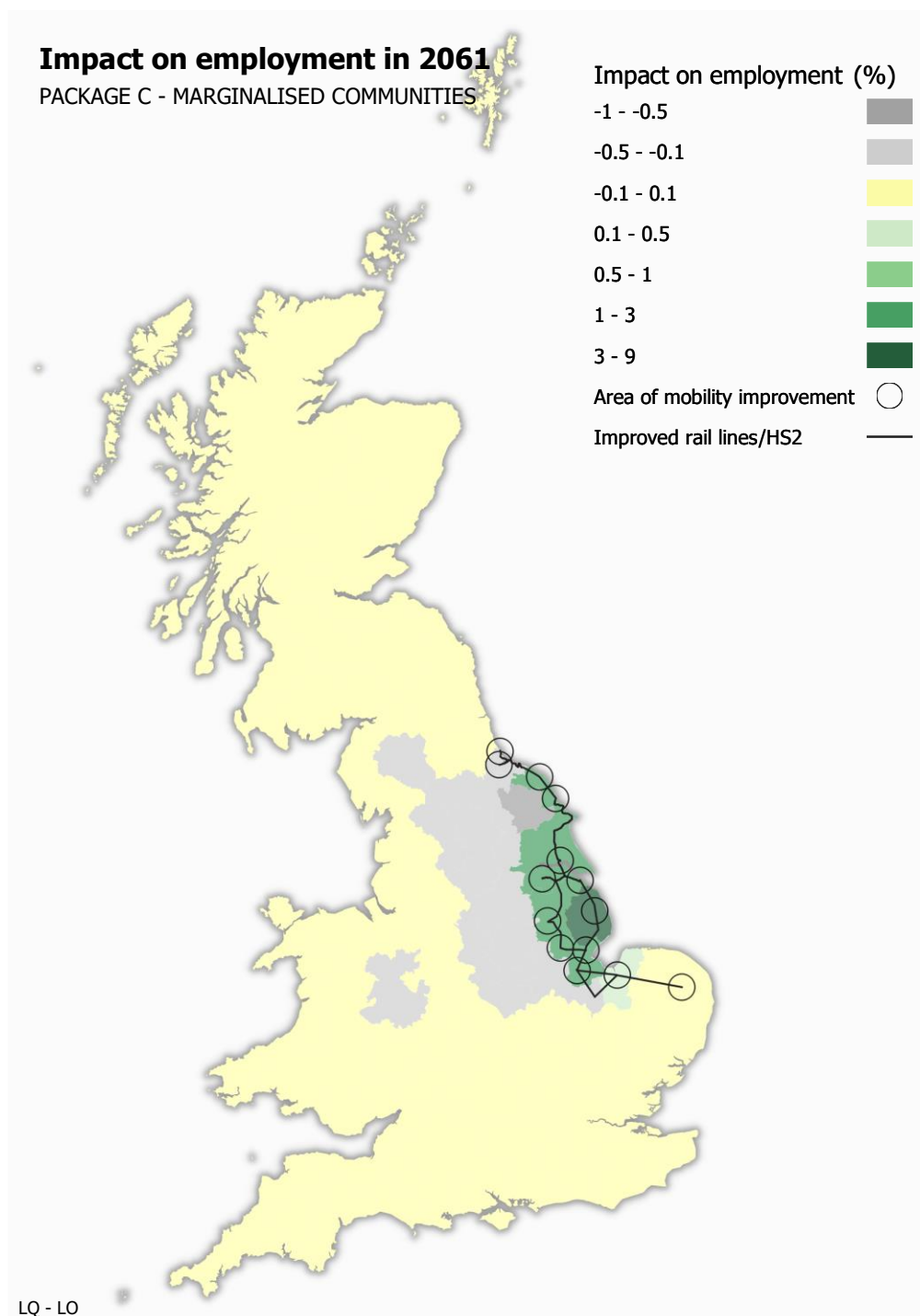


Figure 6-6 Map of impact of reconnecting marginalised communities on employment in 2061

6.3.10 In economic output terms (Table 6-2; Figure 6-7), the nationwide picture looks broadly the same compared with employment – though where employment gains would stabilise, the GVA would continue to grow with multiplier effects and more productive work.

6.3.11 There could be a marginal gain to GVA of £400mn overall; the net gain and redistributed output growth from the rest of GB results in the improvement corridor

improving by an extra £3B by 2061 – almost an extra 10% of GVA growth over time than without the package.

Table 6-2 Impact of reconnecting marginalised communities on GVA

| Region | Scenario | 2011 | 2036 | 2061 | Change 2036 to 2061 | CAGR 2036 to 2061 |
|----------------------|----------|-----------|-----------|---------------|---------------------|-------------------|
| North | Base | 490,825 | 765,757 | 1,234,236 | 468,479 | 1.85% |
| | C | | | 1,232,172 | 466,415 | 1.85% |
| | Impact | | | -2,064 | | |
| South | Base | 760,634 | 1,292,294 | 2,157,568 | 865,275 | 1.99% |
| | C | | | 2,156,758 | 864,464 | 1.99% |
| | Impact | | | -811 | | |
| Improvement corridor | Base | 38,425 | 56,523 | 88,082 | 31,559 | 1.72% |
| | C | | | 91,351 | 34,829 | 1.86% |
| | Impact | | | 3,269 | | |
| Great Britain | Base | 1,289,884 | 2,114,574 | 3,479,887 | 1,365,313 | 1.93% |
| | C | | | 3,480,281 | 1,365,707 | 1.93% |
| | Impact | | | 394 | | |

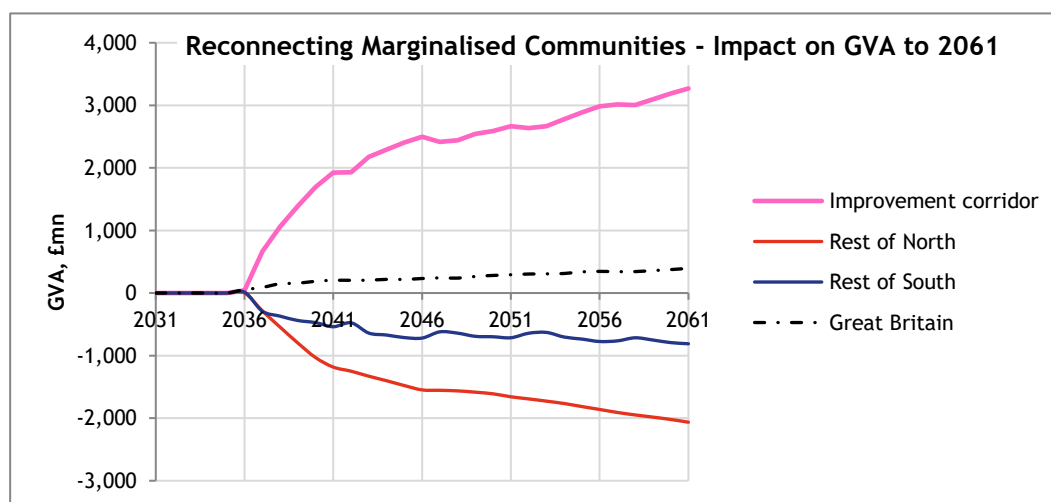


Figure 6-7 Impact of reconnecting marginalised communities on GVA

6.3.12 The spatial distribution of GVA gains (Figure 6-8) would be concentrated largely in the corridor and at its periphery. The areas gaining in employment would all also increase in output; this indicates a significant rebalancing of growth in employment and output towards the improvement corridor.

6.3.13 An interesting finding is that improving connectivity both within and to the corridor (chiefly with links to Lincoln, Hull, Peterborough and Norwich) would boost growth across Norfolk and London – and the corridor in between – and Berkshire. The connectivity facilitates the London/WSE economy by virtue of easing the logistical flows between the region and its satellites, from which some inputs originate. This is a demonstration of the outsize advantage London has in interregional connectivity improvements (speaking in absolute terms).

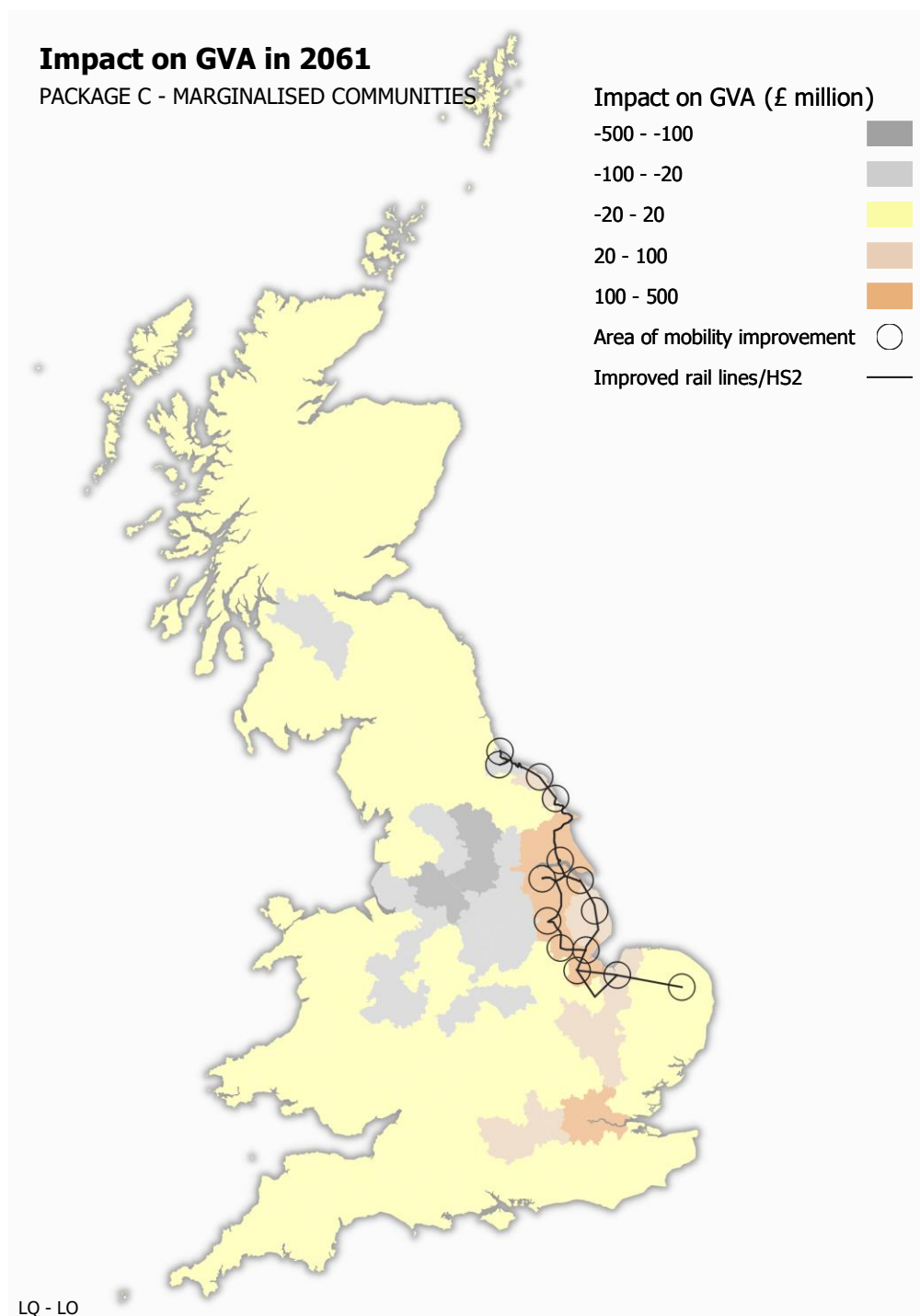


Figure 6-8 Map of impact of reconnecting marginalised communities on GVA in 2061

Demographic indicators

6.3.14 The regional impact on households – which is purely redistributive owing to consistent rest-of-world (and rest-of-UK) migration between scenarios – is shown in Table 6-3 and Figure 6-9.

6.3.15 What we see is that the potential overall population growth increases in the corridor – by almost 22,000 – to 215,000 from 195,000. The majority of this growth is redistributed from the rest of the North; a quarter is from the rest of the South.

Table 6-3 Impact of reconnecting marginalised communities on population

| Region | Scenario | 2011 | 2036 | 2061 | Change 2036 to 2061 | CAGR 2036 to 2061 |
|----------------------|----------|------------|------------|----------------|---------------------|-------------------|
| North | Base | 27,009,976 | 31,083,825 | 34,290,538 | 3,206,713 | 0.38% |
| | C | | | 34,273,071 | 3,189,247 | 0.38% |
| | Impact | | | -17,467 | | |
| South | Base | 31,145,730 | 35,588,452 | 38,999,458 | 3,411,007 | 0.35% |
| | C | | | 38,995,407 | 3,406,955 | 0.35% |
| | Impact | | | -4,051 | | |
| Improvement corridor | Base | 2,110,262 | 2,507,520 | 2,702,049 | 194,530 | 0.29% |
| | C | | | 2,724,005 | 216,485 | 0.32% |
| | Impact | | | 21,955 | | |
| Great Britain | Base | 60,265,968 | 69,179,796 | 75,992,046 | 6,812,250 | 0.36% |
| | C | | | 75,992,483 | 6,812,687 | 0.36% |
| | Impact | | | 437 | | |

6.3.16 The graph suggests that the majority of changes in households are from areas across the North, rather than the South.

6.3.17 Something that is suggested by the relative scale of potential population and employment increases in the corridor is that many of the job opportunities resulting from the scheme would be served by people in the corridor. In other words, *the scheme appears to directly address issues of unemployment and the challenge of bringing households back into work.*

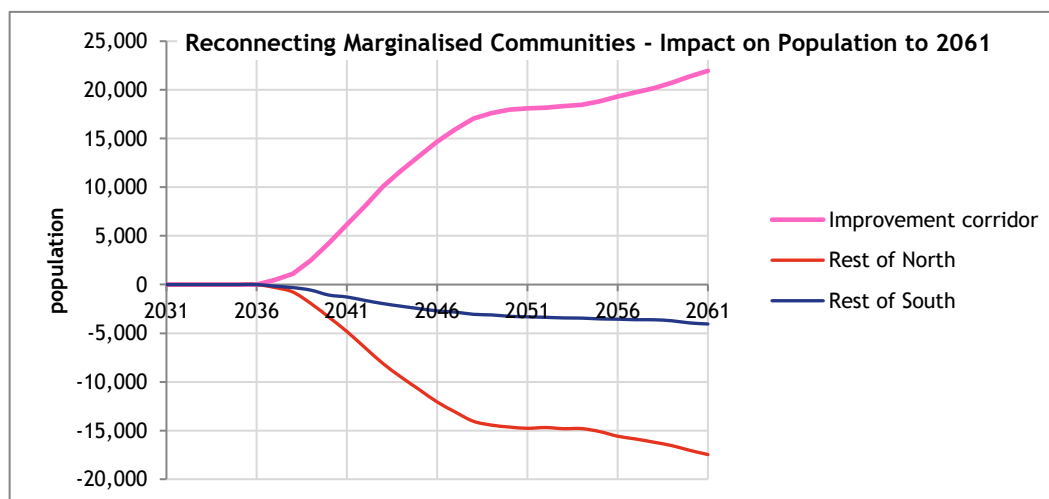


Figure 6-9 Impact of reconnecting marginalised communities on population

6.3.18 The map in Figure 6-10 shows how the impacts are distributed spatially by the end of the forecast. The most significant potential gains are to the portion of the corridor in the Midlands (between the Wash and the Humber) – which is also where the

greatest impact to commuters would be expected. It is unclear from the map whether all the changes in households in the Wider South East are focused in Norfolk, or if they are in the London area. What is clear, though, is that there are substantial percentage gains in Lincolnshire, which is a key area targeted by the package.

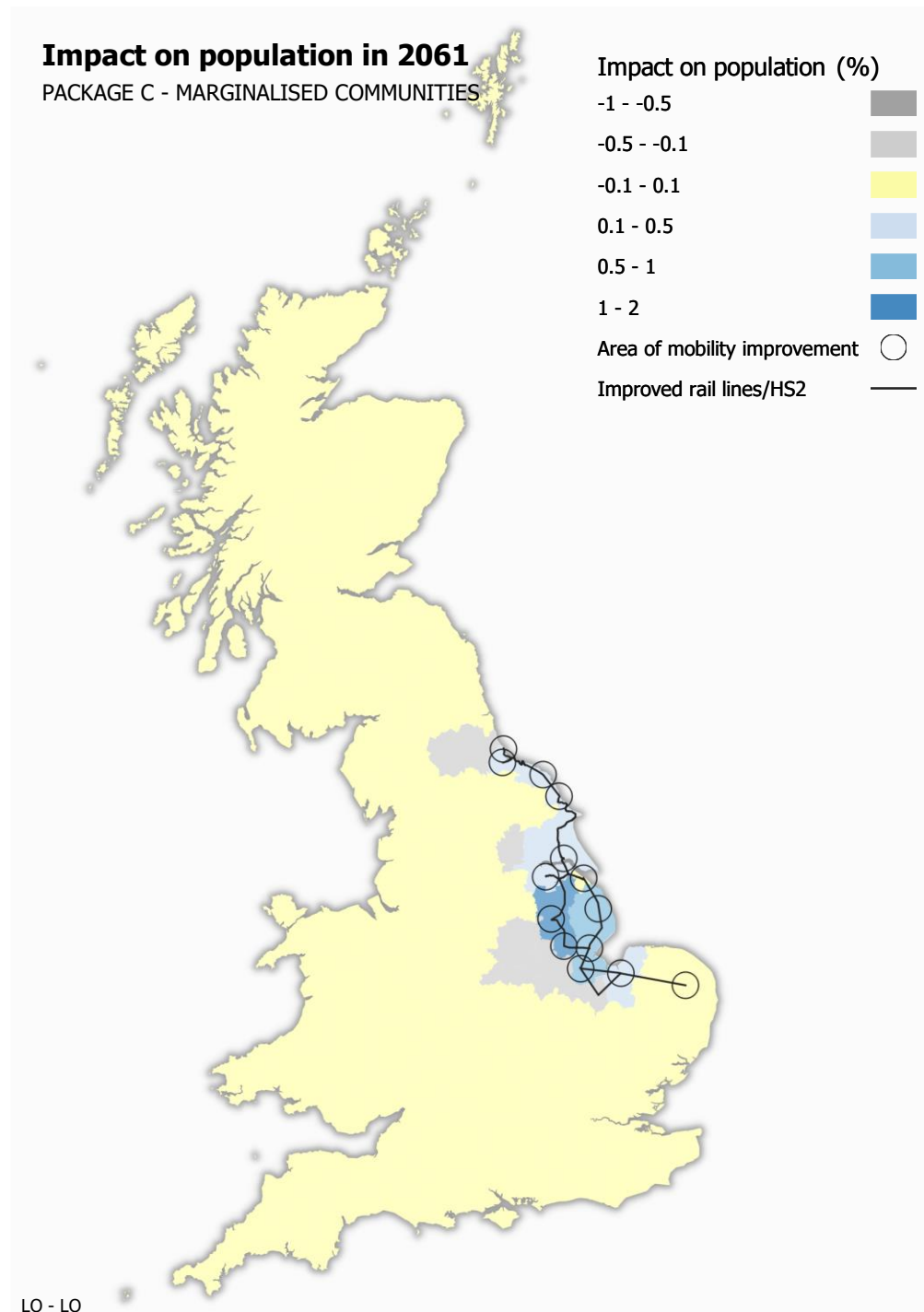


Figure 6-10 Map of impact of reconnecting marginalised communities on households in 2061

6.4 Conclusion

- 6.4.1 Connecting the marginalised communities along the corridor that stretches from Norwich, northwards to Newcastle-upon-Tyne could have a significant regional impact. The number of households in the corridor region could increase greatly, benefiting from a greater degree of accessibility. This would be coupled with more opportunities for employment in the area. The productivity of the improved areas would increase resulting in higher GVA.
- 6.4.2 Accessibility would increase most significantly where existing infrastructure and accessibility are at their worst – in East Lindsey and North East Lincolnshire. But despite the potential effects of the scheme being mostly local in their nature, connections with existing rail interchanges – for instance at Lincoln and Peterborough – could extend the influence on business further south, into London and the South East. This effect seems to have a slightly positive effect in London, owing to its built-in advantage. A minute of improvement there is worth more, in terms of access to opportunities, than a minute in Lincoln.
- 6.4.3 Due to the outsize competitiveness of London compared with the improvement corridor, it is possible that the scheme may have more effect on a national scale, provided its connections with the existing network were more numerous and further inland.
- 6.4.4 The results suggest that a transport connectivity package of the form modelled here might impact significantly on marginalised communities within the corridor, and have the particularly beneficial effect of bringing those within the corridor (back in) to work. A limitation to this representation is that it views the package as occurring in isolation. What is a reality, and what the Commission is arguing for, is a whole-UK (or GB, as modelled here) approach to connectivity – so if this package were bundled with others, we would not expect to see the same benefit (if any at all).

7 CONNECTIVITY REVOLUTION

7.1 Rationale and context

- 7.1.1 Up to this point, we have examined, separately, the three principles of UK2070's vision for a connectivity revolution to rebalance the United Kingdom: connecting cities to one another with high-speed rail and improved last-mile connections; improving mobility within those very same cities and urban areas; and reconnecting marginalised communities at the peripheries.
- 7.1.2 In this section, we explore the impact of a joined-up approach that combines these core principles into a single package, assessing the impact of the whole instead of viewing each in isolation.

7.2 Modelling approach

- 7.2.1 The approach used in combining the packages has followed the same method for each, summarised here. Refer to the map in Figure 7-1 for a representation of all the improvements included.

Improving intercity connectivity

- 7.2.2 Seven key East-West rail corridors identified by Greengauge21 and the Commission have been improved such that, in general, connections between the stations are on a par with the connectivity of those cities with London. HS2 phases 2a and 2b (extending HS2 from Birmingham to Crewe, Manchester and Leeds) have also been included. Farther afield, model zones which interchange with the improvement corridors also see those gains, provided travelling via the interchange offers an improvement. It is accepted that a fully developed national transport strategy would include other elements in the intercity network for improvement.

Improving intraurban mobility

- 7.2.3 The zones within the seven East-West rail corridors have also received improvements to the bus mode in the form of increases in speed of 20% and a reduction in mean waiting time from 15 minutes to 10 minutes. These improvements are intended to simulate the potential accessibility gains LRT/metro/BRT schemes may bring, at the scale of an urban area.
- 7.2.4 Additionally, to simulate the incentive effect of public realm and air quality improvements, alongside efficiency gains from intelligent transport systems (e.g. variable signalling at junctions to allow for enhanced flows) and/or decreased intraurban vehicle flows, walk speeds have been increased from an average of 5km/h to 6km/h within the same zones.

