



Assessing the productivity benefits of improving inter-city connectivity in Northern England

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Executive summary

This report for the UK's National Infrastructure Commission explores the following question:

'Is there a role for improved inter-city transport connections to contribute to the economic performance of the Northern Powerhouse?'

If so:

- (i) **what is the potential scale of productivity impacts?**
- (ii) **what are the conditions under which these impacts are likely to be comparatively greater?'**

To address the question robustly, we have drawn together the best available evidence, both theoretical and empirical. We have complemented this with new analysis, making clear our assumptions and appropriate interpretation. We remain open about the current gaps in knowledge and where uncertainties remain.

This report reflects the forefront of thinking on these issues and seeks to advance the current knowledge and evidence base in a transparent way. We are grateful for the input and oversight of Professor Stephen Gibbons – Director of the Spatial Economics Research Centre at the London School of Economics; and for the modelling support of Stephen Law at the Bartlett Space Syntax Laboratory, University College London.

Key findings

To address our overarching question, we have investigated a number of sub-questions, as shown in **Figure 1**. Overall, we have several key findings for policy makers:

- Improving inter-city transport connections is able to create an opportunity to boost economic performance, especially where investment is targeted on links where there is scope **both** to unlock transport constraints, and to drive enhanced economic performance (subject to other conditions being in place).
- Inter-city transport improvements can unlock gains in productivity particularly where investments are targeted on routes demonstrating signs of current and future congestion and overcrowding; and are heavily used by commuters, freight and business travellers.
- The importance of unlocking the economic potential of transport routes heavily used by freight in the north must be noted given the substantial planned investments in ports (such as Liverpool, Hull and Newcastle) and

the importance of surface access to international airports, such as Manchester Airport, and other regional airports.

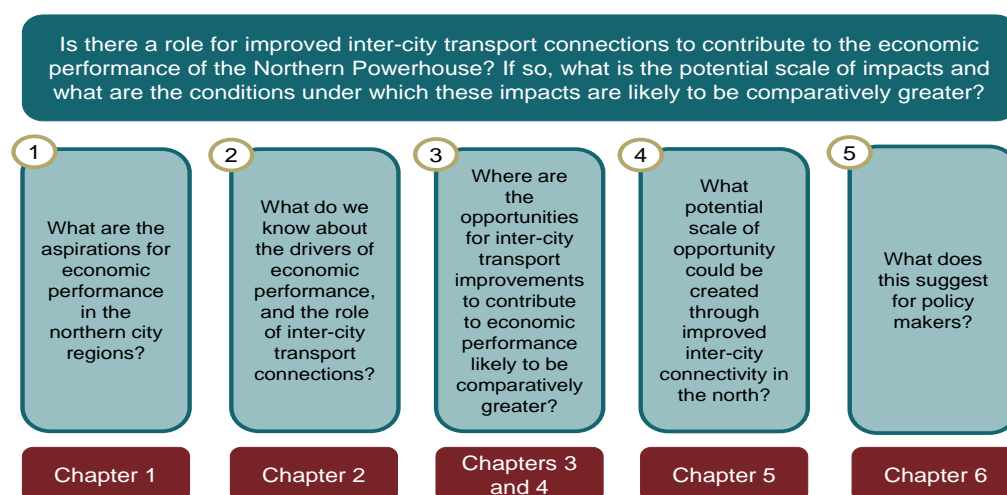
- The extent to which inter-city transport connections are able to drive economic performance will crucially depend on the following.
 - **Other drivers of economic performance.** Transport improvements can only increase access to skills if there are workers with those skills within reach. **Investing in skills of the labour force is critical.** Likewise, other economic drivers (housing, amenities, etc.) must be sufficient and complementary.
 - **Intra-city connections.** Gains from inter-city connectivity can only be fully realised if the door-to-door journey is taken into account. Therefore, within-city travel must be adequate to cope with current and new journeys that are associated with vibrant and growing economic centres.
- Policy makers may therefore wish to focus attention on inter-city connections in which the following characteristics are present.
 - **Large and fast growing cities.** The scale of potential to deliver gains in absolute economic performance (overall earnings) is likely to be greater for large and fast growing cities.
 - **High and intermediate skills.** There is considerable evidence that gains from accessibility are greater for workers with higher, or intermediate, skills levels.
 - **Relatively high shares of sectors for which face-to-face or business-to-business contacts are important.** Producer services (which include finance, insurance, real estate and consulting services)¹ and transport services are most amenable to gains from accessibility improvements.
 - **Cities already relatively closer together (in terms of travel times).** The benefits of increased accessibility decline rapidly with travel time from source, particularly for service sectors.
 - **Adequate intra