Reconnecting marginalised communities

- 7.2.5 Along the coastal belt from the Norwich to Teesside, a multimodal scheme incorporating bus and rail elements has been modelled. The rail mode between zones in this corridor has been improved, with frequencies increasing from one train every

three-to-four hours to one every two; speeds increased from 50km/h to 60km/h on average; and access/egress distances halving from 20km to 10km.

- 7.2.6 The bus mode has been improved such that speeds increase by 20% and waiting times decrease from 15 minutes average to 10 minutes, while the speed of the walking mode (though inconsequential over the distances along the corridor) has also been improved by 20%, from 5km/h to 6km/h.
- 7.2.7 These improvements together simulate the expansion of flexible, express bus services, alongside the reopening/construction of important strategic rail links – most notably, a cross-Humber link, bridging the gap between Hull to the North and Scunthorpe and Grimsby to the South.

Combining rail packages using hubs

- 7.2.8 The rail improvement corridors improving intercity connectivity and reconnecting marginalised communities have been combined into a single package. This package has been linked into the base network, such that any existing origin-destination pair may benefit from an improvement via interchange.
- 7.2.9 The rest of the improvements – those to bus and to walk – have been modelled without direct interchange improvements, since each origin-destination generalised cost is calculated using the straight-line distance between zones.
- 7.2.10 The combined package is modelled as being completed in 2036 – the same year HS2 is modelled as complete. As with other packages, this simplifies analysis and removes complexity around the phasing of different schemes.
- 7.2.11 In totality, the combined package provides one representation of a joined-up, pan-national UK transport network.

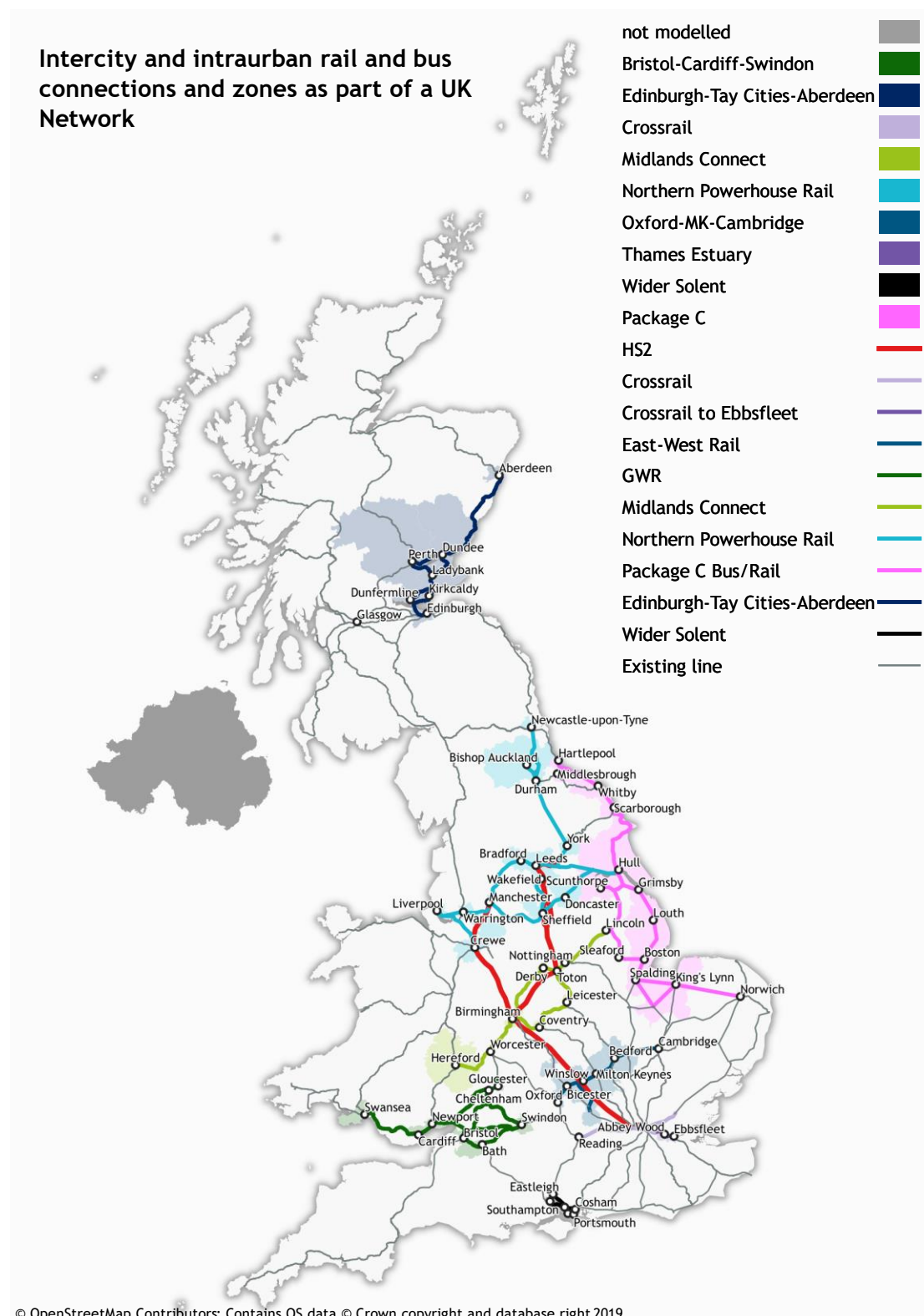


Figure 7-1 Improvement corridors and areas - UK Network⁶

⁶ NB Reading and Glasgow are shown but see no direct improvement.

Indicative travel time savings

- 7.2.12 Figure 7-2 shows the potential travel time savings of the UK Network compared with the base scenario. The savings are shown from eight different urban areas to all other zones in the model. Reading is used as an example of a non-improved interchange hub.
- 7.2.13 Of the cities shown, Hull could see by far the most significant impacts. Travel time savings of up to 250 minutes are possible to almost all zones in the model, as a result of increases in speeds and connectivity. The package would allow those travelling from Hull access to HS2, or more direct and vastly quicker routes into London and onto connecting lines. The savings are a result of improving connectivity on all sides, including over two estuarial crossings.
- 7.2.14 Oxford (and by extension, likely the rest of the CaMKOx corridor) could see significant improvements via connectivity in all directions, but appears to gain especially from its links with Birmingham (interchanging to the North) and Reading (interchanging to the West). As a result, connections across the North could be impacted quite significantly, with the main benefits being to the previously disconnected eastern corridor.
- 7.2.15 The other cities could see broadly similar time savings to other parts of the country. It appears the most beneficial improvements are to the Edinburgh-Tay Cities-Aberdeen axis, the eastern improvement corridor, and to South and West Wales.

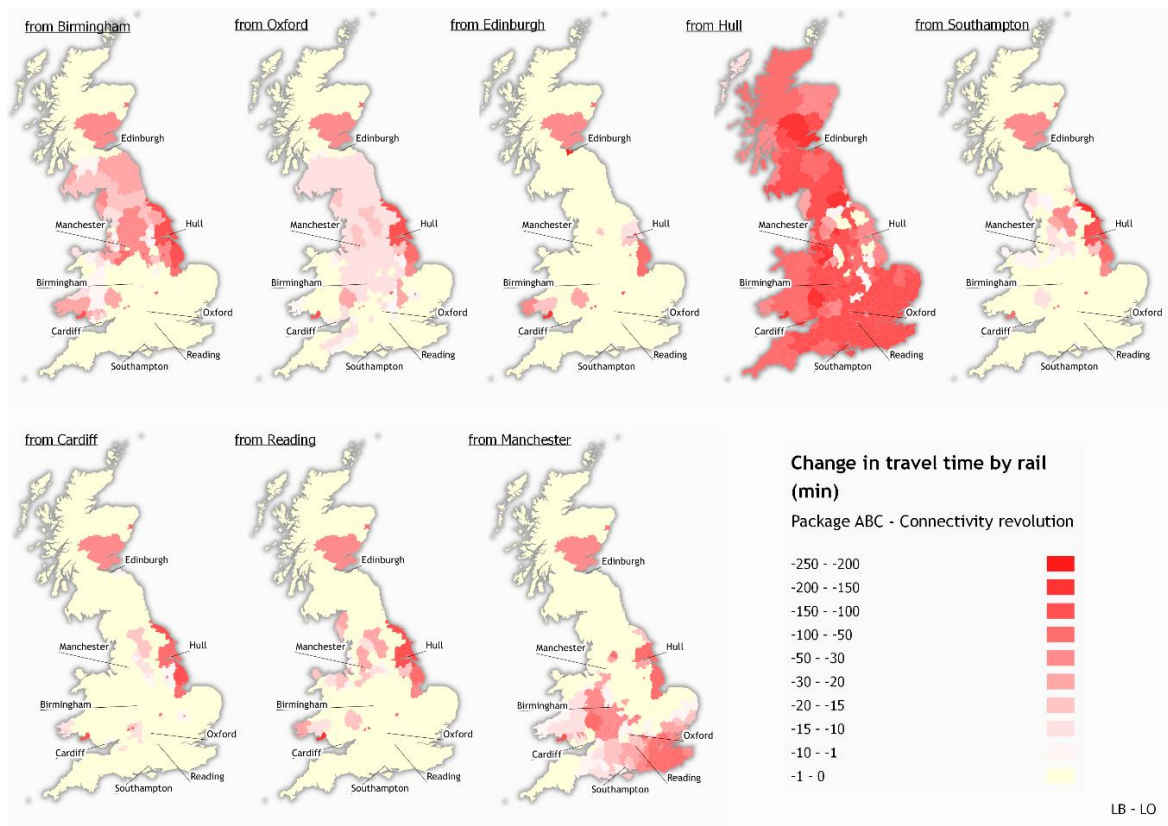


Figure 7-2 Indicative travel time savings by rail from a Connectivity Revolution

7.3 Results

Direct effects - accessibility impacts

- 7.3.1 Accessibility can be regarded as how easy it is to reach opportunities (be they places of work, educational institutions or shops) from a given point – otherwise known as ‘active’ accessibility; or conversely, how easily a given place can be reached by those who may wish to – known as ‘passive’ accessibility. Within the land-use-transport nexus, accessibility is a key determinant of the spatial distribution of activity. This comes about due to the spatial separation of firms doing business with other firms; people in households seeking out or travelling to work; and producers shipping goods to consumers or other, secondary producers.
- 7.3.2 The maps in Figure 7-3 show the modelled active accessibility impacts in the package’s year of opening, for car-owners’ business-to-business travel at local and national scales, and non-car-owning commuters at the lowest socio-economic level. The maps give a good representation of the immediate drivers of the impacts to indicators examined in the rest of this section.

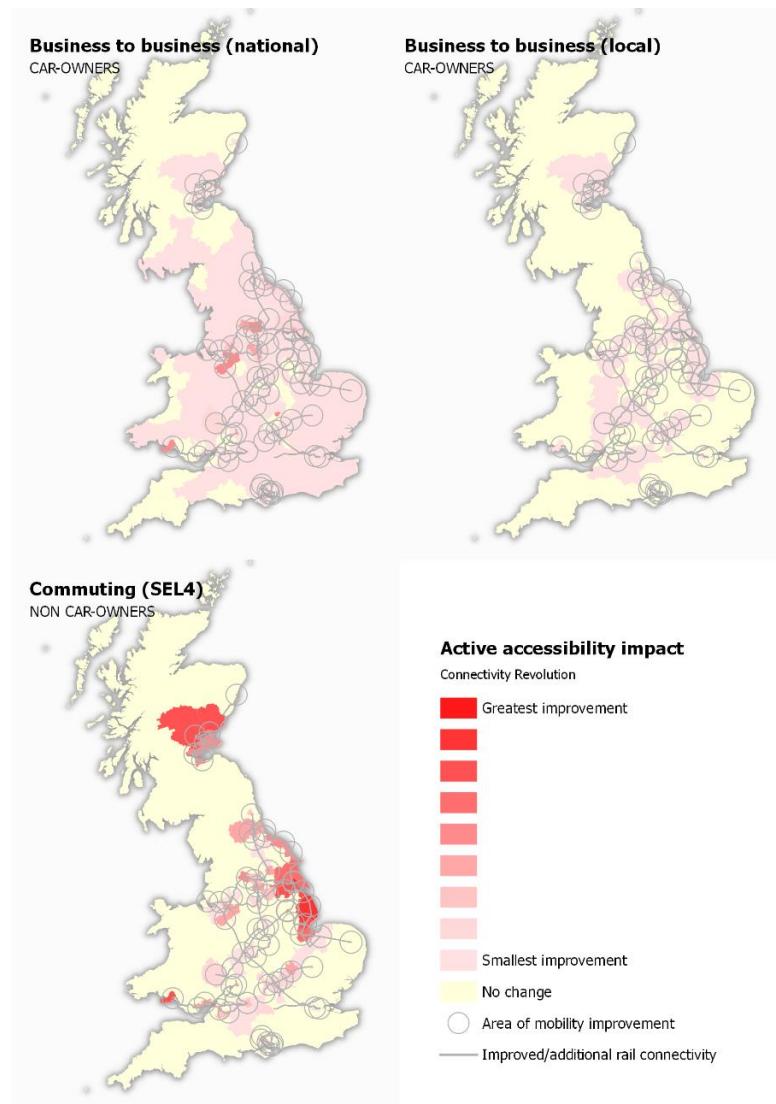


Figure 7-3 Maps of impact of connectivity revolution on accessibility

- 7.3.3 National business-to-business accessibility is most significantly impacted in the cities connected directly to HS2 phase 2. Other potential impacts are less significant but highly widespread, reflecting the far-reaching effects of the connectivity package. The marginalised eastern corridor has been connected into the network to allow for a notable possible improvement in accessibility here.
- 7.3.4 Local business-to-business accessibility gains would likely be exclusively within the improvement corridors, and perhaps most marked in the North and the eastern improvement corridor. Overall, the potential gains are less than those for national business, and for commuters (though this is in part a reflection of the tendency to travel via car for business travel).
- 7.3.5 Commuters would likely see the greatest impacts in the Tay City region, in the eastern improvement corridor, and across the CaMKOx corridor. Additionally, there would be expected to be gains in the Wider Solent region (slightly obscured), which would spread northwest towards Salisbury and Bath/Bristol.

- 7.3.6 The potential direct accessibility impacts are at their greatest where public transport figures less in the current mix, opening up the opportunity for greater improvements farther afield. The indirect/interchange impacts follow the opposite pattern, where higher public transport accessibility enables more of a knock-on effect. This couples with the greater propensity for longer-distance rail travel than any other mode, particularly for business.

Economic indicators

- 7.3.7 Overall rebalancing impacts of employment in northern/southern Britain are shown in the Table 7-1.

Table 7-1 Impact of Connectivity Revolution on employment

| Region | Scenario | 2011 | 2036 | 2061 | Change 2036 to 2061 | CAGR 2036 to 2061 |
|---------------|----------|------------|------------|----------------|---------------------------|-------------------------|
| North | Base | 12,660,730 | 14,057,665 | 15,073,614 | 1,015,950 | 0.27% |
| | ABC | | | 15,117,503 | 1,059,838 | 0.28% |
| | Impact | | | 43,888 | | |
| South | Base | 15,228,278 | 17,628,725 | 19,112,810 | 1,484,085 | 0.31% |
| | ABC | | | 19,076,691 | 1,447,967 | 0.30% |
| | Impact | | | -36,118 | | |
| Great Britain | Base | 27,889,008 | 31,686,390 | 34,186,424 | 2,500,034 | 0.29% |
| | ABC | | | 34,194,194 | 2,507,805 | 0.29% |
| | Impact | | | 7,770 | | |

- 7.3.8 The main takeaways from the regional impacts of the scheme are:
- 8,000 additional jobs are created across Britain by 2061;
 - All of the net gain to employment is seen in the North, which sees an additional 44,000 jobs by 2061 compared with the base scenario;
 - 36,000 fewer jobs are created over time in the South – this is owing to higher jobs growth in the North – though there is still forecast growth here of 1.448mn jobs between 2036 to 2061.
- 7.3.9 The temporal impact on employment is shown in Figure 7-4. The possible gains to employment growth in the North occur rapidly in the decade following the package opening, before plateauing at 44,000 jobs over the base scenario.

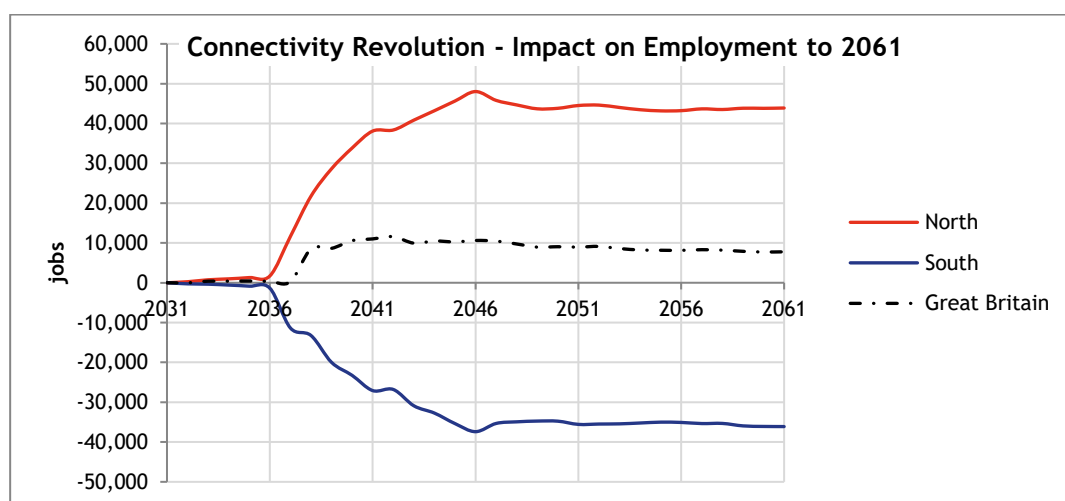


Figure 7-4 Impact of connectivity revolution on employment

- 7.3.10 In Figure 7-5 we see the spatial distribution of the employment impacts by macrozone (housing market area/travel to work area). It appears that almost the entirety of Great Britain would see some change, whether positive or negative. The area that would be expected to gain the most, proportionally, is Northamptonshire and the CaMKOx corridor. Elsewhere, the largest of potential gains are centred around the Liverpool-Crewe and Leeds-Sheffield axes; at the extremities of the eastern improvement corridor; in the Wider Solent; and around the Great Western Powerhouse region. The entire corridor south of Aberdeen could gain through redistribution from other parts of Scotland.
- 7.3.11 Overall, the growth gains appear to be in more central areas. For instance, Hull would likely see little employment impact (or its gains are counterweighed by East Riding's losses), with the Northern impacts being clustered primarily in the Leeds-Bradford urban area, and along the Liverpool-Crewe axis. Similarly, the East-West rail improvement would have a significant impact between Bicester and Bedford (i.e. along the central/western part of the corridor, as opposed to at the extremities). In Wales, impacts are clustered within the Greater Cardiff area; in the South West, potential impacts are very firmly clustered around the Bristol-Cheltenham-Gloucester-Swindon areas.
- 7.3.12 The spatial profile follows closely that seen when only the intercity links were improved. An exception is the eastern improvement corridor, which sees the potential for up to a 0.5% gain to employment growth over time – this compares with lower growth in either of Packages A and B, and much higher growth in Package C. This shows how intra- and inter-regional interdependencies can positively or negatively impact an area, and affirms the need to look at schemes in a holistic rather than isolated way.

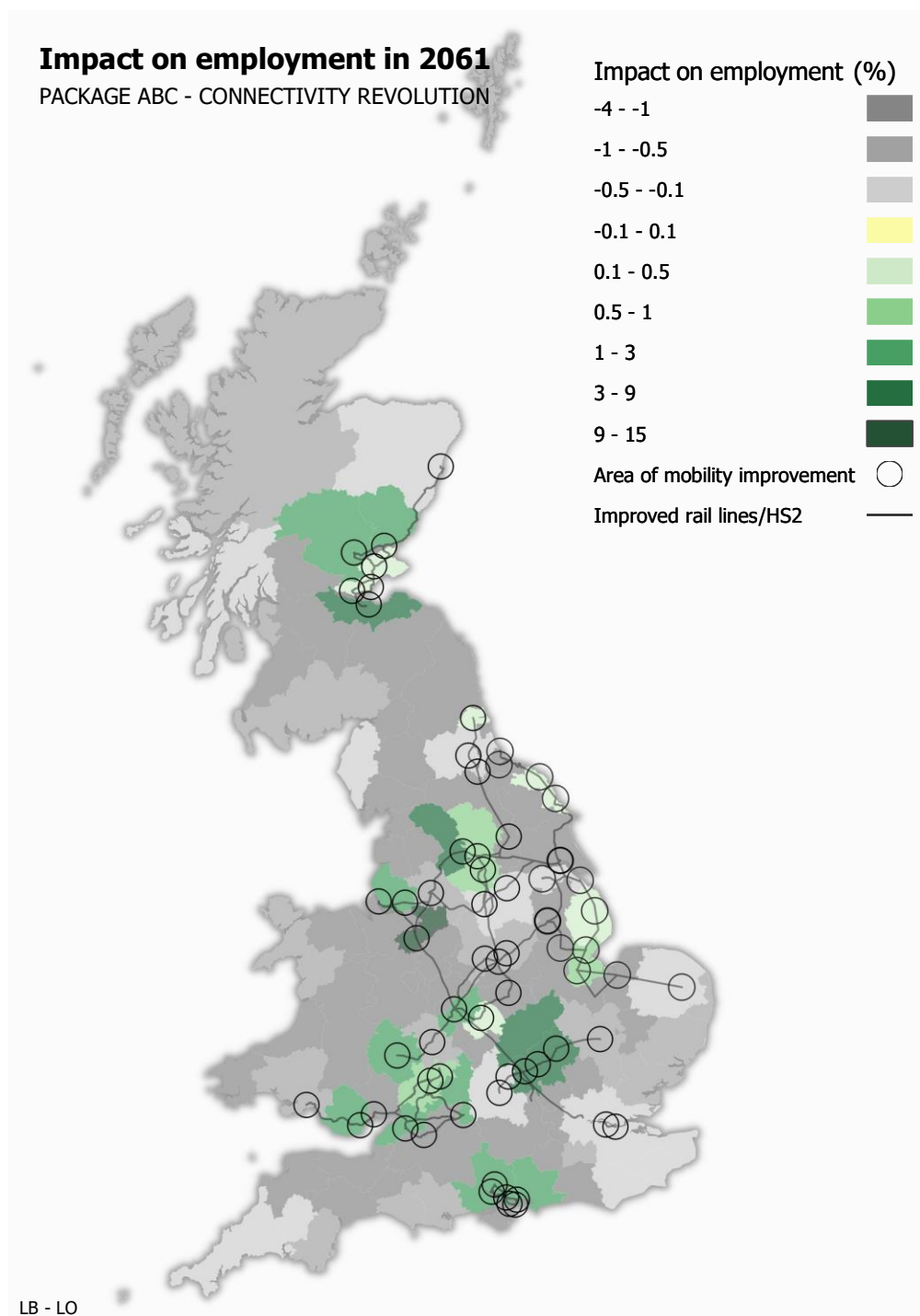


Figure 7-5 Map of impact of connectivity revolution on employment in 2061

7.3.13 Table 7-2 shows the overall impact of the Connectivity Revolution on GVA. The key takeaways from this are that:

- Britain overall could gain £6.7B in GVA growth over time;
- This would be distributed mostly to the North, which sees an extra £4.7B GVA growth;

- That compares to an extra £2B for the South (which is despite an overall lower rate of growth in employment).

Table 7-2 Impact of Connectivity Revolution on GVA

| Region | Scenario | 2011 | 2036 | 2061 | Change 2036 to 2061 | CAGR 2036 to 2061 |
|---------------|----------|-----------|-----------|--------------|---------------------|-------------------|
| North | Base | 514,493 | 800,112 | 1,287,117 | 487,005 | 1.85% |
| | ABC | | | 1,291,831 | 491,719 | 1.86% |
| | Impact | | | 4,714 | | |
| South | Base | 775,392 | 1,314,462 | 2,192,770 | 878,308 | 1.99% |
| | ABC | | | 2,194,739 | 880,277 | 1.99% |
| | Impact | | | 1,969 | | |
| Great Britain | Base | 1,289,884 | 2,114,574 | 3,479,887 | 1,365,313 | 1.93% |
| | ABC | | | 3,486,570 | 1,371,997 | 1.94% |
| | Impact | | | 6,684 | | |

7.3.14 Figure 7-6 shows the impact on GVA output over time. The gains are immediate and the ramp in growth is most significant in the North. It appears that there is a multiplier effect driving growth in the South after 2046.

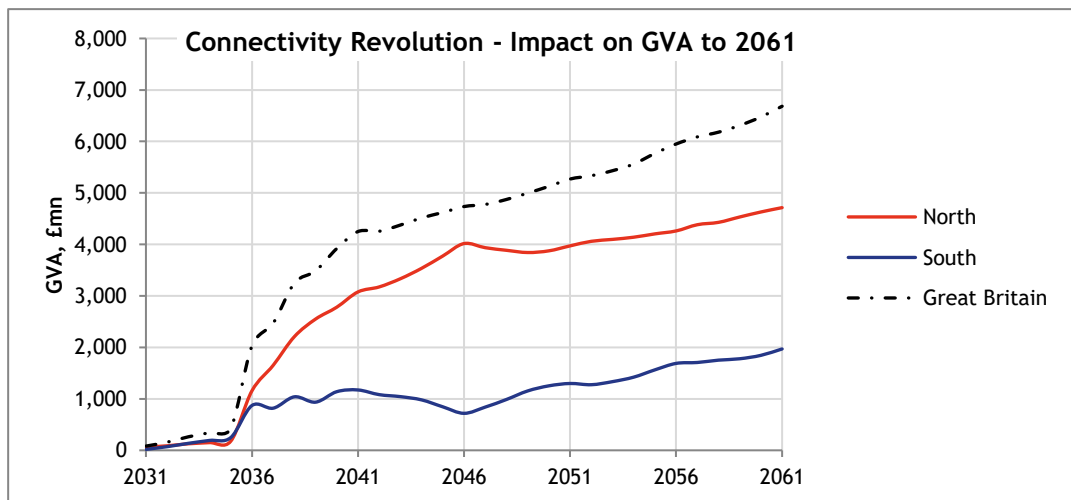


Figure 7-6 Impact of connectivity revolution on GVA

7.3.15 The spatial distribution of GVA gains by 2061 is shown in Figure 7-7. Output is likely to increase in most of the areas which see transport improvements. There are two expected inter-regional growth areas: one spans South Wales to the South West and into the Midlands and South East; the other sees potential gains from HS2 in Manchester distributed more evenly around the North, to Leeds, Bradford, Wakefield, Sheffield, Doncaster and Liverpool, and spreads slightly further south into Derbyshire, Lincolnshire and (East) Cheshire. The Tay Cities corridor sees substantial growth potential in GVA, especially in Lothian.

7.3.16 The distribution of potential gains suggests that, by and large, the biggest economic gains are expected in areas that already have large economies. Most significant of which is London, which could see a substantial gain in GVA growth despite seeing

lower overall employment growth than in the base. This gives weight to the notion that there is an in-built advantage in many of these places.

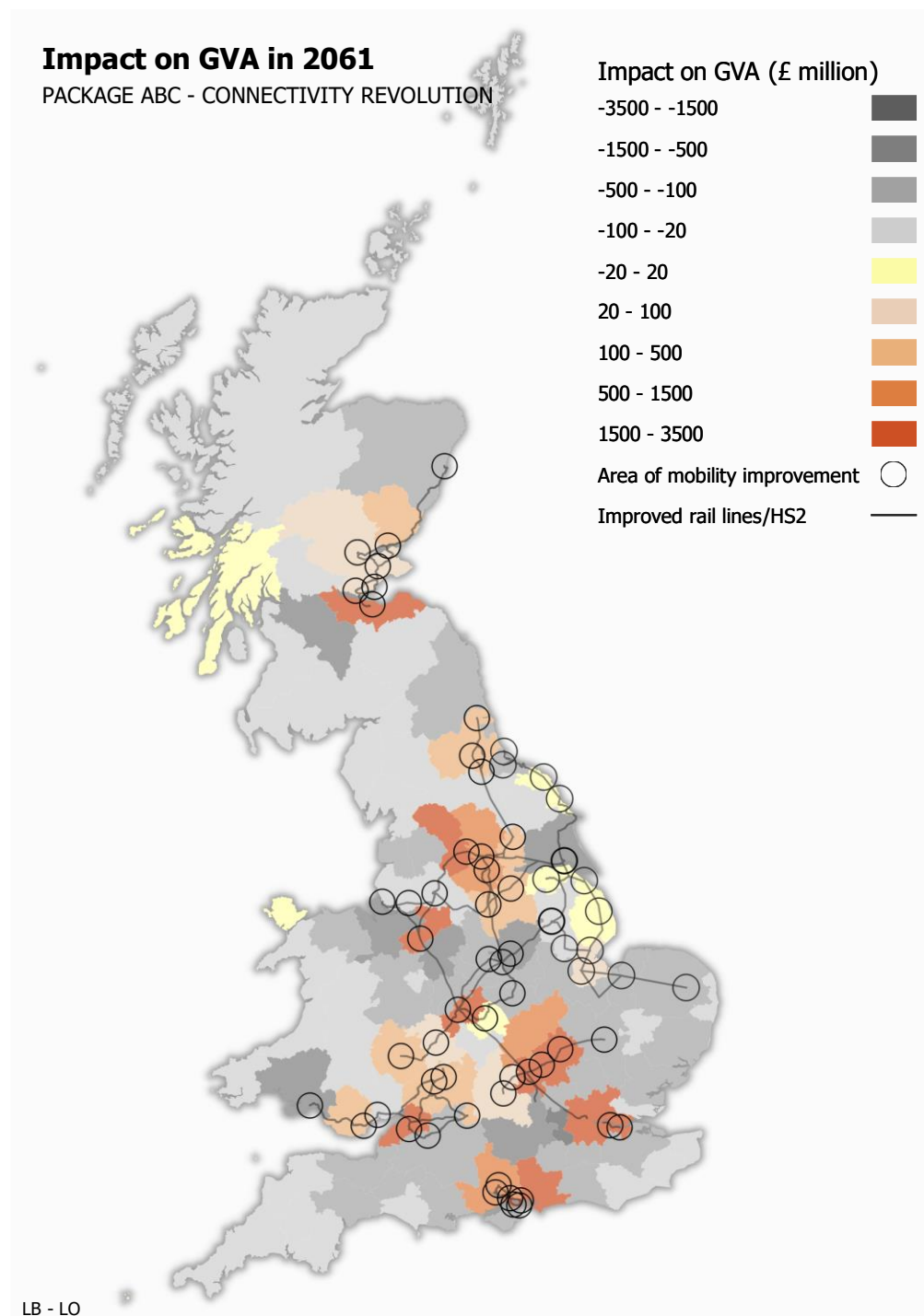


Figure 7-7 Map of impact of connectivity revolution on productivity in 2061

Demographic indicators

7.3.17 Table 7-3 shows the impact on population over time over the North and South. Demographic scenarios are constant between the two scenarios, so any deviation from the overall figure should be regarded as rounding error.

7.3.18 The rebalancing of population as a result of the package is 38,000 from South to North – notably lower than the rate of increase in employment of 44,000, which implies a net reduction in people out of work in the North.

Table 7-3 Impact of Connectivity Revolution on population

| Region | Scenario | 2011 | 2036 | 2061 | Change 2036 to 2061 | CAGR 2036 to 2061 |
|--------|----------|------------|------------|----------------|---------------------|-------------------|
| North | Base | 28,380,907 | 32,663,381 | 36,002,917 | 3,339,536 | 0.38% |
| | ABC | | | 36,040,994 | 3,377,613 | 0.38% |
| | Impact | | | 38,076 | | |
| South | Base | 31,885,061 | 36,516,415 | 39,989,129 | 3,472,713 | 0.35% |
| | ABC | | | 39,951,572 | 3,435,156 | 0.35% |
| | Impact | | | -37,557 | | |

7.3.19 Figure 7-8 shows the expected regional impact over time on households. The increasing rebalancing in population from the South to the North takes place gradually over time, with a faster pace initially to serve the growing employment numbers. Whereas employment figures plateau, population would continue to flow into the North until the end of the forecast.

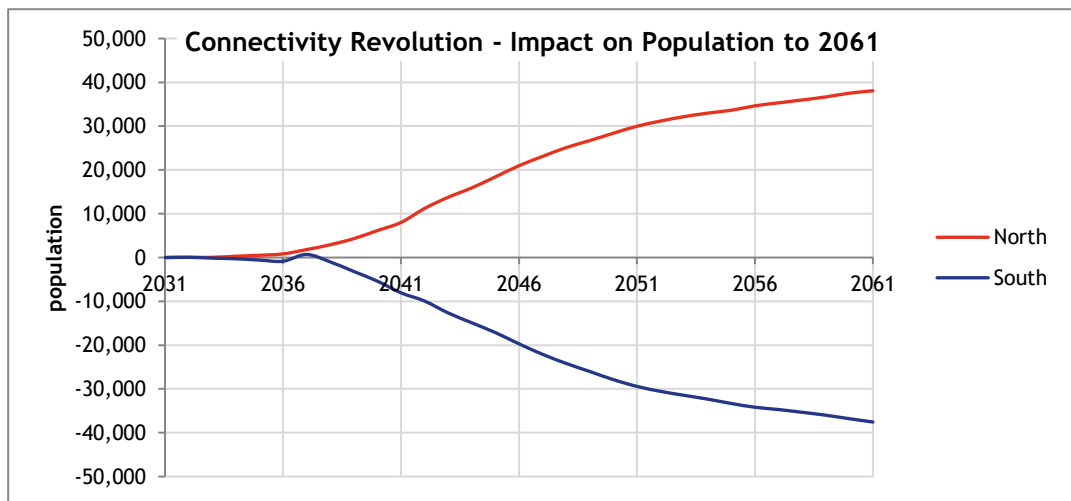


Figure 7-8 Impact of connectivity revolution on population

7.3.20 Figure 7-9 is a map of household change by 2061, by macrozone (housing market/travel to work area). The distribution follows that of employment impacts quite closely – aside from in Swansea, and the entire eastern improvement corridor. These areas see potential gains in households despite some expected reductions in that rate of growth in employment, suggesting they are benefitting from the additional ease of travelling to work in other areas. This may also suggest benefits from enhanced wellbeing (in the economic sense) as a result of easier access to employment, and lower rents.

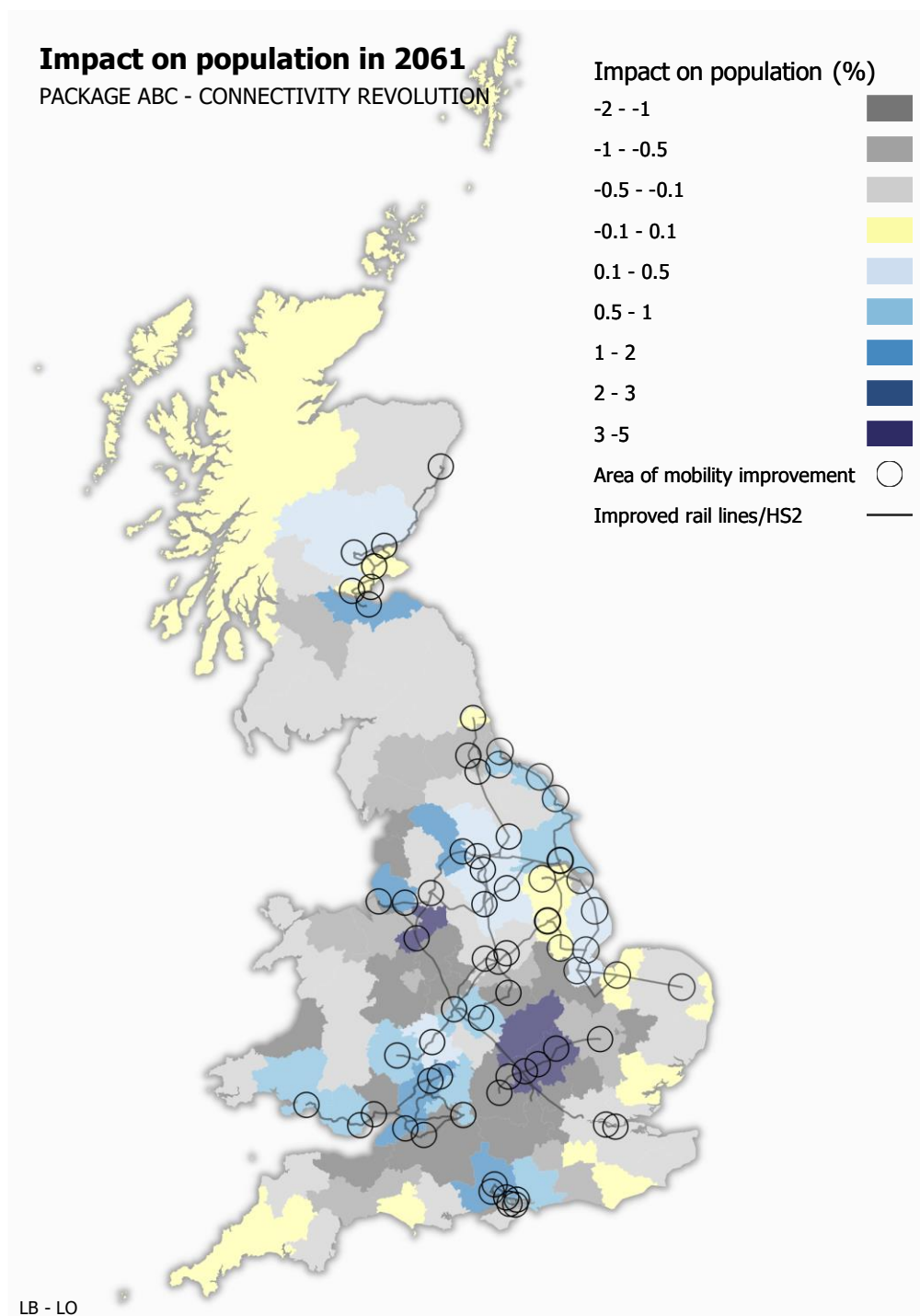


Figure 7-9 Map of impact of connectivity revolution on households in 2061

7.4 Conclusion

7.4.1 In all, a pan-national UK Network of the form modelled here could serve to boost growth in employment and economic output overall. It would increase the accessibility both from and to urban areas which have been connected into the wider network, resulting in boosts to household numbers and net gains to employment.

- 7.4.2 Improvements at a national scale broadly tend to see gains split between the northern extremity of HS2 and spread across the region, and in areas already well-connected to London, like in the Great Western region, or along the CaMKOx corridor.
- 7.4.3 Improving mobility within urban areas serves to even out impacts when compared with reliance on intercity links alone. This is more of a local effect, facilitating the local economies of these areas.
- 7.4.4 The largest impact otherwise can be seen in transforming the connectivity of areas that have been left behind or marginalised. Schemes of this nature have been shown here to have positive effects locally, though this can sometimes be at the cost of growth in other areas.

8 A CONNECTIVITY REVOLUTION WITH AN ENHANCED NORTHERN GROWTH SCENARIO

8.1 Rationale and context

- 8.1.1 Up to this point, we have examined the land-use impacts of improving transport connectivity in isolation. As has been mentioned already in this paper and by the Commission, transport connectivity alone is by no means the solution to regional imbalances in the UK. A joined-up UK Network only forms part of the vision for the UK in the future, and will facilitate other solutions, rather than solving issues in its own right.
- 8.1.2 There is a need, therefore, to examine the possible impacts of improvements to economic growth in the UK, much like Jin, Denman and Wan (*op cit*) of the Martin Centre at the University of Cambridge have done for the Commission already. Whereas LUISA, utilised in the Martin Centre's work, is a redistributive model that receives model inputs in the form of GDP and jobs growth (among many other inputs), SNM as used here models macroeconomic scenarios using a variable productivity approach. It allows for jobs to be more or less productive owing to sector or locational differences, meaning that as parts of the economy grow or move around, overall increases to productivity can result. These overall changes are captured in the model.
- 8.1.3 The Commission has posited that 'global Centres of Excellence' should be a cornerstone of the UK's strategic planning for the future. These are Oxbridge style research and innovation districts focused not just on research and development, but on the transition *from* research *to* development (Bridges, 2019). That is, providing a globally competitive environment to attract the brightest and best – to educate them and contribute to their development, then to facilitate and incubate innovation.
- 8.1.4 While there are a great many possible areas of focus which could rebalance the economy of the UK, in this section, we focus entirely on possible impacts of boosting the economy across cities in the North of England with strong universities, when coupled with a connectivity revolution. The scenario is not intended to reflect the entirety of the Commission's vision – only to illustrate the potential benefits, to the North and to a wider area.

8.2 Modelling approach

- 8.2.1 The approach taken here is to use UK Innovation Districts as a blueprint for the broad nature of the scenario inputs. Arup, in collaboration with the UK Innovation Districts Group, put out a report (Arup/IDG, 2018) in 2018 outlining what innovation districts are, and their effect on the economy at multiple scales. The report argues that innovation districts can address issues of productivity and inclusive growth. It also argues that more investment should be made into innovation districts, which should also work together more closely **in a national network**.
- 8.2.2 Figure 8-1 shows the main features of UK innovation districts. The upper and left circles are most appropriate to be modelled in what is viewed as an economic growth scenario – it is possible to model public realm improvements within SNM, but for

simplicity we focus here on sectoral improvements. The Arup/IDG report highlights the sectors most prevalent and successful in innovation districts as:

- Healthcare and medical technologies;
- Materials science;
- Big data;
- AI and robotics;
- Transport technology/AV;
- Advanced urban services;
- Fintech;
- Infectious diseases [research]; and
- Creative digital.

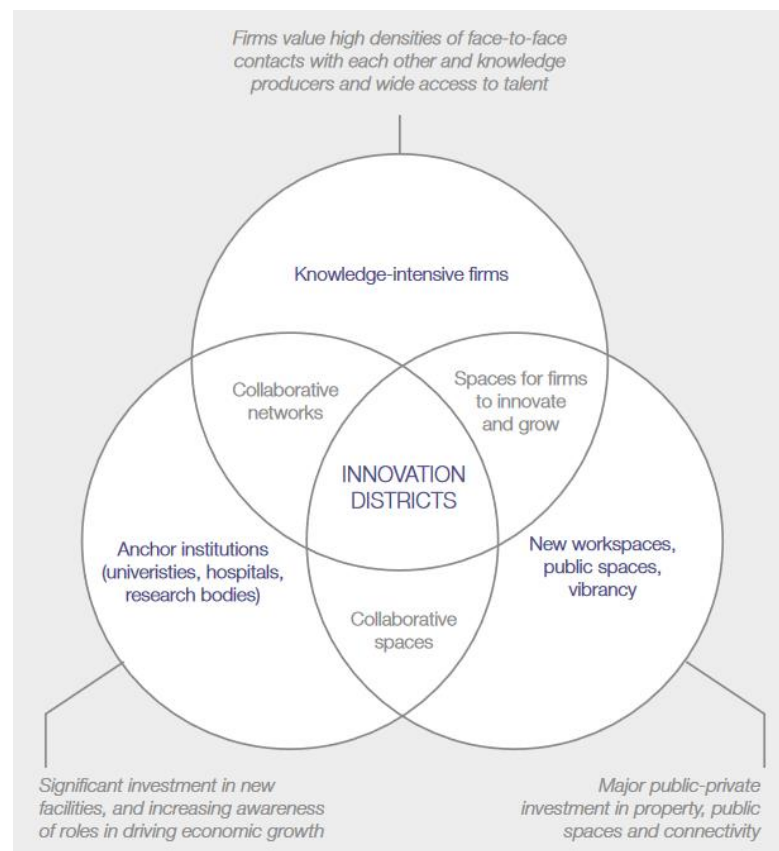


Figure 8-1 Main features of UK Innovation Districts

Source: Arup (from Bridges, 2019)

8.2.3 The approach taken here is to boost exports (as a proxy for increased production and intermediate consumption) in the closest sectors to those highlighted by Arup/IDG. These are:

- High-tech manufacturing;
- Transport;
- Information and communication;
- National/international finance;
- Other highly concentrated business services;
- Higher education.

- 8.2.4 Total exports have been modelled as increasing by 0.015% of total final demand, across the entire model, per year from 2037 to 2046. This means that in 2046, exports have increased across the whole of GB by 0.14% of total final demand. This equates to an additional £47B.
- 8.2.5 The increase in exports has been distributed evenly among the housing market areas (the smallest regional economic zoning) containing the larger northern university cities of **Liverpool, Manchester, Sheffield, Leeds, York and Newcastle**. This means that the output of each city and its housing market area increases by between £700mn and £800mn per year for ten years, then grows with the rest of the scenario (~0.17% per year) to the end of the forecast.
- 8.2.6 The exports have been split between the sectors listed above according to the proportion of each within Oxbridge. The overall input by 2046 for each of the areas in the North, after the ten-year ramp from 2037, is shown in Figure 8-2. In total, the net addition to overall exports in 2046 is £48B, increasing to £60B by 2061.

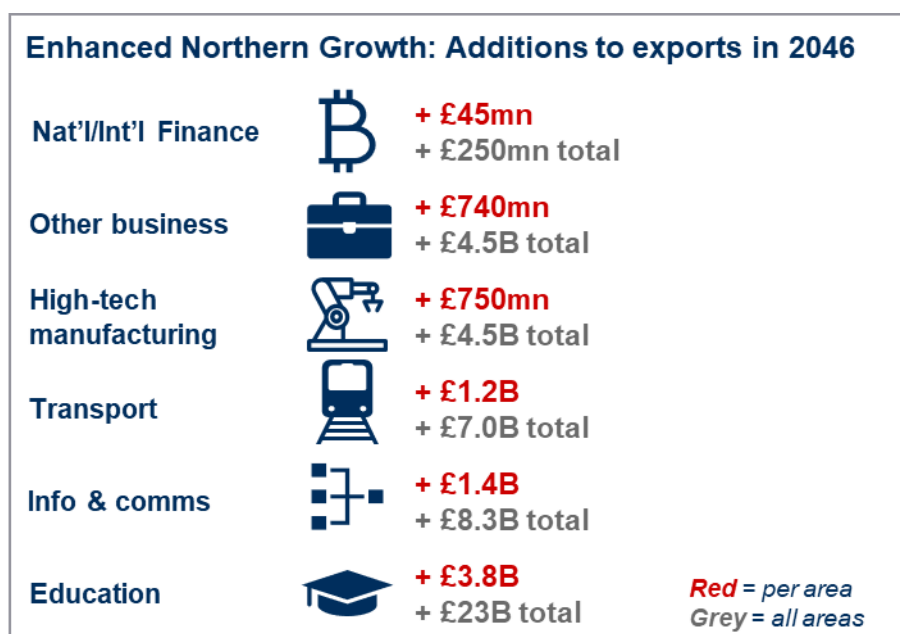


Figure 8-2 Additions to exports for each city in Enhanced Northern Growth scenario

- 8.2.7 The additional exports are modelled as being produced in the areas containing the districts receiving the boost. This has the direct effect of improving productivity, which boosts demand for other sectors' services and commodities in accordance with the sectors' input-output distributions. The location and scale of increased demand is dependent on a number of things, including transport accessibility. The scenario has been run both with and without the Connectivity Revolution package of improvements previously tested.

8.3 Results

Economic indicators – GVA

8.3.1 Gross value-added impacts on North-South rebalancing can be seen in Figure 8-3 and Table 8-1. Overall, we see that:

- Great Britain's growth in output over the forecast increases by £38B, contributing to a +0.05% change to compound annual growth from 2036-61;
- The North would see £24B of the gain, whereas the South would see £14B;
- The North's take-off would be immediate, and over time the impacts on productivity would spread further into the South;
- Growth would continue after the initial ten-year ramp stops.

Table 8-1 Impact of Connectivity Revolution and Enhanced Northern Growth on GVA (£mn)

| Region | Scenario | 2011 | 2036 | 2061 | Change 2036 to 2061 | CAGR 2036 to 2061 |
|---------------|----------|-----------|-----------|---------------|---------------------|-------------------|
| North | Base | 514,493 | 800,112 | 1,287,117 | 487,005 | 1.85% |
| | ABC+ | | | 1,311,299 | 511,187 | 1.92% |
| | Impact | | | 24,183 | | |
| South | Base | 775,392 | 1,314,462 | 2,192,770 | 878,308 | 1.99% |
| | ABC+ | | | 2,206,666 | 892,205 | 2.01% |
| | Impact | | | 13,897 | | |
| Great Britain | Base | 1,289,884 | 2,114,574 | 3,479,887 | 1,365,313 | 1.93% |
| | ABC+ | | | 3,517,966 | 1,403,392 | 1.98% |
| | Impact | | | 38,079 | | |

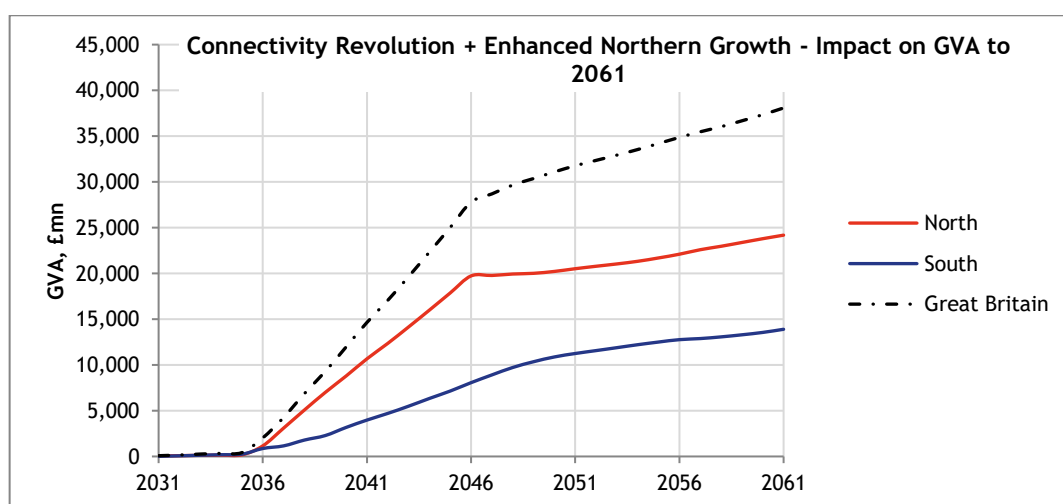


Figure 8-3 GVA impact to 2061 of Connectivity Revolution and Enhanced Northern Growth

8.3.2 The spatial distribution of impacts to growth in output by the end of the forecast are represented in Figure 8-4. Forecast increases to GVA growth are by far the largest

in the areas with directly increase exports, at up to £6.8B. Aside from these, the areas which see connectivity improvements from the package would generally see the largest boosts in GVA by the end of the forecast. The only exceptions are Swansea and Hull, which would most likely see gains in their respective urban areas attenuated by slightly lower rates of growth in the surrounding area. Generally, what we expect is that the improved areas which saw little additional GVA growth from the Connectivity Revolution gain substantially from the Enhanced Growth package.

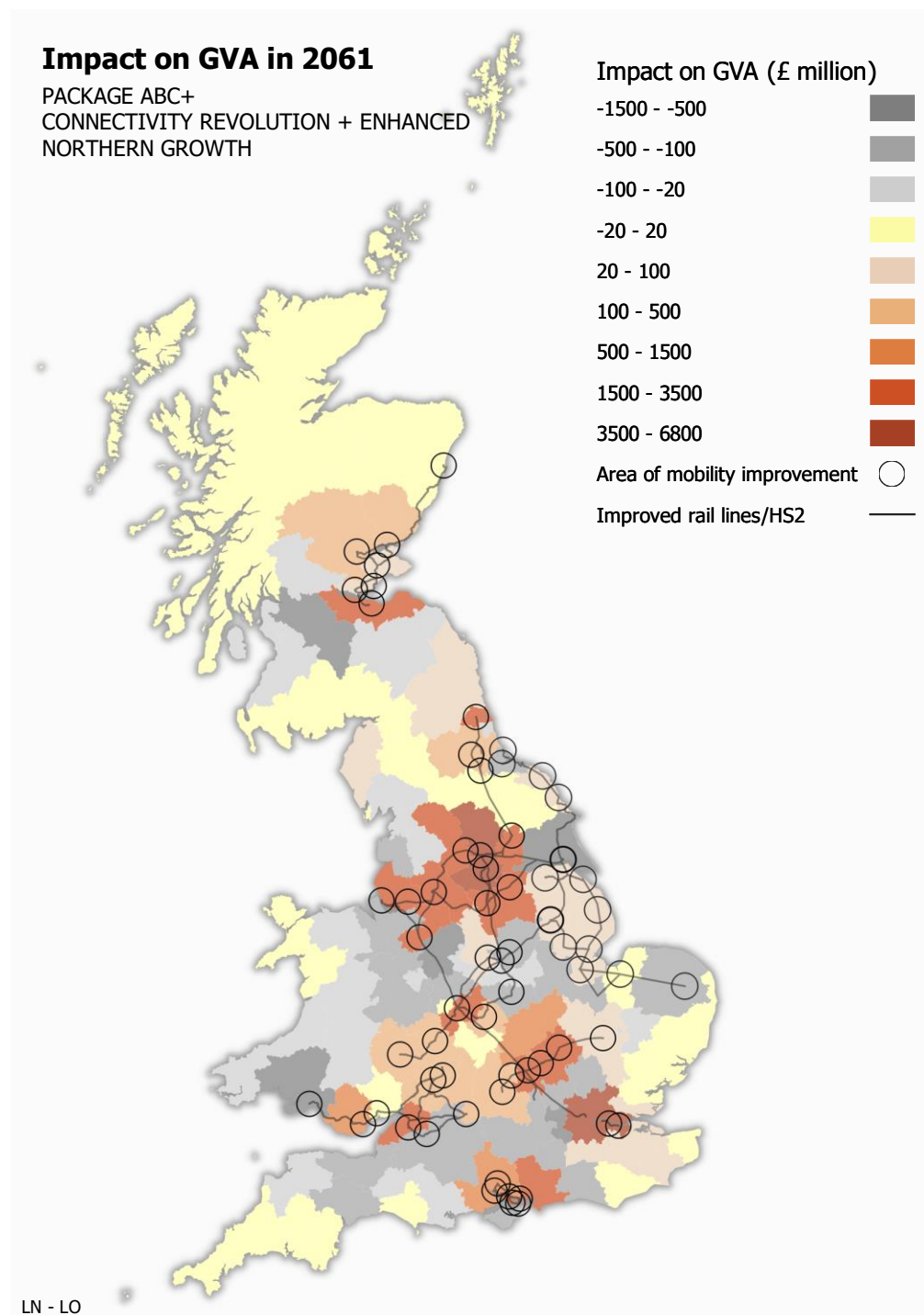


Figure 8-4 Impact on growth in GVA by 2061 with Connectivity Revolution and Enhanced Northern Growth

Economic indicators – employment

8.3.3 The employment impacts of the Connectivity Revolution and Enhanced Northern Growth combined are shown in Figure 8-5 and Table 8-2. Major takeaways are that:

- Britain as a whole could gain 250,000 jobs;
- Most of these are located in the North, which could see an extra 215,000 jobs;
- The South would gain from indirect impacts to demand, to an extra 34,000 jobs by the end of the forecast;
- The potential gains to the South are more gradual than those for the North, which would see an immediate gain to support the increased production necessary;
- Once the initial ramp ends (in 2046), additional employment growth lessens, showing increased productivity per head overall when viewed with the GVA increases over this period;
- Lower rates of growth in South/West Wales, Glasgow and Somerset/Devon highlights the need for further intervention in those places.

Table 8-2 Impact of Connectivity Revolution and Enhanced Northern Growth on employment

| Region | Scenario | 2011 | 2036 | 2061 | Change 2036 to 2061 | CAGR 2036 to 2061 |
|---------------|----------|------------|------------|----------------|---------------------|-------------------|
| North | Base | 12,660,730 | 14,057,665 | 15,073,614 | 1,015,950 | 0.27% |
| | ABC+ | | | 15,287,998 | 1,230,333 | 0.32% |
| | Impact | | | 214,383 | | |
| South | Base | 15,228,278 | 17,628,725 | 19,112,810 | 1,484,085 | 0.31% |
| | ABC+ | | | 19,146,605 | 1,517,880 | 0.32% |
| | Impact | | | 33,795 | | |
| Great Britain | Base | 27,889,008 | 31,686,390 | 34,186,424 | 2,500,034 | 0.29% |
| | ABC+ | | | 34,434,602 | 2,748,213 | 0.32% |
| | Impact | | | 248,178 | | |

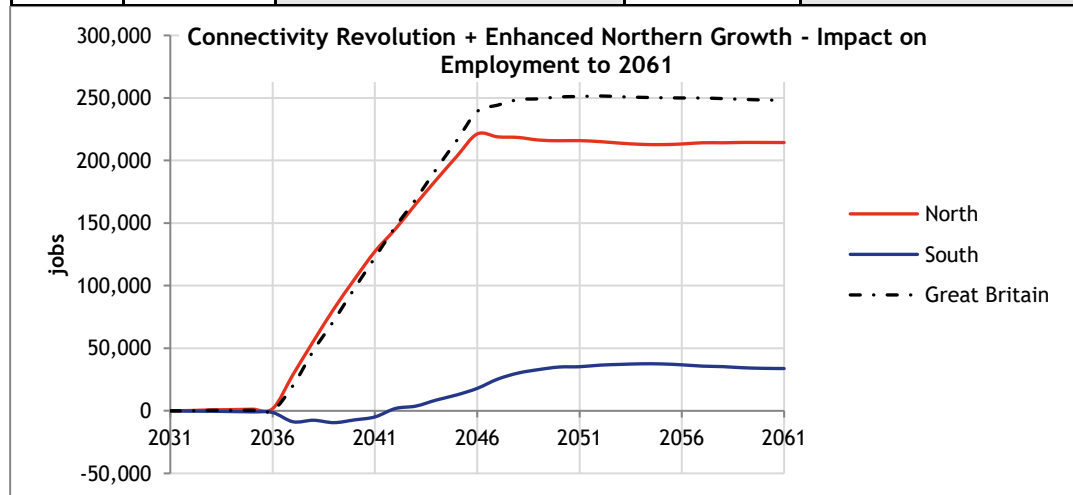


Figure 8-5 Employment impact of Connectivity Revolution and Enhanced Northern Growth to 2061

- 8.3.4 The spatial distribution of the impacts is shown in Figure 8-6. The potential additional growth to employment compared with the base scenario is almost exclusively located within areas of mobility improvement. The overall pattern is similar, outside the North, to the Connectivity Revolution, except there are *substantial* increases in employment growth in *all* areas, aside from Hull and Swansea as mentioned before.

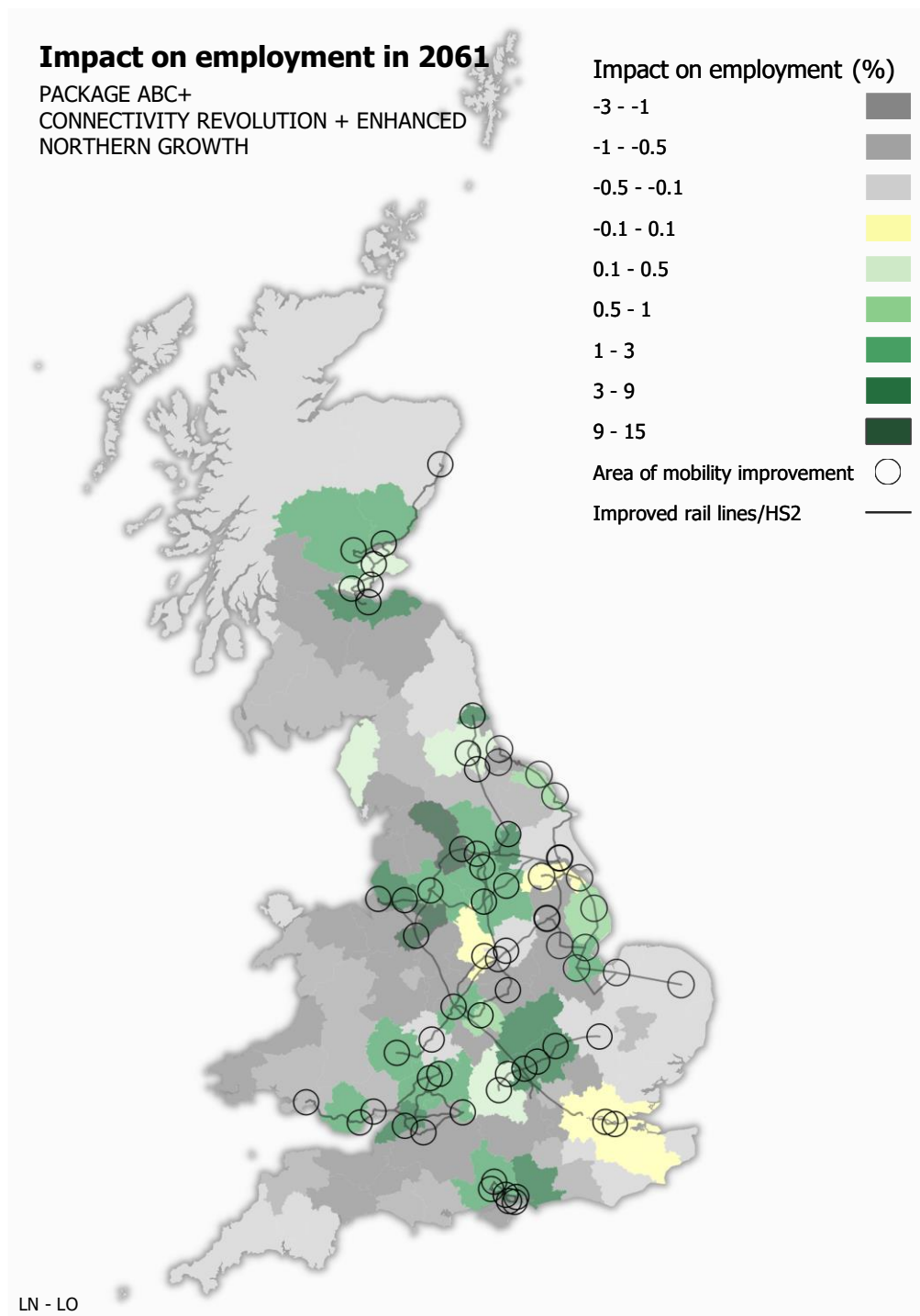


Figure 8-6 Impact of Connectivity Revolution and Enhanced Northern Growth on employment relative to base, 2061

Demographic indicators

- 8.3.5 The impacts on growth in population between the North and South as a result of the Centres of Excellence package are shown in Table 8-3 and Figure 8-7.
- 8.3.6 Population adjustments within the modelled area are purely redistributive, owing to fixed inputs in the modelling assumptions for rest-of-world migration. What we see in the redistribution is noteworthy – rather than a steep ramp in the first years and then a plateau, as is seen with employment numbers, there is a constant rebalancing of households and population from South to North as the forecast continues. This could well be due to the frequency of household moves – on average, a household is expected to move once in every five to ten years, meaning improvements in accessibility to and availability of employment and services take some time to trickle down to all people affected.

Table 8-3 Impact of Connectivity Revolution and Enhanced Northern Growth on population

| Region | Scenario | 2011 | 2036 | 2061 | Change 2036 to 2061 | CAGR 2036 to 2061 |
|--------|----------|------------|------------|----------------|---------------------|-------------------|
| North | Base | 28,380,907 | 32,663,381 | 36,002,917 | 3,339,536 | 0.38% |
| | ABC+ | | | 36,062,328 | 3,398,947 | 0.38% |
| | Impact | | | 59,410 | | |
| South | Base | 31,885,061 | 36,516,415 | 39,989,129 | 3,472,713 | 0.35% |
| | ABC+ | | | 39,930,799 | 3,414,384 | 0.34% |
| | Impact | | | -58,329 | | |

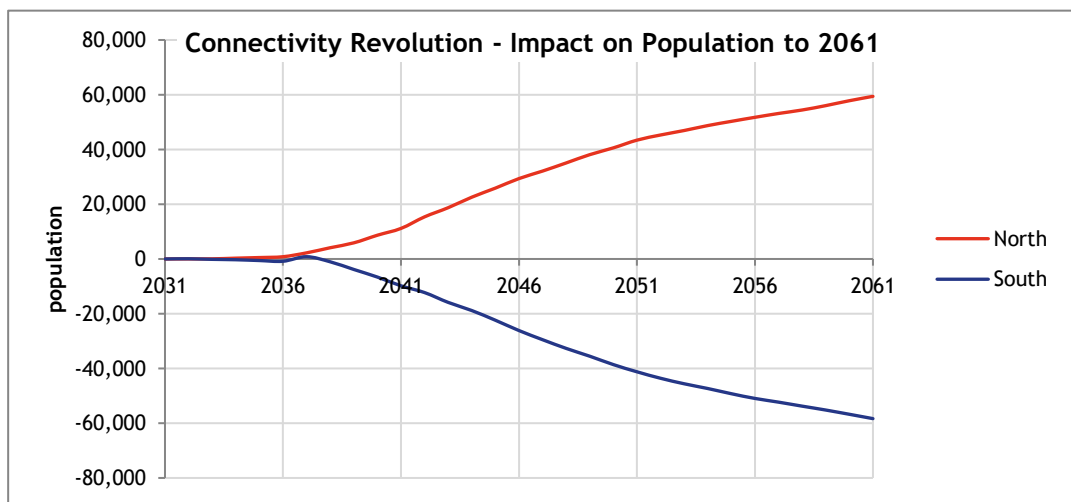


Figure 8-7 Impact of Connectivity Revolution and Enhanced Northern Growth on population to 2061

- 8.3.7 Figure 8-8 shows the spatiality of the population growth impacts. The areas where growth in population increases are generally the improved connectivity areas. The most significant gains appear to be a direct effect of the increase in exports. The gains in growth show the additional population required to service the demand for labour in the region.

- 8.3.8 Where the increased growth scenario differs from the pure transport scenario is with the growth in population across the North. Compared with the Connectivity Revolution package, there are few differences south of the divide; North, increases in growth are more widespread and greater in magnitude.

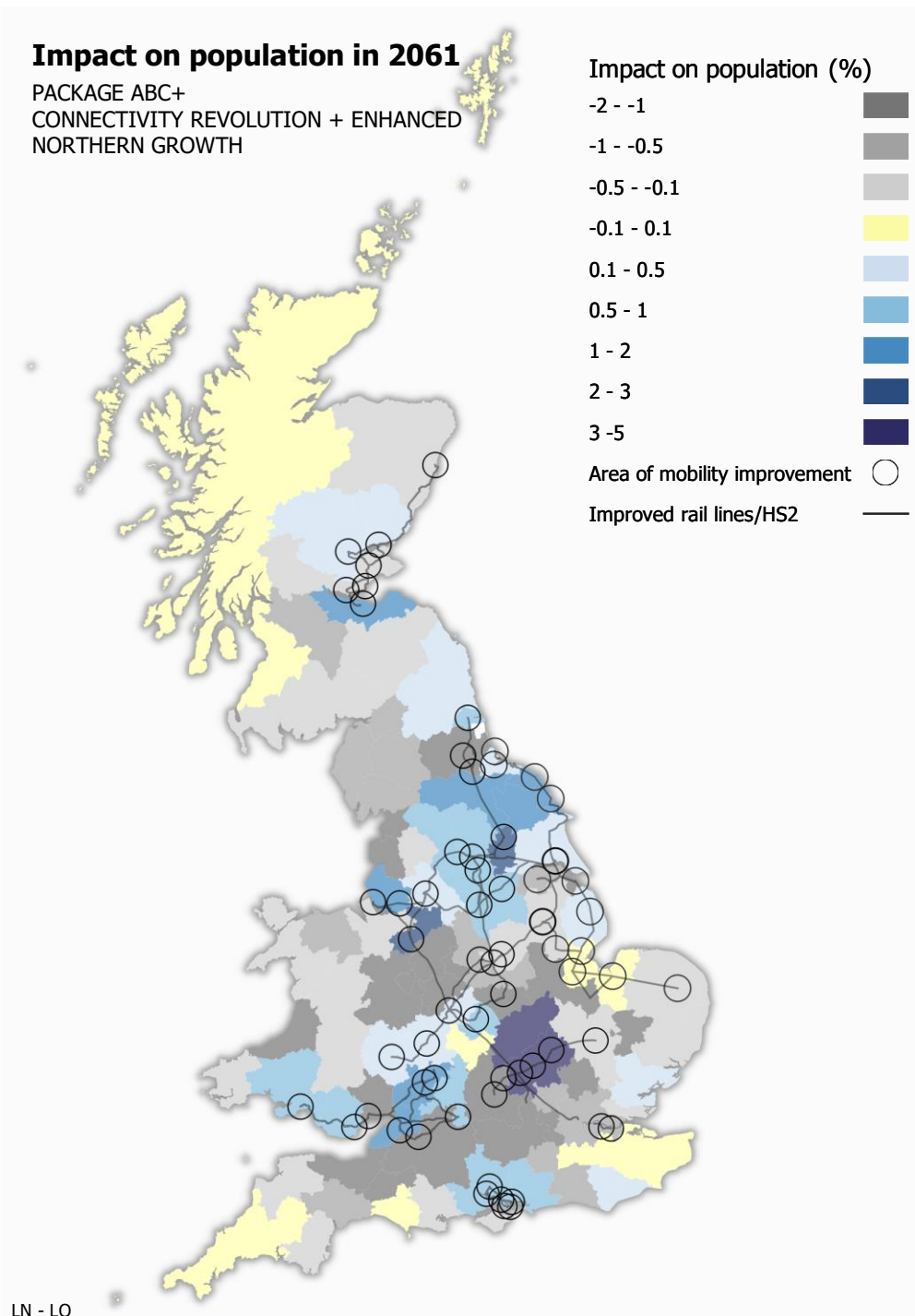


Figure 8-8 Impact of Connectivity Revolution and Enhanced Northern Growth on population relative to base scenario, 2061

8.4 Conclusion

- 8.4.1 The results show that increasing economic activity within a selection of areas across the North and in only a selection of sectors could have wide ranging, positive economic impacts. These positive effects would likely occur both within the North as direct effects, and could also spread through the supply chain across the North at large and into the South.
- 8.4.2 From an increase in exports of £60B by 2061, we see a potential increase in output in GVA terms of £38B. The distribution of the potential impacts favours the North, by almost a factor of two. However, it is the possible pure employment gain that is far more positive for the North than the South, signifying a major rebalancing. Of the roughly 250,000 possible net additional jobs by 2061, more than five sixths are expected to be created in the North. Elsewhere, employment gains are expected to follow areas of increased connectivity as a result of the transport improvements.
- 8.4.3 Expected demographic changes tend to be steadier over time, and the distribution of these favours the Centres of Excellence areas directly, alongside smaller shifts in the transport connectivity improvement areas.
- 8.4.4 The balance of growth improvement potential tends to follow transport and productivity improvement area lines – so where there are no input changes relative to the base scenario (for instance in Glasgow or Plymouth), there tends to be lower potential growth as a result. This highlights the need for a systematic and wide-reaching approach in appraising potential transport improvements or boosts in economic growth: it is important that in improving some areas, others are not left to become marginalised in the decades to come.

9 DEVELOPING AN APPRAISAL OF THE PACKAGES

9.1 Introduction

- 9.1.1 One of the concerns raised by the UK2070 Commission is that the current methods of appraising public expenditure, particularly for transport investment, do not give sufficient attention either to the wider spatial and social context or to the spatial consequences of that expenditure⁷.
- 9.1.2 DSC have been working on these issues for many years, and have recently implemented a new method to appraise interventions in transport and in land-use and economic development, either separately and in comparison with one another, or in combination. This method is known as Unified Land-use/Transport Appraisal (ULTrA) and has been developed over a number of years, particularly in successive projects for TfL. This chapter sets out the background to this work and the objectives of the new method, explains the basis of the main benefit calculations, and presents the results obtained. The results are necessarily limited by the lack of data on the costs of the proposals considered, so the discussion is more about the scale and nature of benefits, and the method of appraisal, than about Net Present Value or Benefit:Cost Ratios that one would ultimately wish to use.

9.2 Structure of the chapter

- 9.2.1 This chapter is organized as follows.
- 9.2.2 Section 9.3 defines the problem that we are attempting to address in looking at transport, land-use and economic development appraisal.
- 9.2.3 Section 9.4 sets out the approach we have adopted.
- 9.2.4 Sections 9.5, 9.6, 9.7, and 9.8 discuss how we define and estimate the benefits to different sectors of the economy.
- 9.2.5 Sections 9.9 and 9.10 discuss how we define and estimate (or would like to estimate) benefits that fall outside the conventional definition of the economy, namely in terms of benefits to the environment and in rebalancing the economy. Section 9.11 and 9.12 describe how we have implemented the benefits in rebalancing the economy; this has been discussed in previous work but this is the first time estimates of these benefits have been included in ULTrA analysis.
- 9.2.6 Section 9.13 summarises the set of benefits that is being considered and the resulting structure of the ULTrA summary table; and section 9.14 finally shows the ULTrA results.

9.3 The problem to be addressed

- 9.3.1 It has been known for many years that the application of conventional “transport economic efficiency” appraisal is, at best, incomplete and potentially misleading in situations where the response to transport change includes land-use effects. An initial round of work on developing a broader method of land-use/transport economic

⁷ We follow standard UK government terminology of referring to the *ex ante* analysis of the merits and demerits of a proposed intervention as *appraisal*, and to *ex post* analysis as *evaluation*.

efficiency was carried out by DSC and others circa 2001, which identified a number of possible ways forward⁸. The question was discussed at intervals, and then revisited in work for TfL during 2012. Recently DSC have invested further in the software for the method, and TfL have supported initial applications with reference to major proposals in London⁹. This has provided the basis for the calculations reported here.

- 1.1.02 The central problem we are addressing is that of developing a welfare-based method of economic efficiency appraisal which looks at land-use and transport markets together, and which can be used to appraise land-use and transport interventions in comparison or in conjunction with one another. This contrasts with the current convention of Transport Economic Efficiency (TEE) appraisal which can only consider transport interventions and – at least for its explicit calculations – assumes and indeed requires that land-uses are fixed.
- 9.3.2 The argument that TEE, assuming fixed land-uses, is a valid basis for appraisal even when it is widely accepted that transport is a significant influence on land-use and land markets, is that markets outside transport are assumed to be perfect, meaning *inter alia* no externalities. This has been criticised in a number of different ways.
- 9.3.3 There is first the argument which Professor David Metz has been developing for several years¹⁰, which is in brief that
 - land-uses **do** respond to transport;
 - these responses change the demands for transport and result in changes in congestion and environmental impact;
 - the present TEE approach doesn't capture those congestion and environmental externalities and hence is to some extent wrong.
- 9.3.4 Secondly there is an argument that there are externalities in the land-use system itself which ought to be taken into account in considering the impacts of transport change, especially where development processes are affected (as they will be in most places in the longer term). For example, if a transport change improves access to a town centre and causes an increase in demand for shopping and services there, this is likely to lead to an improvement in the retail offer of that centre, which will be an externality benefit to residents with easy access to that centre.
- 9.3.5 Thirdly, there are the distributional questions: TEE ignores the fact that (for example) landlords (and owner-occupiers at the time the scheme modifies rents) may well capture a large proportion of the benefits which in TEE appear to accrue to users of improved transport. TEE also tends to ignore the spatial distribution of benefits; at least as promoted in TAG, it assesses costs and benefits only at a national level, and does not contribute either to testing whether the transport intervention being

⁸ David Simmonds Consultancy and John Bates Services (2001): *Appraisal in land-use/transport interaction: design*. Report to Government Office for the North-West.

⁹ The TfL work is related to the LonLUTI model, which is in effect the SNM as used in the UK2070 project with additional detail in the London area, linked to TfL's main strategic transport model, LTS.

¹⁰ Metz, D (2008): The myth of travel time saving. *Transport Reviews*, vol 28, pp321-336; and (2010): "Saturation of demand for daily travel" *Transport Reviews* vol 30 pp659-674.

appraised supports or obstructs government rebalancing and regeneration policies, or even inform assessment of spatial impacts, despite recognition that this is a valid question for public policy debate¹¹.

9.3.6 Fourthly, there is the argument that existing appraisal is misleading because it tends to focus on time savings which in practice will be largely or wholly converted into more travel at higher speeds; even if this didn't generate more (or less) congestion, this would still be an area where the appraisal could be reformulated to give decision-makers a clearer view of the expected impacts of the scheme. This again has been argued in particular by Metz, though the argument that "road improvements simply generate more traffic" is widespread. Note that we are definitely not pursuing the question of "what do people do with time savings" for its own sake; we are only concerned with the cases where people opt for more rather than faster travel, because – through congestion and environmental effects - this choice affects the outcome for everyone.

9.3.7 To address current criticisms, there is therefore a need to improve (or replace) appraisal methodology so as

- to correct distortions due to exclusion of feedback effects;
- to improve understanding of distributional effects, both social and spatial; and
- to improve understanding of the nature of the consequences.

9.4 What approach are we taking to these issues?

9.4.1 In earlier work we discussed the possibility that an integrated land-use/transport appraisal method could be developed either

- by extending the range of benefits and disbenefits considered in a conventional TEE framework, i.e. developing a series of adjustments to transport-only benefits measured, in the first instance, on a fixed-land-use basis; or
- by devising a new approach based on measuring benefits and disbenefits to households and other actors, using measures of benefit from improved accessibility as the means of capturing both the direct benefits of transport improvement and some of land-use effects.

9.4.2 The approach we have taken is the latter, and more specifically to concentrate on a land-use/transport economic efficiency analysis calculated as far as possible within the land-use/economic part of the land-use/transport interaction model, using zonal variables rather than the zone*zone matrix variables typical of TEE. This has the advantage that nearly all of the required variables, including in particular the accessibility measures, are already implemented in the land-use/economic model as influences on the locations of households and jobs. It also avoids the complication

¹¹ Venables, A J, J Laird and H Overman (2014): *Transport investment and economic performance: implications for project appraisal*. Paper commissioned by UK Department for Transport. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/386126/TI_EP_Report.pdf

of trying to convert a benefit accruing to a household (such as a gain in housing floorspace) into generalised cost changes on all the trips made by that household. It represents an alternative approach to conventional TEE than an add-on to TEE.

- 9.4.3 This choice of approach means that the direct effects of transport change appear in accessibility variables. These represent the value that actors in the land-use markets – households and firms – place on accessibility to destinations, as opposed to the value that users in the transport system place on time savings.
- 9.4.4 The chosen approach is therefore to apply conventional welfare-based cost-benefit analysis, using the standard rule-of-a-half method for consumer and producer surpluses, to
- the zonal variables of an integrated land-use/transport model,
 - allowing for working with fixed or variable economic scenarios,
 - showing benefits by broad sectors or categories of economic actors (i.e. households, firms, etc),
 - considering transfers between these, and
 - showing benefits spatially where appropriate.
- 9.4.5 The defined sectors are
- households;
 - firms;
 - property owners;
 - government; and
 - other benefits.
- 9.4.6 This structure aims to make transfers between the different sectors explicit¹². We recognize that directly or indirectly, benefits to firms and property will accrue to individuals (for example, as shareholders or as the beneficiaries of pension funds) as should savings to government. However, from the point of view of understanding the form that benefits are expected to take, this structure seems more informative. In addition, identifying the impact of the intervention on money flows to government is potentially an important component in financial appraisal.
- 9.4.7 The SNM treats all households, and all firms that are modelled as occupying floorspace, as if they rented the space they occupy. This approach is taken in a wide range of economic models. The category of “landlords” therefore covers the owners of all of the modelled residential and non-residential floorspace. The results presented below are shown in those terms.
- 9.4.8 The public sector could in principle be disaggregated into local and national government, and potentially other agencies; this has not been pursued to date.

¹² This approach is of course not original; the treatment of different sectors (without the “other” category”) is something of a tradition in the limited number of model-specific designs developed for land-use/transport appraisal. See for example Flowerdew, A D J (1978): Evaluation models for city and regional planning. *Australian Road Research Board Proceedings*, vol 9, pp 87-107.

9.4.9 The “other benefits” category is intended to capture estimates of benefits where the beneficiaries cannot be clearly identified, such as the benefit of reductions in greenhouse gases measured savings in the shadow price of carbon, or of regeneration and rebalancing benefits appropriate shadow values can be attributed to such effects.

9.4.10 The different sectors are discussed under the following headings.

9.5 **Benefits to households**

9.5.1 The general design carries out conventional rule-of-a-half type calculations of the changes in consumer surplus in which

- the overall “price” variable (on the vertical axis) is the **disutility** of locating in a zone, for a given type of household in a given year;
- the “quantity” variable (on the horizontal axis) is the number of households of that type located in that zone in that year.

9.5.2 The household location model itself works in terms of “utility of location” rather than “disutility of location”. The disutility is simply the negative of the utility variable. The use of disutility rather than utility is simply to allow us to retain the familiar rule-of-a-half diagram, rather than drawing an “upside-down” version in terms of utility.

9.5.3 The classic diagram to explain transport economic efficiency is shown in Figure 9-1. The equivalent for ULTrA is then the very similar diagram shown in Figure 9-2.

9.5.4 Note that in each case the calculation suggested by the diagram is independent of where the benefit area is located relative to the vertical axis. For the purposes of appraisal (as distinct from the underlying model) it is only the absolute change in generalised cost or disutility that matters on the vertical axis¹³.

9.5.5 Benefits to households are calculated for each household type in each zone. Total benefits are found by summing over household types and zones, in the same way that they are found in TEE by summing over purposes, modes, zone pairs, etc.

9.5.6 In the urban transport system, much of the equilibration between supply and demand takes place through changes in congestion. In the land-use market, much of the equilibration takes place (gradually) through rents. The key difference is that prices are paid by one agent but received by another (and may then be taxed). One of the contrasts between ULTrA and a conventional transport appraisal is that a larger part of ULTrA is about who pays more and who is paid more as a result of changes in rents.

¹³ Note that for some time there was a common view in transport appraisal discussions that “the use of rule-of-a-half is wrong if land-uses change”. That was never our assertion: the point is that “the standard TEE rule-of-a-half based on trip numbers and trip generalised costs is wrong if land-uses change”. James Laird has in work for DfT confirmed that there is nothing wrong in principle with using rule-of-a-half appraisal where land-use changes are considered; the issue is to apply it to the right variables.

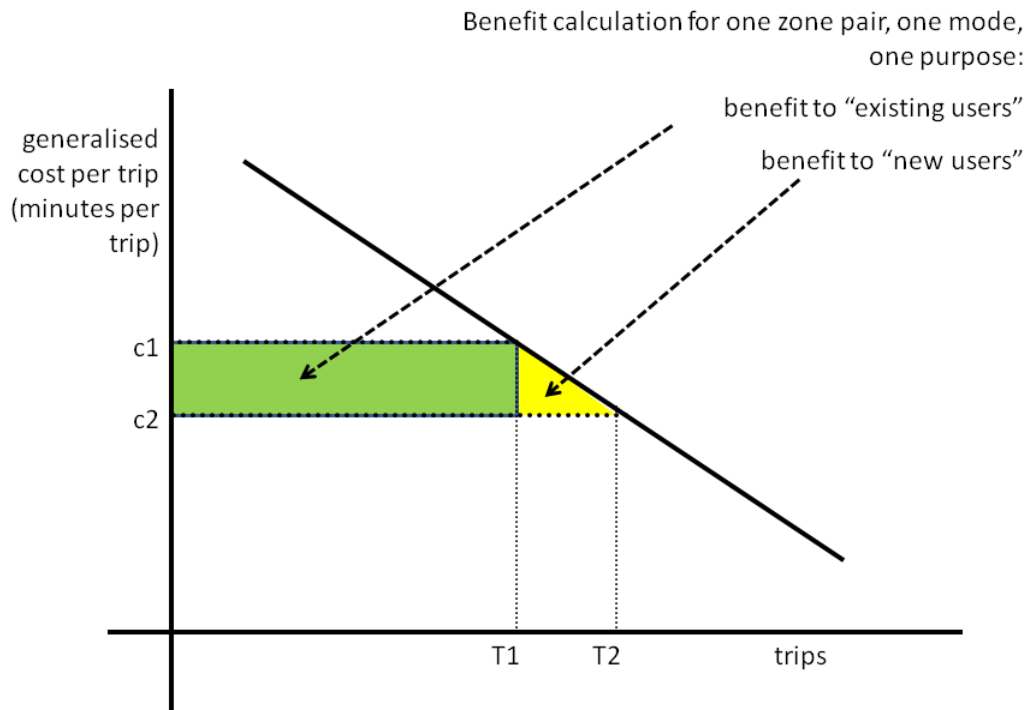


Figure 9-1 Conventional TEE: main concept for user benefit calculation

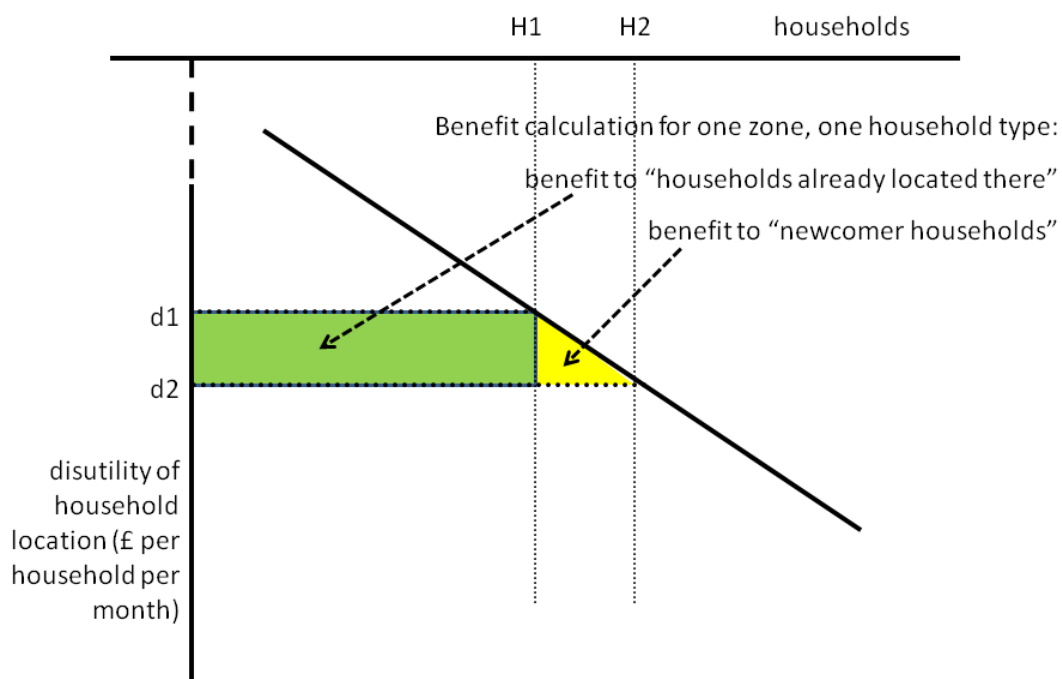


Figure 9-2 ULTrA: main concept for consumer benefit calculation

9.5.7 The ULTrA analysis has to deal with the complications arising because the land-use model is not wholly in equilibrium at any point in time. This is dealt with by separating the disutility of location into two parts:

- one where effects arise immediately, for all households, and

- one where effects arise only when a household makes a location decision in the housing market.
- 9.5.8 The former are calculated separately for each year, from the opening year of the intervention being appraised to the end of the forecast. The latter are calculated in each year for the households that are making location choices in that year, and the resulting annual costs or benefits persist for those households until the household moves again, or dissolves.
- 9.5.9 After taking the negative of each term to convert utility to disutility, and separating terms to distinguish those that can be simply recalculated each year from those that need to be recalculated only when households locate, the disutility measure consists of
- cost of location (i.e. $\text{rent/m}^2 * \text{floorspace/household}$),
 - minus the utility of discretionary floorspace (in money units),
 - plus accessibility in money units,
 - plus costs of car ownership,
 - minus quality of the zone (in money units),
 - minus environmental quality (in money units),
 - minus income (after income tax and benefits),
 - plus the generalised cost of commuting (for people who gain work as a result of the intervention being appraised),
 - plus the value of leisure time lost to working (for people who gain work as a result of the intervention being appraised),
 - plus council tax paid
 - plus VAT paid on household expenditure.
- 9.5.10 All of these terms are present or can be generally derived from the variables in the model. The one exception in the present case is that the environmental quality, which is generally treated (for transport schemes) as a function of the volume of traffic in each zone, as a proxy for the noise, air pollution, accident risk and severance arising. In the present work we do not have any inputs for traffic volumes and cannot consider this type of benefit.

9.6 **Benefits to firms**

- 9.6.1 The treatment of firms is much simpler. The available variables allow us to assess
- savings in terms of better accessibility to other businesses (typically to clients/customers);
 - savings in cost of location (i.e. reductions in rent);
 - increases in value added due to agglomeration, relocation and multiplier effects.

- 9.6.2 All of these would constitute increases in profits; a standard tax rate is applied which transfers part of these additional profits from firms to the government sector.

9.7 Benefits to property owners and developers

- 9.7.1 The benefits to property owners and developers (who are treated as a single sector) consist of

- increased income from rent (whether from higher rents for the same property, or additional rents for additional property), plus
- any savings from the amortized cost of supplying less floorspace, if this is forecast within the model or imposed as a policy intervention, plus
- any reductions in taxes paid.

- 9.7.2 In many cases, of course, we would hope to see more floorspace (especially more housing) being supplied as a result of a planning intervention, so we would expect to see a net disbenefit (or malefit) in the cost of floorspace item. Depending on the exact analysis required, such a cost may appear as a negative (malefit) in the numerator of a benefit:cost ratio, or as an additional cost in the denominator.

9.8 Benefits to the public sector

- 9.8.1 The benefits to the public sector consist entirely of additional revenues from taxes and charges, or of reduced expenditure on certain benefits. These are:

- direct taxes i.e.
 - changes in income taxes (including National Insurance contributions) arising from changes in household incomes;
 - changes in corporation taxes arising from changes in profits both of firms in general and of property owners other than the owner-occupiers of housing;
- indirect taxes i.e.
 - changes in council tax paid by households (as occupiers) and business rates paid by occupiers of commercial floorspace;
 - VAT (which is treated as a consumer sales tax paid only by households; all VAT paid by firms and government is assumed to be reclaimed);
- reductions in unemployment benefits if the effect of the intervention being appraised is to reduce unemployment;
- other charges e.g. community infrastructure levies (CIL) paid by developers
- fuel taxes and tolls (including congestion charges, where applicable);
- public transport fares.

- 9.8.2 The last three bullet points have not been considered in the present study: CIL is not considered in the modelling, and we do not have sufficient modelling of transport to estimate the revenues from fuel taxes, tolls and fares. All of the others are considered

9.9 “Other” sector benefits: environmental

- 9.9.1 Reductions in greenhouse gas emissions should be valued using the Government’s shadow value for such reductions from non-traded carbon. This requires more detailed transport modelling to assess the potential reductions from decreased use of private vehicles, and analysis of the energy used, and the sources of that energy, for increased operation of public transport.
- 9.9.2 Shadow prices could also be developed and applied for other environmental benefits e.g.
- “environmental services” value of additional trees where increased open space is provided and planted¹⁴;
 - health benefits from increased walking and cycling (if not allocated to the households whose residents engage in the increased activity)
 - health benefits from reduced air pollution (if not already included in benefits to households experiencing improved air quality). A case could be made for attributing shadow prices to other aspects of regeneration e.g. the value of reducing concentrations of involuntary unemployment.
- 9.9.3 Within the constraints of the present work we have not attempted to go into any of these more complex issues.

9.10 “Other” sector benefits: rebalancing and regeneration

- 9.10.1 One of our objectives in the development of ULTRA has been to find ways of measuring and including some of the benefits which policies or investments are seen as delivering to particular areas or regions. These benefits in “regeneration” or “rebalancing” are often excluded from formal cost:benefit analysis and, at least in the case of transport schemes, are treated as part of the “strategic” case rather than the more formal “economic” case - the implication being that any achievements in regeneration or rebalancing do not contribute to the “value for money” assessed in the economic case. We have long considered that treatment unfortunate, and that it should be possible to bring such effects into the economic case - not least so as to be able to make comparisons between, for example, schemes which deliver different levels of regeneration benefits at different costs.
- 9.10.2 We made our own assessment of the potential sources of value from achieving regeneration of particular target areas, and of how these values might be expressed in monetary units given the kinds of output available to ULTRA. We propose that possible bases for identifying benefits include:
- differences in the marginal utility of income;
 - externality effects;
 - unmodelled issues of “other infrastructure” capacity.

¹⁴ We have for example seen an estimate of US\$1000 per tree per year for New York. Some of that would presumably be from carbon capture; that should probably be valued using the same shadow price of carbon as for reduced emissions, but the carbon capture would be an additional benefit over and above the reduced emissions from the transport.

Background from the “3Rs” Book

- 9.10.3 Official advice (the “3Rs” book) on the evaluation of regeneration measures is somewhat unhelpful in this context, in that it gives very little specific guidance on valuing measures that have positive impacts in target areas (as opposed to achieving wider economic benefits by targeting underused resources (e.g. labour or land) that happen to be in those target areas). The paragraphs on valuing spatial distributions basically say that it is too difficult.
- 9.10.4 The paragraphs on valuing employment gains in target areas (see extract in table below) are slightly more constructive, in so far as they conceded that something can be done. However, they first suggest using what we would term a “shadow price” derived from what government would need to spend to create equivalent results in another location (and by a different kind of intervention), but recommend against this on the grounds that such a method is not robust; then they go on to suggest that reductions in unemployment should be valued by their reduction in social problems resulting from unemployment and in particular from concentrations of unemployment (e.g. poor health, crime, low educational attainment, family break-up etc.), which is perfectly reasonable – but there is no guidance on how to forecast or to value effects such as low educational attainment resulting from concentrations of unemployment .

Table 9-1 3Rs Guidance on local employment effects

Where jobs are additional to a specific area only (i.e. there would be expected to be compensating losses in other areas) then it is not appropriate to value the jobs at the wage rate since the value attached to these employment opportunities is based on redistributive. Identifying and measuring outputs/outcomes concerns, or a desire to reduce the social problems associated with unemployment in particular areas, rather than for additional economic activity. In these cases it is possible to use the notion of a replacement cost (the amount government would spend creating these outputs elsewhere) or to interpret approved projects’ cost per unit costs as expressions of social willingness to pay to secure the benefits. However, there are many difficulties with such approaches, affecting the robustness of the results obtained, and it is not recommended.

Generally in such cases it will be better to consider the impact of the reduction in unemployment on the social problems experienced by particular areas (health, crime, low educational attainment, family break-up etc.). This is particularly relevant where unemployment concentrated in particular areas leads to elevated and concentrated problems - for example because of the presence of feedback effects

3Rs Guidance, A7-2.12-13

Measures for Rebalancing Benefits

- 9.10.5 We have considered three possible measures:
- higher marginal utility of income;
 - shadow value of relocating a job to a target area;
 - implicit savings in cost of other infrastructure.

Higher marginal utility Income

- 9.10.6 The higher marginal utility of Income is recognized in Green Book but it is tricky to justify the application in a situation where we forecast that incomes will go up in a region but we can't describe in detail the people whose incomes will go up.
- 9.10.7 The differences within regions (or indeed districts i.e. individual model zones) are likely to be much greater than the differences between regions (or districts), and even with multiple household types we can't tell exactly who is getting a new job (it could go to someone who living alone on benefits, or to the partner of someone who is relatively high-earning)
- 9.10.8 It is also complicated by the facts that we have (a) migration (adding more uncertainty to "who gets the higher income" and "who gets the additional job") and (b) variable housing rents – so at a minimum there would be the need to assess the utility of marginal real income.
- 9.10.9 Marginal utility of income is impractical to implement. The Treasury Green Book says that it "may be necessary or desirable" to weight costs and benefits according to the social group they fall in, on the economic principle of diminishing marginal utility of income, i.e. that an additional £1 of income is more valuable to a low-income recipient than to a high-income one (see Table 9-2 for the full advice).
- 9.10.10 Some aspects of this effect are reflected within ULTrA already through
- the higher value of additional floorspace for households living at very high densities (who are likely to be on lower incomes);
 - different values of time used in calculating generalised costs for different occupational groups.
- 9.10.11 The approach could be taken further, whilst taking care not to double-count differences that are already built in. However, it must be recognized that the household incomes are only averages (means) for each household type in each zone, and that most of these will be the mean of a fairly wide distribution.

Table 9-2 HM Treasury Green Book advice on marginal utility of income

When assessing costs and benefits of different options it may be necessary or desirable to "weight" these costs and benefits, depending on which groups in society they fall on. This is in addition to estimating the "unweighted" costs and benefits, which is the minimum requirement of Social CBA. In weighted analysis, financial benefits for lower income households are given a higher social value than the equivalent benefits for higher income households. Weighted estimates should be presented alongside unweighted estimates to demonstrate the impact of the weighting process.

The basis for distributional weights is the economic principle of the diminishing marginal utility of income. It states that the value of an additional pound of income is higher for a low-income recipient and lower for a high-income recipient. Broadly a value of 1 for the marginal utility of income would indicate that the utility of an additional pound is inversely proportional to the income of the recipient. An additional £1 of consumption received by someone earning £20,000 per year would be worth twice as much than to a person earning £40,000. Higher estimates of the marginal utility of income will mean the value of an additional pound declines more quickly relative to increases in income.

A review of international evidence¹⁵ provides an estimate of the marginal utility of income [...] This is used by DWP in distributional analysis. The estimate of the marginal utility of income can be used to calculate welfare weights to adjust costs and benefits.

HM Treasury *Green Book*, 2018, A3.12-14

Shadow value of relocating

9.10.12 Externality effects can probably be grouped into two types

- those arising from the presence of derelict, disused or neglected land or buildings, and more specifically from the negative effects that this has on people in or passing through the neighbourhoods affected;
- those arising from concentrations of problems such as (in particular) unemployment, and more specifically from the negative effects that these problems have on other people living in the same area.

9.10.13 The effects arising from derelict or disused property can range from the very immediate – residents in adjoining housing being plagued by vermin – to the much less immediate – potential investors being discouraged by the poor appearance of the city. Some of the effects in housing may already be captured in the housing quality sub-model. These effects could in specific cases be measured by loss of value of other properties affected, though these losses are likely to be quite sensitive to details of individual sites e.g. whether a derelict site is a nuisance for everyone in the area or just an eyesore for occupiers in a minority of properties that happen to overlook it.

9.10.14 The kinds of effects arising from concentrations of unemployment include higher and more persistent unemployment (because informal networks for finding work where others are working cease to function, and because unemployed workers become discouraged when most of their friends and neighbours are also unemployed), lower educational attainment and social problems among children (because of the lack of relatively successful working adults as role models), and so on.

9.10.15 A critical part of the argument here is that problems are more serious and more intractable when concentrated in particular parts of a city or region. This of course comes back to the list of issues mentioned earlier - poor health, crime, low educational attainment, family break-up etc - which can stem from or be exacerbated by unemployment, and to the difficulties of valuing reductions in these.

9.10.16 The shadow value of relocating jobs to a target area is what we are paying to achieve the same effect in other ways (NB same principle is used for carbon pricing). This assumes that generating jobs in defined regeneration areas, or (better) generating jobs that are taken up by residents in defined areas of deprivation, creates benefits even if those jobs are displaced from other (non-regeneration or less deprived) areas; and argues that the value of the job must be equal to or greater than the costs incurred in generating such jobs through other policies (assuming that those other policies are rational and reasonably efficient).

¹⁵ Layard et al. (2008): The marginal utility of income. *Journal of Public Economics*, Vol. 92, pp. 1846-1857

- 9.10.17 This method does not say anything about the real benefits of a job being (or being filled) in one place rather than another, but it is implicitly (we suggest) about the social benefits of reducing unemployment rates in areas where they are high, including reconnecting communities to the wage economy (high unemployment leads to people losing the habit or motivation to work, removes the informal networks that provide information about where jobs are available (and possibly about how to get to them), can lead to concentrations of under-maintained property (or of illegal economic activity) which repel potential working residents etc). In general, we would argue that this is a (highly imperfect) measure of the assumed social benefit of generating jobs in the target areas.

Social Infrastructure Savings

- 9.10.18 The issues of “other infrastructure” capacity relate to the possibility that growth in regeneration areas could make use of otherwise underused capacity in (for example) power and drainage networks, or in schools and hospitals, which would require new and more expensive investment in equivalent infrastructure if the development went elsewhere.
- 9.10.19 The implicit savings on Cost of social infrastructures is to do with the costs of “other” infrastructure, apart from the “scheme” we are evaluating, that would need to be provided in different places as a result of the scheme’s impact, and where this would have cost implications for the public sector.
- 9.10.20 The most obvious categories where such needs arise (as a matter of clearly defined policy of provision) and where the costs would most clearly fall on the public sector would be in education and health. Community Infrastructure Levy and/or s106 agreements (or equivalent) can cover some of this, but this does not affect the argument that maintaining standards of public provision will cost more in some locations, not least through land costs.

Conclusions: approach for the UK2070 project

- 9.10.21 Shadow cost of moving jobs and savings in costs of other infrastructure are, we believe, separate – the former is the value of getting someone in a deprived area into employment, the latter is the saving in costs from not having to build social infrastructure for people moving into more expensive locations. These could easily move in opposite directions – an intervention generating jobs for people in deprived parts of London would have a shadow benefit of getting them into employment, but a shadow cost in infrastructure provision if the effect of the intervention was also to draw more people into London.
- 9.10.22 We therefore propose that both Shadow cost and Infrastructures savings measures could be used without double counting.

9.11 Implementation of the shadow value of a job in a deprived area

Most deprived zones

- 9.11.1 The shadow value of having more resident workers in a deprived area needs to be calculated for the target areas.

9.11.2 The identification of the target areas has been done by using the index of multiple deprivation for each of the three nations within Great Britain. We have carried out our own analysis, informed by other previous work¹⁶, to identify the 20% most deprived local authorities across the whole of Great Britain. These are listed in Figure 9-3 and mapped in Figure 9-4. The English local authorities that appear on this list correspond closely to the separate analysis of the 20% more deprived local authorities in England published by MHCLG.

| Depriv ed zones UK | LA | Depriv ed zones UK | LA | Depriv ed zones UK | LA |
|-----------------------------|-----------------------------|-----------------------------|----------------|-----------------------------|----------------------|
| 3 | Hartlepool | 68 | Bradford | 198 | Lewisham |
| 4 | Middlesbrough | 74 | Leicester | 199 | Newham |
| 11 | South Tyneside | 75 | Nottingham | 200 | Southwark |
| 12 | Sunderland | 92 | Boston | 201 | Tower Hamlets |
| 13 | Blackburn with Darwen | 93 | East Lindsey | 203 | Westminster |
| 14 | Blackpool | 94 | Lincoln | 204 | Barking and Dagenham |
| 17 | Halton | 106 | Ashfield | 207 | Brent |
| 20 | Barrow-in-Furness | 110 | Mansfield | 211 | Enfield |
| 22 | Copeland | 115 | Stoke-on-Trent | 212 | Greenwich |
| 25 | Bolton | 130 | Birmingham | 222 | Waltham Forest |
| 27 | Manchester | 131 | Coventry | 228 | Portsmouth |
| 28 | Oldham | 133 | Sandwell | 231 | Southampton |
| 29 | Rochdale | 135 | Walsall | 240 | Hastings |
| 30 | Salford | 136 | Wolverhampton | 264 | Thanet |
| 32 | Tameside | 145 | Luton | 300 | Torbay |
| 35 | Burnley | 146 | Peterborough | 326 | West Somerset |
| 38 | Hyndburn | 151 | Fenland | 338 | Neath Port Talbot |
| 40 | Pendle | 161 | Harlow | 343 | Merthyr Tydfil |
| 41 | Preston | 164 | Tendring | 345 | Blaenau Gwent |
| 47 | Knowsley | 178 | Great Yarmouth | 358 | North Ayrshire |
| 48 | Liverpool | 181 | Norwich | 360 | Glasgow City |
| 50 | St. Helens | 185 | Ipswich | 361 | North Lanarkshire |
| 53 | Kingston upon Hull, City of | 192 | Hackney | 365 | Inverclyde |
| 64 | Barnsley | 194 | Haringey | 366 | West Dunbartonshire |
| 65 | Doncaster | 195 | Islington | | |
| 66 | Rotherham | 197 | Lambeth | | |

Figure 9-3 : Most deprived districts in GB (in SNM zone number order)

¹⁶ *Adjusted indices of multiple deprivation to enable comparisons within and between constituent countries of the UK including an illustration using mortality rates* <https://bmjopen.bmj.com/content/6/11/e012750>

20% Most Deprived Zones

VN 20/12/19
c95_1

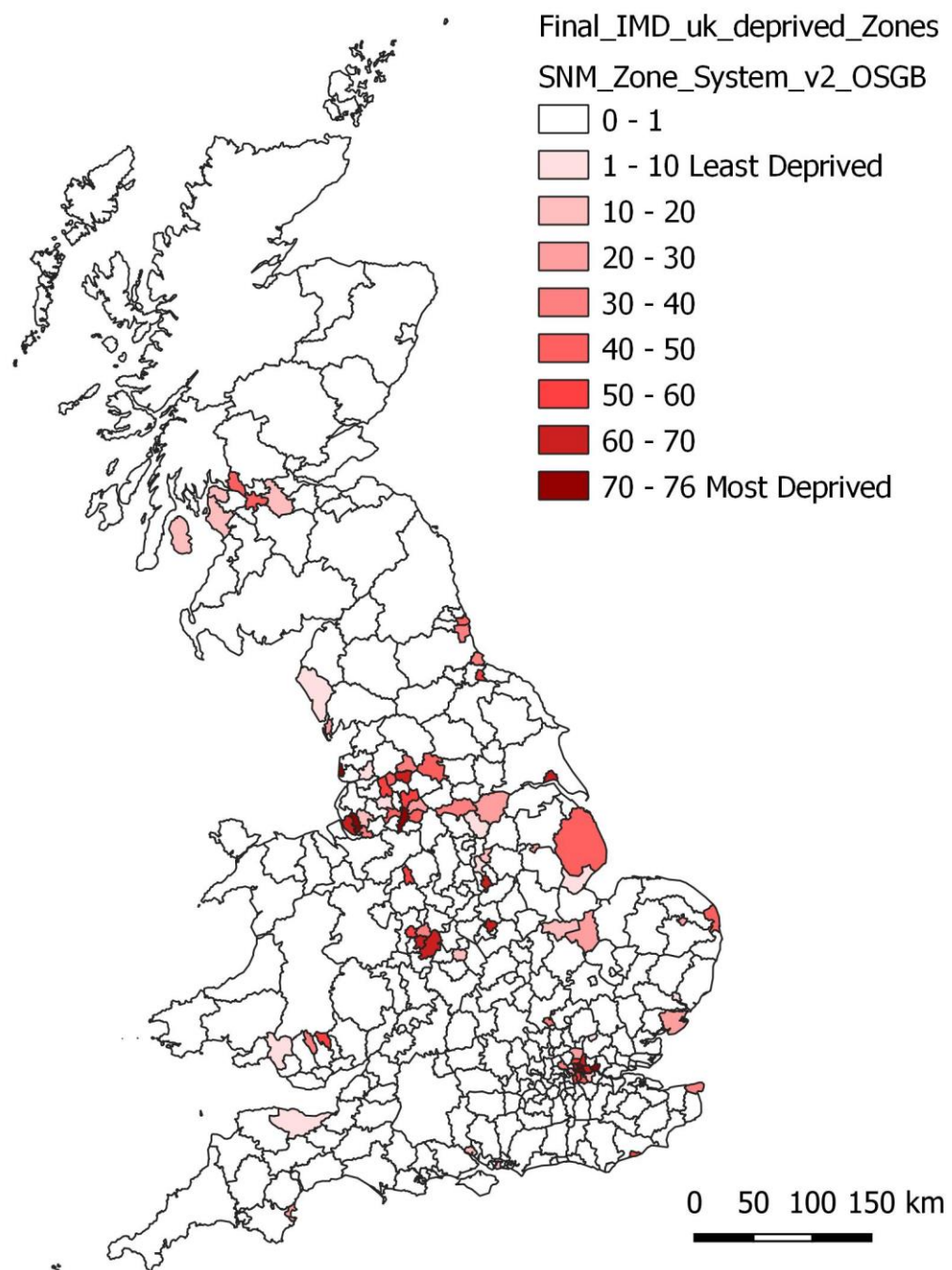


Figure 9-4 Most deprived districts in Great Britain

Gross cost per net additional job

9.11.3 The most recent work we have found for cost per job is by the Homes and Communities Agency in 2015. This gives a “lower” value per job of £28,500.

Assuming that a "permanent" job is one that lasts for 10 years, the yearly cost of additional job is £2850 (in 2015 prices)

- 9.11.4 This figure has been adjusted over time: the value rises in line with GVA/personⁱ.
- 9.11.5 Only for the 20% most deprived areas, we calculated the shadow cost/benefit of jobs moving out/in each deprived local authority in each year by multiplying the shadow cost adjusted over time by the difference in Resident Workers between the test where the scheme is implemented (Alternative Test) and the Reference test.
- 9.11.6 This means that where workers are moving out a deprived zone, there is a disbenefit that needs to be taken account of, while when the scheme is increasing the number of Resident workers in a deprived zones this produces a benefit.

9.12 Implementation of infrastructure savings

- 9.12.1 The infrastructure saving has to do with the costs of "other" infrastructure, apart from the "scheme" we are evaluating, that would need to be provided in different places as a result of the scheme's impact.
- 9.12.2 The calculation of the infrastructure savings is done in 3 steps:
- Estimation of the land required for schools and health facilities per 1,000 residents
 - Use of the residential land values by local authority estimated by MCHLG for England to calculate the land value also for Scotland and Wales.
 - Estimation of the change in the cost of land required for schools and health facilities as a simple linear function of the differences in population – if people move to more expensive areas, this will be a cost, if they move to cheaper areas, a benefit.
- 9.12.3 Information on cost differentials for "other infrastructure" is fairly readily available for England (for example construction costs are generally higher in London – one index put 2018 Outer London construction costs at 111 and Inner London at 117 compared to a UK average of 100; another source gives a building cost per m² of regional hospital at £3,100 in London compared to £2,440-£2,460 for "UK Central" and "UK North", a premium of about £650/m²).
- 9.12.4 The difficult aspect of assessing "other infrastructure" costs is not so much in finding information on cost differentials per unit of provision (either in capital or operational costs) but in establishing
- the additional level of requirement in the area where additional growth is forecast (e.g. how many m² of hospital floorspace would be required per additional resident)
 - the effects in areas where reduced growth (or faster decline) is forecast.
- 9.12.5 A cautious approach would be to assume that "other infrastructure" needs to be renewed in all regions, so – assuming a given demographic scenario for Britain – an intervention drawing more people to London from the Midlands and the North would require so many m² of hospital floorspace at a capital cost of about £650/m² more than if the relocation did not occur. A similar approach could be taken to school provision.

- 9.12.6 Using information from ONS Land Use statistics 2017¹⁷ showing that approximately 0.7% of the land in UK is devoted to community services, we have estimated that this means each person needs roughly 0,0025 ha for schools and hospitals. We have looked at the residential land values as the basis for taking 1ha of land for community services (i.e. we assume it could otherwise be used to build more housing). For these values, we have taken government estimates for England¹⁸. These values are intended for use in appraisal when transport or other schemes bring more land into residential use, so it seems reasonable to use them when population moves effectively take land out of residential use. We have estimated the equivalent values for Scotland and Wales pro rata to the floorspace rents used in the SNM. We have assumed a yield of 5% in order to convert the capital price of land into an annual rent, and we have assumed that land values grow in line with the scenario for growth in GVA/ worker.
- 9.12.7 This sequence of calculations gives a rent value of land required for social infrastructure per resident, for each zone and for each future year. The calculation applied in the ULTrA programs is simply to apply that by the negative of the impact on population, i.e. a decrease in population in one zones at one point in time produces a saving (i.e. a benefit), and an increase produces an extra cost (i.e. a malefit). Given that the demographic scenario is treated as fixed, i.e. the population is assumed not to be changed by the alternative being tested, an overall benefit will result if the net effect of the scheme is to move population to cheaper locations, and vice versa.

9.13 Structure and content of the summary benefits table

- 9.13.1 As an aid to interpreting ULTrA outputs, Table 9-3 summarises the definition of each item in the summary table.

¹⁷ www.ons.gov.uk/aboutus/transparencyandgovernance/freedomofinformationfoi/ukpopulation2017

¹⁸ www.gov.uk/government/publications/land-value-estimates-for-policy-appraisal-2017

Table 9-3 Summary benefits:costs table: definitions

Units: all in £million, 2010 values, discounted to 2010 (except BCR). Shaded items are not currently calculated because they require additional transport network or other analysis not available in the present study.

| Sector | Item | Definition |
|------------|-----------------------------------|--|
| Households | Accessibility | Benefit to households from improved accessibility to opportunities for work and services. NB improved accessibility may arise from any or all of: better transport provision; higher car ownership; more or better-located opportunities |
| | Household environment | Benefit to households from reduced traffic (dependent on data passed from transport model) |
| | Housing consumption | Benefit to households from lower housing cost per household and/or improved space per household. NB all households are represented as renters. |
| | Income | Benefit to households from increased income net of income tax, Council Tax and VAT on household expenditure. Income per household may increase through more household members in work or higher wages per worker. Wages may increase due to higher wages in particular work zones or increased commuting to zones offering higher wages. |
| | Leisure time and commuting costs | Benefit to households in increased leisure time and reduced commuting costs if the number of workers per household decreases. (So if income increases due to more household members in work, this will be negative i.e. a loss of benefit.) |
| | Car ownership costs | Benefit to households from reduced expenditure on car ownership. (So if increased incomes lead to increased car ownership, some of the benefits in income and accessibility will be offset by a negative here representing increase expenditure on car ownership.) |
| | Housing quality | Benefit to households from improved quality of housing areas i.e. from externality effects of higher-quality new development or better maintenance/improvement by other residents |
| | Total - households | Sum of the household benefit components listed above |
| Firms | Productivity | Gains to firms' profits from productivity effects e.g. agglomeration effects (increase in GVA minus increase in wages paid), moves to more productive locations |
| | Accessibility | Benefit from improved accessibility to other businesses |
| | Rent | Benefit from reduced rents |
| | Tax paid | Benefit from reduced taxes on profits. This represents the part of the above gains that is taken in corporation tax, so will always be negative (more tax paid) if the sum of the above three items is positive (more profit made). |
| | Total - firms | Sum of the firms' benefits listed above |
| Developers | Rent income | Benefit to developers/property owners from increases in (gross) income from rents (housing and commercial floorspace) |
| | Development and maintenance costs | Benefit to developers/property owners from reduction in development and maintenance costs (housing and commercial) (so an intervention that increases floorspace supply will show a negative here) |
| | Tax paid | Benefits from reduced taxes on profits. Equivalent to tax paid by firms (see above) except that a proportion of households are assumed to be owner-occupiers and not to pay tax on rent "income" |

| Sector | Item | Definition |
|----------------------|------------------------------|--|
| | Total – developers | Sum of the above benefits to developers/property owners |
| Public sector | Income tax revenue | Increase in government revenue due to more income tax paid |
| | VAT revenue | Increase in government revenue due to more value-added tax paid |
| | Unemployment benefit savings | Reduction in government expenditure due to less unemployment benefit paid |
| | Council tax revenues | Increase in (local) government from more council tax paid |
| | Business rates revenues | Increase in (local) government from more business rates paid |
| | Taxes on profits | Increase in government revenue due to more corporation tax paid |
| | PT revenues | |
| | Total – public sector | Sum of above increases in revenue (or reduction in cost) to public sector |
| Other | Regeneration | Shadow value of net increases in employment for residents in most deprived local authorities |
| | Social infrastructure costs | Savings in cost of land for social infrastructure (schools, hospitals) from population locating in areas where land is cheaper |
| | Environmental | Shadow value of greenhouse gas reduction (and possibly other benefits) |
| | Total | Sum of the benefits to the “other” sector |
| PVB | | Present Value of Benefits = sum of all benefits listed above |
| PVC | | Present Value of Costs (input exogenously) |
| NPV | | Net Present Value = PVB-PVC |
| BCR | | Benefit:Cost Ratio = PVB/PVC |

9.14 Results

9.14.1 After the lengthy explanations in the previous sections, this section finally presents the results of the ULTrA appraisal for the three different Packages, separately and when applied together.

9.14.2 The first four tables show the benefits for

- Great Britain (Total);
- “North” and “South” as defined in Figure 3-1;
- the Package C Corridor as defined in Figure 6-2.

9.14.3 Note that the “North” and “South” figures sum to the Total GB benefit; the Package C Corridor is separate and includes zones in both North and South. All figures are discounted to 2010 and rounded to millions of £ at 2010 prices.

9.14.4 Separate tables for each Scheme have been prepared with the further detail of the results split by “North” and “South” and also for the Package C corridor when relevant.

9.14.5 Table 9-4 shows the ULTrA results for Package A. The overall present values of the benefit this would deliver is in excess of £100 billion – but it should be remembered that this would be an extremely expensive package of investment. The largest single categories of benefits are, not surprisingly, the benefits in accessibility. Benefits to firms are greater than benefits to households, which again is not surprising given the emphasis on inter-city and inter-regional connectivity in this Package, and the importance of business travel rather than commuting or other household travel in those markets.

Table 9-4 Benefits of Package A

| Package A (KX-KS) | | Total | North | South | Package C corridor |
|--|---|----------------|---------------|---------------|--------------------|
| Cost/benefit (£millions, 2010 £, discounted to 2010) | | | | | |
| Households | CS: Accessibility | 35,023 | 20,190 | 14,833 | 2,629 |
| | CS: Car ownership costs | -28 | -17 | -10 | 6 |
| | CS: Income | 7,370 | 4,046 | 3,324 | -114 |
| | CS: Leisure time | -536 | -642 | 106 | 116 |
| | CS: Housing quality | 53 | 49 | 5 | 8 |
| | CS: Housing consumption | 632 | -722 | 1,354 | -91 |
| | CS: Commuting cost | -118 | -274 | 156 | 30 |
| Households total | | 42,396 | 22,629 | 19,767 | 2,585 |
| Firms | PS: Accessibility | 47,593 | 24,878 | 22,716 | 5,534 |
| | PS: Costs | -3,002 | -6,137 | 3,135 | -2,808 |
| | PS: Production | 9,212 | -3,893 | 13,106 | 14,265 |
| | Corporation tax savings | -11,088 | -3,016 | -8,072 | -3,505 |
| Firms total | | 42,715 | 11,831 | 30,884 | 13,485 |
| Developers | Development costs | 556 | 190 | 366 | 207 |
| | Rental income | 1,634 | 8,384 | -6,750 | 3,682 |
| | Property owners' tax savings | 371 | -63 | 434 | -23 |
| Developers total | | 2,561 | 8,511 | -5,950 | 3,866 |
| Public sector | Income tax revenue | 2,468 | | | |
| | VAT revenues | 491 | | | |
| | Unemployment benefit savings | 544 | | | |
| | Council tax revenues | -403 | | | |
| | Business rates revenues | 567 | | | |
| | Tax on profit | 11,088 | | | |
| | Property owners' tax revenues | -371 | | | |
| Public sector total | | 14,384 | | | |
| Rebalancing Benefits | Shadow value of jobs for workers in deprived zone | 741 | 884 | -143 | 262 |
| | Social Infrastructure Saving | 494 | 28 | 466 | -9 |
| Rebalancing Benefits total | | 1,235 | 912 | 323 | 254 |
| Present value of benefits (PVB) | | 103,292 | 43,883 | 45,025 | 20,190 |

9.14.6 For households, there are as just mentioned substantial benefits in accessibility (including the effects of jobs moving to locations that are more accessible for potential workers, and some effects from improved car ownership). The second largest category of benefit is in income (£7 billion (net of taxes) compared to the £35 billion in accessibility benefits) which arises from higher wages and slightly more people in work. Both of these types of benefit are substantially greater in the North than in the South.

9.14.7 The next category of benefit to households from Package A, that in housing consumption (i.e. from being able to occupy a larger dwelling, or paying less for the same dwelling), is much smaller again (£600 million in total), but shows a negative (disbenefit or malefit) in the North and a larger benefit in the South. This is a consequence of the shift in housing demand from South to North, increasing demand in the North and to some extent reducing it in the South, without sufficient compensating changes in the pattern of development. Measures to allow or encourage additional development in the North could convert the negative into a positive, though these would also involve additional development costs.

9.14.8 Moving on to benefits to firms, it can be seen that the same spatial pattern appears in [rent] costs, i.e. a benefit in the South but a malefit in the North. The benefits in improved accessibility [to markets and other businesses] are much greater, and like those for households they are greater in the North than in the South. Additional profits from increased production and productivity are negative in the North and

positive in the South; as discussed in presenting the impacts of the Package, this suggests that higher productivity jobs are tending to concentrate in the South. As mentioned before, this is a matter for potential further investigation and for consideration of how accompanying policy measures could be developed to further enhance the gains to the North.

- 9.14.9 Property owners and developers realise relatively small increases in profits as a result of Package A, with those in the North gaining and those in the South losing.
- 9.14.10 About 14% of the overall benefit, or rather more than £14 billion, is identified as accruing to the public sector, i.e. it would be collected through existing taxes applied to higher earnings, profits or rents, or (to a small extent) through reductions in unemployment benefits. Note that this excludes the use of any additional measures to capture value arising from benefits (such as supplementary business rates or additional community infrastructure levies). Also, the gains or losses to the public sector are all transfers from other sectors, though the transfers for households are not explicit in the table (they are within the income line).
- 9.14.11 Finally, there are fairly modest items for the rebalancing benefits discussed earlier i.e. for the shadow value of redistributing jobs to workers in deprived local authorities, and for the savings in social infrastructure. The scale of these benefits is damped by the fact that Package A does not necessarily redistribute jobs purely to the most deprived authorities, or population to zones where land for social infrastructure is cheaper; it has a general tendency in that direction, but also to create the greatest benefits in major regional centres which are not the most deprived or cheapest locations. As mentioned before, it is difficult to “focus” transport infrastructure projects – especially on this scale – on particular locations. It should also be noted that there is a negative effect for shadow value of jobs in the South, due to jobs being drawn away from more deprived locations such as parts of Inner London.
- 9.14.12 The ULTrA results for Package B are shown in Table 9-5. The general level of benefits here is smaller than that from Package A, by about 40%. The difference in accessibility benefits is particularly marked, with benefits to households almost halved, and benefits to firms reduced by two-thirds. One consequence is that for this more urban/more local package, accessibility benefits directly to households are greater than those to firms, reflecting the higher levels of household travel in more local markets.
- 9.14.13 Benefits from higher incomes are not reduced so much, and very little reduced in the North. In contrast, benefits in housing consumption switch from positive in Package A to negative in Package B, and become more negative in the North, indicating that the demand for housing is being pushed higher than desirable in some locations. Cost disbenefits to firms, arising from higher rents, also increase markedly in the North whilst benefits in the South are reduced. Gains to firms from production and productivity are positive in both North and South, suggesting that more of the gains are due to increasing the productivity of activities in each area rather than transferring low productivity activities northwards as in Package A.

Table 9-5 Benefits of Package B

| Package B (KY-KS) | | Total | North | South | Package C corridor |
|--|---|--------|---------|--------|--------------------|
| Cost/benefit (£millions, 2010 £, discounted to 2010) | | | | | |
| Households | CS: Accessibility | 18,336 | 13,679 | 4,657 | 819 |
| | CS: Car ownership costs | -12 | -1 | -10 | 0 |
| | CS: Income | 5,219 | 3,879 | 1,340 | 147 |
| | CS: Leisure time | -402 | -303 | -99 | -38 |
| | CS: Housing quality | 155 | 119 | 36 | 7 |
| | CS: Housing consumption | -863 | -1,010 | 147 | -68 |
| | CS: Commuting cost | -267 | -273 | 6 | -12 |
| Households total | | 22,167 | 16,091 | 6,076 | 854 |
| Firms | PS: Accessibility | 15,489 | 11,632 | 3,857 | 763 |
| | PS: Costs | -9,307 | -10,505 | 1,198 | -1,509 |
| | PS: Production | 10,149 | 5,455 | 4,695 | 5,963 |
| | Corporation tax savings | -3,289 | -1,364 | -1,924 | -997 |
| Firms total | | 13,043 | 5,217 | 7,825 | 4,219 |
| Developers | Development costs | 372 | 174 | 198 | 46 |
| | Rental income | 14,433 | 15,541 | -1,109 | 2,079 |
| | Property owners' tax savings | -56 | -138 | 82 | -21 |
| Developers total | | 14,748 | 15,577 | -829 | 2,105 |
| Public sector | Income tax revenue | 2,789 | | | |
| | VAT revenues | 500 | | | |
| | Unemployment benefit savings | 514 | | | |
| | Council tax revenues | 93 | | | |
| | Business rates revenues | 1,350 | | | |
| | Tax on profit | 3,289 | | | |
| | Property owners' tax revenues | 56 | | | |
| Public sector total | | 8,591 | | | |
| Rebalancing Benefits | Shadow value of jobs for workers in deprived zone | 611 | 270 | 341 | 146 |
| | Social Infrastructure Saving | 50 | 7 | 43 | -4 |
| Rebalancing Benefits total | | 661 | 277 | 383 | 141 |
| Present value of benefits (PVB) | | 59,209 | 37,162 | 13,456 | 7,319 |

9.14.14 One point to note about both Package A and Package B is that households and firms gain in both the North and South, though the benefits in the North are relatively greater in Package B. In both cases property owners and developers in the South lose.

9.14.15 The benefits of Package C are shown in Table 9-6. These are, as intended, concentrated in the Package C Corridor, and indeed for firms it can be seen that the total benefits are slightly less than those in the Corridor. The general scale of the benefits is less than half that of Package A.

Table 9-6 Benefits of Package C

| Package C (LA-KS) | | Total | North | South | Package C corridor |
|--|---|--------|--------|--------|--------------------|
| Cost/benefit (£millions, 2010 £, discounted to 2010) | | | | | |
| Households | CS: Accessibility | 4,900 | 2,726 | 2,174 | 4,023 |
| | CS: Car ownership costs | -5 | 1 | -6 | -25 |
| | CS: Income | 906 | -274 | 1,180 | 2,106 |
| | CS: Leisure time | -75 | 59 | -133 | -424 |
| | CS: Housing quality | -6 | 1 | -7 | 8 |
| | CS: Housing consumption | -86 | 111 | -197 | -442 |
| | CS: Commuting cost | -61 | -6 | -56 | -124 |
| Households total | | 5,572 | 2,617 | 2,955 | 5,123 |
| Firms | PS: Accessibility | 16,149 | 6,670 | 9,480 | 7,253 |
| | PS: Costs | -1,095 | 300 | -1,395 | -1,777 |
| | PS: Production | 2,283 | -1,303 | 3,586 | 13,265 |
| | Corporation tax savings | -3,609 | -1,186 | -2,423 | -3,862 |
| Firms total | | 13,728 | 4,481 | 9,247 | 14,878 |
| Developers | Development costs | -33 | 5 | -38 | -164 |
| | Rental income | 1,420 | -600 | 2,020 | 3,359 |
| | Property owners' tax savings | -14 | 22 | -36 | -119 |
| Developers total | | 1,373 | -573 | 1,946 | 3,076 |
| Public sector | Income tax revenue | 410 | | | |
| | VAT revenues | 69 | | | |
| | Unemployment benefit savings | 71 | | | |
| | Council tax revenues | 14 | | | |
| | Business rates revenues | 128 | | | |
| | Tax on profit | 3,609 | | | |
| | Property owners' tax revenues | 14 | | | |
| Public sector total | | 4,314 | | | |
| Rebalancing Benefits | Shadow value of jobs for workers in deprived zone | 241 | 83 | 158 | 337 |
| | Social Infrastructure Saving | 2 | 9 | -8 | -15 |
| Rebalancing Benefits total | | 243 | 93 | 150 | 322 |
| Present value of benefits (PVB) | | 25,230 | 6,617 | 14,299 | 23,398 |

9.14.16 The results for the Combined Package are shown in Table 9-7. These are probably best considered by looking at the total (GB) results in comparison with those from the three separate packages; this comparison is presented in Table 9-8.

Table 9-7 Benefits of the Combined Package (A+B+C)

| All Packages (LB-KS) | | Total | North | South | Package C corridor |
|--|---|----------------|---------------|---------------|--------------------|
| Cost/benefit (£millions, 2010 £, discounted to 2010) | | | | | |
| Households | CS: Accessibility | 57,906 | 37,396 | 20,511 | 7,257 |
| | CS: Car ownership costs | -19 | -10 | -9 | -1 |
| | CS: Income | 10,374 | 9,101 | 1,273 | 904 |
| | CS: Leisure time | -822 | -1,250 | 428 | -104 |
| | CS: Housing quality | 247 | 179 | 69 | 40 |
| | CS: Housing consumption | 39 | -1,888 | 1,927 | -458 |
| | CS: Commuting cost | -395 | -683 | 288 | -46 |
| Households total | | 67,331 | 42,845 | 24,487 | 7,593 |
| Firms | PS: Accessibility | 67,624 | 38,771 | 28,853 | 9,794 |
| | PS: Costs | -13,474 | -16,296 | 2,822 | -3,570 |
| | PS: Production | 18,317 | 8,930 | 9,388 | 20,286 |
| | Corporation tax savings | -14,923 | -6,489 | -8,434 | -5,303 |
| Firms total | | 57,544 | 24,916 | 32,628 | 21,207 |
| Developers | Development costs | 994 | 264 | 730 | 49 |
| | Rental income | 17,858 | 24,228 | -6,370 | 6,370 |
| | Property owners' tax savings | 321 | -240 | 561 | -168 |
| Developers total | | 19,173 | 24,253 | -5,079 | 6,250 |
| Public sector | Income tax revenue | 4,151 | | | |
| | VAT revenues | 815 | | | |
| | Unemployment benefit savings | 834 | | | |
| | Council tax revenues | -305 | | | |
| | Business rates revenues | 2,091 | | | |
| | Tax on profit | 14,923 | | | |
| | Property owners' tax revenues | -321 | | | |
| Public sector total | | 22,189 | | | |
| Rebalancing Benefits | Shadow value of jobs for workers in deprived zone | 1,405 | 1,109 | 296 | 647 |
| | Social Infrastructure Saving | 454 | 31 | 424 | -37 |
| Rebalancing Benefits total | | 1,859 | 1,139 | 719 | 610 |
| Present value of benefits (PVB) | | 168,096 | 93,153 | 52,755 | 35,661 |

Table 9-8 Comparison of total (GB) benefits

| | | Package A | Package B | Package C | All Packages |
|--|---|----------------|---------------|---------------|----------------|
| Cost/benefit (£millions, 2010 £, discounted to 2010) | | Total | Total | Total | Total |
| Households | CS: Accessibility | 35,023 | 18,336 | 4,900 | 57,906 |
| | CS: Car ownership costs | -28 | -12 | -5 | -19 |
| | CS: Income | 7,370 | 5,219 | 906 | 10,374 |
| | CS: Leisure time | -536 | -402 | -75 | -822 |
| | CS: Housing quality | 53 | 155 | -6 | 247 |
| | CS: Housing consumption | 632 | -863 | -86 | 39 |
| | CS: Commuting cost | -118 | -267 | -61 | -395 |
| Households total | | 42,396 | 22,167 | 5,572 | 67,331 |
| Firms | PS: Accessibility | 47,593 | 15,489 | 16,149 | 67,624 |
| | PS: Costs | -3,002 | -9,307 | -1,095 | -13,474 |
| | PS: Production | 9,212 | 10,149 | 2,283 | 18,317 |
| | Corporation tax savings | -11,088 | -3,289 | -3,609 | -14,923 |
| Firms total | | 42,715 | 13,043 | 13,728 | 57,544 |
| Developers | Development costs | 556 | 372 | -33 | 994 |
| | Rental income | 1,634 | 14,433 | 1,420 | 17,858 |
| | Property owners' tax savings | 371 | -56 | -14 | 321 |
| Developers total | | 2,561 | 14,748 | 1,373 | 19,173 |
| Public sector | Income tax revenue | 2,468 | | | |
| | VAT revenues | 491 | | | |
| | Unemployment benefit savings | 544 | | | |
| | Council tax revenues | -403 | | | |
| | Business rates revenues | 567 | | | |
| | Tax on profit | 11,088 | | | |
| | Property owners' tax revenues | -371 | | | |
| Public sector total | | 14,384 | 8,591 | 4,314 | 22,189 |
| Rebalancing Benefits | Shadow value of jobs for workers in deprived zone | 741 | 611 | 241 | 1,405 |
| | Social Infrastructure Saving | 494 | 50 | 2 | 454 |
| Rebalancing Benefits total | | 1,235 | 661 | 243 | 1,859 |
| Present value of benefits (PVB) | | 103,292 | 59,209 | 25,230 | 168,096 |

9.14.17 The key finding here is that the effects of the three different Packages are broadly cumulative; as the UK2070 commission intended in proposing them, they serve different and complementary purposes. However, it can also be seen that the combined benefit of all three packages is a little less than the sum of the three packages individually. This indicates that there is some degree of conflict between the different packages, rather than the synergy that might be hoped for. This is not that surprising given the broad-brush way in which the Packages have been defined for modelling and appraisal purposes, and given that each Package is effectively a first attempt. Past experience suggests that synergy between different packages of an overall transport policy is not as easy to achieve as one would hope. We are not at all surprised to find that the Packages considered here would need to be refined – and refined together rather than in three independent exercises – in order to maximise

the benefits obtained from implementing them together. And, of course, any such exercise would need to be undertaken in conjunction with consideration of their costs.

10 DISCUSSION

10.1 Notes on the results

- 10.1.1 The packages modelled here are aimed at representing in part or in full the UK2070 Commission's vision for a future UK Network. The focus is on the infrastructure changes posited as necessary to contribute to a rebalancing of growth and outcomes within the UK.
- 10.1.2 Its impacts are expressed as the impacts of the packages at regional and sub-regional scales, compared to the base scenario in which there are two major transport investments (Crossrail and HS2 phase 1) but where otherwise the assumption is one of "business as usual".
- 10.1.3 Planning policies (permissions) reflect what is required at a Local Authority level in order that these Local Authorities grow in line with NTEM forecasts and maintain the same density of floorspace occupation as today. Broad representation of UK-global Centres of Excellence in the North of England has been included, though other pertinent proposals, like a 'National Spatial Plan' for the UK, have not.
- 10.1.4 The transport network is modelled at a large scale, reflecting the strategic route network and the density of the rail network and its connections. Congestion effects, and indeed the feedback from land-use back into the transport system are modelled only indirectly. There is scope for more detailed transport modelling that could then feed into the land-use modelling done here.

10.2 Limitations

Zone size and coverage

- 10.2.1 The model uses zones which are coterminous with Local Authority districts across Great Britain. This representation enables the use of many datasets which are not available at any smaller disaggregation. It also enables fast, high-level modelling at the expense of more detailed spatial disaggregation which may be slower. It excludes explicit modelling of Northern Ireland, as housing markets and job markets tend to follow island boundaries. The complexities involved with modelling cross-border interactions, and issues with data would greatly increase the cost and complexity of this study. It has been noted by DSC that UK-wide modelling would be preferred to GB-wide, and work to do this is ongoing.
- 10.2.2 There are inconsistencies that emerge from the approach of using Local Authorities as boundaries. While they are good political boundaries, whose use facilitates the utilisation of a large number of datasets, they are poor at representing socio-demographic and economic interactions. A number of these interactions occur at a sub-zonal level and are therefore not considered in detail. Other interactions occur at a higher level (for instance, property/development markets, and commuting patterns). To some extent this has been mitigated, using explicit representation of housing market and travel-to-work areas.
- 10.2.3 The boundary limitations have also limited the coding of intraurban mobility improvements. A vast disparity in size and coverage is seen when comparing, for

instance, boroughs of London with city authorities like Birmingham, or other, smaller cities and towns like Oxford or Milton Keynes. The main questions are around whether the single district is adequate to represent bus/LRT/tram/metro schemes, and if it should be spread out more evenly. There is certainly a case for this in Birmingham, where mobility into the centre spreads beyond its boundary. The same goes for Cambridge, Lincoln, or Hull, where the city authorities are based within whole-county districts, and mobility improvements arguably wouldn't spread much further than the city peripheries. Hereford is an example where the city is not a unitary authority and lies within the Herefordshire boundary, meaning improvements necessarily have had to be extended beyond the city.

Corridor choice

10.2.4 We are confident that the corridors chosen reflect in many ways the various efforts, nationwide, being explored, planned or undertaken to improve mobility within and between urban areas. There are some areas where the input doesn't necessarily reflect the schemes mentioned, and this may be due to the detail of the model, the time it would take to accurately reflect the scheme proposals, or the overall purpose of the modelling.

10.2.5 The corridors chosen reflect to a large extent the most important city travel-to-work areas outlined by Martin *et al.* (2019). Notable omissions include parts of the South West – particularly Exeter – parts of Sussex, Kent and Essex, parts of the East Midlands, and Glasgow and the surrounding area. Scottish impacts would have been more widespread were they to include Glasgow, however, broadly the approach was taken to include a corridor per region.

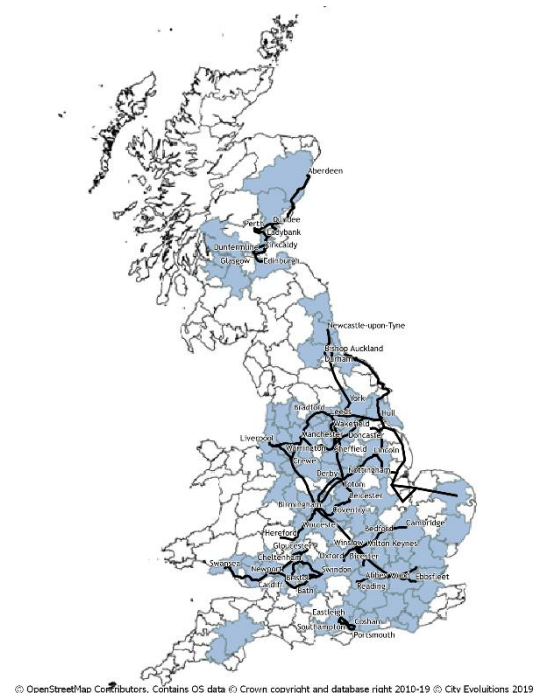


Figure 10-1 85 major city TTWAs, with rail improvements from this study overlaid

Source: © City Evolutions (Martin et al., 2019)

11 SUMMARY AND CONCLUSION

11.1.1 Conclusions can be drawn at three different levels – about

- the packages that have been analysed, and their impacts;
- the methods applicable to analysis and appraisal of such packages;
- the planning process within which transport schemes are identified and selected.

11.1.2 As we have emphasized, the packages that have been tested are broad-brush illustrations of what might be done in the three different aspects of the connectivity revolution that the UK2070 Commission is considering, and in promoting rebalancing of the economic through promoting the growth of advanced manufacturing and related services around a major research and development hub. The results show that such measures can make a significant contribution to rebalancing, though other initiatives are still needed. They also show that care and the careful definition and selection of projects are needed in order to identify a potentially successful package of investment. The example packages modelled in the present project are not entirely complementary to one another; the benefits of the three packages combined are rather less than the sum of their individual benefits, where ideally one would like to see some synergy giving rise to an overall benefit greater than the sum of the parts - though it remains to be considered whether it is really possible to expect such synergy from packages which are trying to deliver benefits to a range of very different areas.

11.1.3 This last point relates in particular to the question of how much conventional impact or benefit can be expected to arise from policies along the lines of Package C which are by definition trying to improve the quality of life for people in relatively small settlements and small local economies. This leads into the second conclusion, which is that we believe the analysis reported here, whilst broad-brush both in the definitions of schemes and in much of the detail of the modelling, does in our view demonstrate that it is possible, using these or comparable methods, to carry out systematic impact assessment and appraisal of the economic impacts of such packages on a national scale. Within this analysis, more attention needs to be given to the value that can be attributed to achieving rebalancing. To exclude rebalancing from the benefits considered in assessing the economic case for a proposal, leaving it purely to the strategic case and so assuming that it has no value, seems clearly wrong; but measuring and valuing rebalancing is a challenge. The shadow values that we have used as the basis for the value of getting additional jobs into deprived areas is based on the low end of a range of costs for getting the same effects by other economic regeneration measures. It can be argued both that using the low end of the range is optimistic, and that the resources put into economic regeneration of deprived areas have clearly been insufficient; and hence for both reasons that the valuation of additional jobs in deprived areas should be higher. At the same time it should be kept in mind that transport investment is not a precise tool for trying to achieve social change; the results in this report show that where less prosperous areas are connected to more prosperous ones, a significant part of the resulting gains flows to the more prosperous end.

11.1.4 Finally, there are the questions of how an extensive programme of interlocking investments packages and other improvements in transport might be delivered. We are not attempting here to consider that in terms of the forms of planning and governance that might be required to design and deliver such a programme. What we can consider is that, in addition to the improvements in appraisal methodology referred to above, there is a need to advance the ways in which appraisal methods are used so as to inform programme design processes and to drive these processes so that they focus on meeting targets in terms of achieving at least a specified form and degree of rebalancing across different parts of the country. A successful programme of national rebalancing is highly unlikely to emerge from one-at-a-time scheme appraisals (or from reforming the appraisal of schemes), but requires an iterative process between analysis of what whole programmes can deliver, consideration of what targets are to be met, and refinement of the possible programmes. This process has to have the capacity to seek to devise and design interventions to meet particular requirements where other aspects of the planning system are failing to bring these forward (Package C in the present work is a very simple example of this, in defining a set of interventions to meet a particular need). This process can and should still use analysis and appraisal to test the expected impacts of investment and other proposals but looking at multiple schemes and applying a more inclusive definition of value for money.

11.2 **Areas for further exploration**

Outline

11.2.1 The work done here only models one part of the 2070 vision for UK infrastructure. There are multiple land use policy levers which can be modelled within DELTA and the SNM which haven't been explored here. Two key areas for expansion of this work would be first to look at the wider economic effects of the schemes explored – that is, how the value of the schemes extends beyond gains to accessibility and redistribution/growth in employment and output. The other is to look at how other revolutionary effects in parts of the UK economy outside the transport network and boosts to R&D might maximise the value and benefits of a UK Network.

The impact of change in non-transport markets

11.2.2 The approach taken within this study looks mainly at the issue of additional transport investment/improvement compared to the current situation. In addition, it includes a sweeping look at the institution of UK-global centres of excellence and the potential effects of enhanced productivity growth in the North. It does not consider other areas of exploration outlined by the Commission, like the following, which would affect forecast growth trajectories input to the model:

- a national spatial plan for the UK;
- a significantly enhanced UK Investment Fund;
- a rise in the 'cap' on public sector funding of major infrastructure; or
- other structural changes to public sector investment and access to funds.

- 11.2.3 This report also does not consider how changes to taxation – specifically to share the uplift in land values – might change analysis of the outcomes of the modelling.
- 11.2.4 These areas for further exploration do not detract from the fact that this report has demonstrated some significant possible effects of a Connectivity Revolution and/or enhanced growth across the North within Great Britain and, by extension, the UK

REFERENCES

- Arup. (2018). *UK Innovation Districts and Knowledge Quarters: Driving more productive growth*. Arup. Retrieved from <https://www.arup.com/-/media/arup/images/publications/i/uk-innovation-districts-group.pdf>
- Bridges, T. (2019). *The MIT of the North? Building an innovation-driven economy*. Arup. Retrieved from http://uk2070.org.uk/wp-content/uploads/2019/09/Bridges_UK2070_Think_Piece.pdf
- Greengauge 21. (2012). *Great Western Conditional Output Statement*. Greengauge 21. Retrieved December 3, 2019, from <http://www.greengauge21.net/wp-content/uploads/GWP-COS.pdf>
- IPPR. (2018). *Prosperity and Justice: A Plan for the New Economy*. Cambridge: IPPR Commission on Economic Justice. Retrieved December 3, 2019, from https://www.ippr.org/files/2018-08/1535639099_prosperity-and-justice-ippr-2018.pdf
- Jin, Y., Denman, S., & Wan, L. (2019). *UK2070 Futures Modelling Technical Report Draft*. University of Cambridge, Department of Architecture. Cambridge: Martin Centre for Architectural and Urban Studies. Retrieved December 3, 2019, from <http://uk2070.org.uk/wp-content/uploads/2019/05/UK2070Commission-MODELLING-TECHNICAL-REPORT.pdf>
- Martin, R., Bailey, D., Evenhuis, E., Gardiner, B., Pike, A., Sunley, P., & Tyler, P. (2019). *The Economic Performance of Britain's Cities: Patterns, Processes and Policy Implications*. City Evolutions. Retrieved December 3, 2019, from <https://www.centreforcities.org/wp-content/uploads/2019/02/The-Evolving-Economic-Performance-of-Britain%E2%80%99s-Cities-Patterns-Processes-and-Policy-Implications.pdf>
- Metro Dynamics. (2019). *A Powerhouse for the West*. Metro Dynamics. Retrieved December 3, 2019, from <https://www.apowerhouseforthewest.org.uk/wp-content/uploads/2019/07/A-Powerhouse-for-the-West-Metro-Dynamics-July-2019.pdf>
- Midlands Connect. (2018). *Our Routes to Growth*. Retrieved December 3, 2019, from https://www.midlandsconnect.uk/media/1204/midlands-connect-ar-v18_final_web.pdf
- Transport for South Hampshire. (2013). *Transport Delivery Plan 2012-2026*. Retrieved December 3, 2019, from <https://documents.hants.gov.uk/transport-for-south-hampshire/TransportDeliveryPlan.pdf>

APPENDIX A TRANSPORT INPUTS TO SNM

A.1 Car

A.1.1 Car generalised costs are calculated using straight line distances between zone centroids and a piecewise interpolation of speed with a minimum and a maximum for distances below and above 10 and 80km respectively. Figure A-1 gives a representation of car speed over distance.

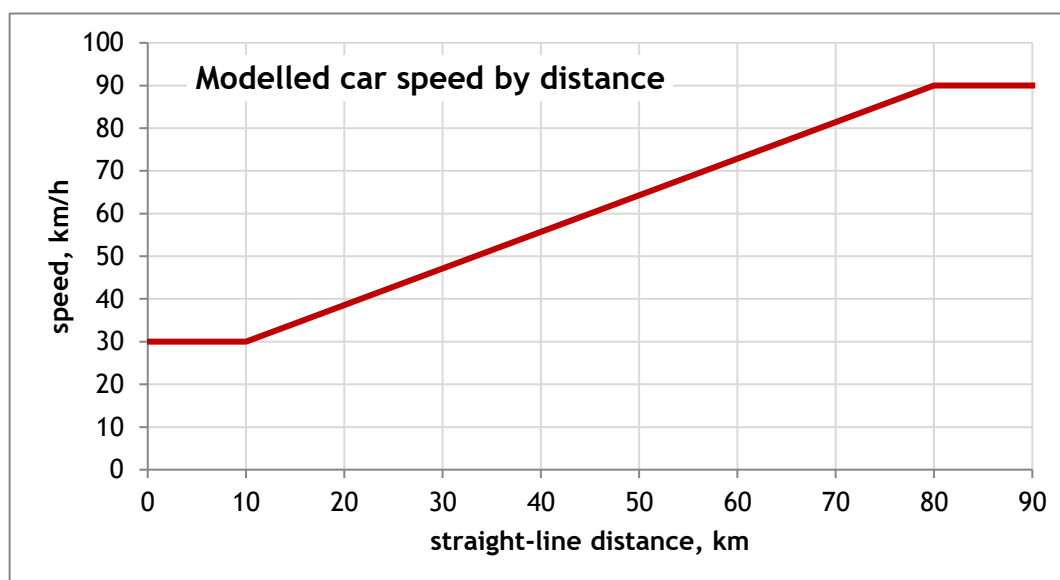


Figure A-1 Car speeds in SNM

A.1.2 Vehicle operating costs are calculated by km using WebTAG¹⁹ forecast growth over time.

A.1.3 Conversion to minutes has been done using WebTAG values for VOT.

A.2 Rail

A.2.1 The matrices of rail generalised costs have been produced using the following process:

- Categorisation of zone pairs based on the density of network and whether in high-speed (intercity) rail corridor;
- assumptions about speed, access-egress distance, service frequency and wait time; and
- assumptions about fare per kilometre by category and purpose.

A.2.2 The categorisation was done by superimposing the UK railway network onto the SNM zoning system.

¹⁹ WebTAG ('TAG' for Transport Analysis Guidance) gives guidance to transport practitioners, with guidelines on how to build and operate models. The data here are derived from these values which are standardised across practitioners.

A.2.3 Each SNM zone was classified sequentially according to the following exclusive criteria (that is, one SNM zone could fall in a number of those categorizations, but the cost between a zone-pair would only be taken at the first instance of appearance of that zone pair, considered in the order given below):

1. High-speed rail (high-speed by current standards):
 - a. *London – Non-London*
 - b. *London - Exeter*
 - c. *London - Bristol*
 - d. *London - Cardiff*
 - e. *London – Birmingham – Manchester*
 - f. *London – Glasgow (via Preston)*
 - g. *London – Sheffield*
 - h. *London - Nottingham*
 - i. *London - Leeds*
 - j. *London - Edinburgh (via York)*
2. SNM zones falling in regions with dense railway network:
 - a. *London and adjoining parts of South-East and the East of England*
 - b. *West Midlands*
 - c. *Liverpool-Manchester*
 - d. *Leeds-Sheffield*
 - e. *Glasgow*
3. SNM zones belonging to intermediately dense railway network
4. SNM zones belonging to sparse railway network (i.e. connected to only 2 or 3 other SNM zones via rail)
5. Extremities: SNM zones with a railway station that is only connected by one line to another station in a different SNM zone: i.e. Central Wales to Shrewsbury, Borders to Edinburgh) (for these, identify what that point is, i.e. Shrewsbury for Central Wales);
6. All other zones that do not fall those categories.
7. SNM zones with no rail stations.

A.2.4 Below, in Table A-1 are the speed and frequency assumptions by category:

Table A-1 Rail distance, speed and frequency by category in SNM

| Category | Distance | Speed (km/h) | Frequency (per hour) |
|---|-----------------------------------|--------------|----------------------|
| Within London | All | 30 | 6 |
| Within any one of the “intensive service” regions | up to 15km | 30 | 3 |
| | 15-60km | interpolated | 3 |
| | over 60km | 70 | 3 |
| Between “stations” on any one of the “high-speed” routes | up to 16km | no service | no service |
| | 16-100km | 60 | 3 |
| | 100-500km | 90 | 2 |
| | over 500km (i.e. London-Scotland) | 120 | 1 |
| Between “stations” on the HS2 route | up to 16km | no service | no service |
| | 16-200km | 150 | 6 |
| | 200km-500km | 180 | 4 |
| | Over 500km | 220 | 3 |
| Medium-service region to London | all | 60 | 0.5 |
| Low-service region to London | all | 50 | 0.33 |
| Within the low-service region | all | 40 | 0.25 |
| All other possibilities | all | 50 | 0.33 |

A.2.5 Following in Table A-2 are fare rates by purpose:

Table A-2 Rail fares in SNM

| Category | Distance | Business | | | Commuting | | | Other | | |
|----------------|----------|----------|------|--------|-----------|------|----------|-------|------|--------|
| | | Min | £/km | Max | Min | £/km | Max | Min | £/km | Max |
| Within London | All | 4.00 | 0.50 | 10.00 | 4.00 | 0.50 | no limit | 3.00 | 0.33 | 7.50 |
| To/from London | All | 4.00 | 0.40 | 150.00 | 4.00 | 0.40 | no limit | 3.00 | 0.20 | 100.00 |
| All other | All | 3.00 | 0.30 | 100.00 | 3.00 | 0.30 | no limit | 2.00 | 0.20 | 75.00 |

A.2.6 The following assumptions were made for distance from origin and destination, to which the same function for generalised cost was applied:

- High Speed 2: 2km
- London/High-Speed rail: 1km
- Dense railway network regions: 4km
- Medium-dense network regions: 10km
- Low-density/extremities: 20km

- A.2.7 Regarding **waiting times**, high frequency services (frequency > 8tpd) have a waiting time of half of headway. Medium frequency services (1tpd < frequency < 8tpd) have wait times calculated using the function

$$w = \alpha h \times \exp(-\beta h) + \gamma$$

- A.2.8 The model uses parameters $\alpha = 0.62$, $\beta = 0.00085$, and $\gamma = -6.82$, which results in waiting times following the curve outlined in Figure A-2.

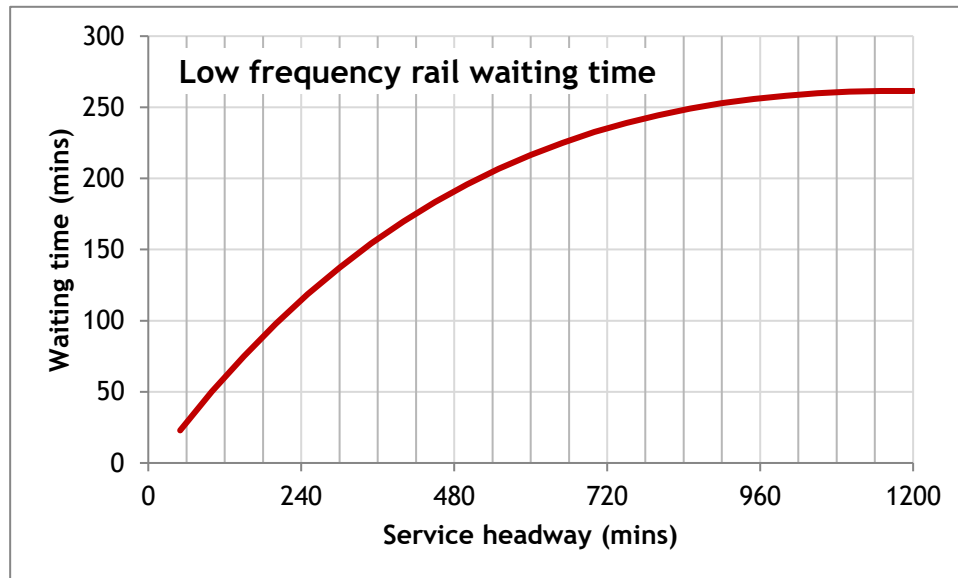


Figure A-2 Low frequency waiting time function for rail

- A.2.9 As with all other modes, any non-time costs are converted to time using VOT by purpose.

A.3 Air

- A.3.1 Air matrices are input for journeys between airports (hubs). The total generalised cost from each SNM zone to every other SNM zone is calculated using the hub-to-hub matrix and the fastest mode from origin to hub and from hub to destination. Only those journeys over 400km are considered in the final matrix, and then only for business and other purposes (not commuting).

A.4 Bus

- A.4.1 Bus matrices comprise in-vehicle time, a constant wait time of 15 minutes, and a fare rate of 40p/km for business/commuting (20p/km for other).
- A.4.2 For distances below 5 mi/8 km are a constant 7.5 mph/12.0 km/h, so as to avoid negative speeds. Above 8 km, a logarithmic function is used, as shown in Figure A-3.

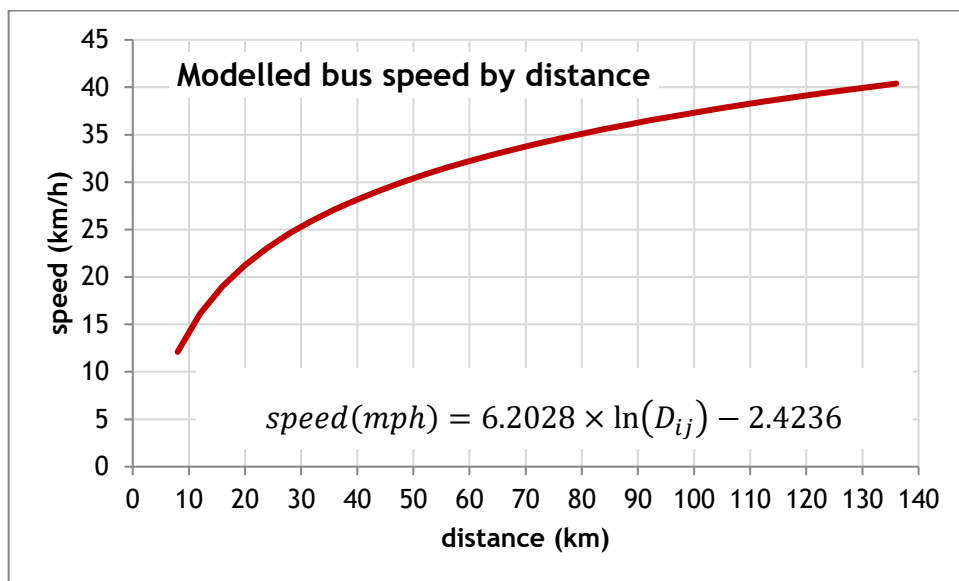


Figure A-3 Bus speeds in SNM

A.5 Walk

Walk generalised costs are input simply as the travel time between zones at a mean speed of 5km/h. No distances greater than 8 km are considered for walking

1. ⁱ (from the SNM work [\\selenium\Projects\0_34_SNM\Project_work\REM\Economic_Scenario_NTEM7_act31_corrected.xlsx](#))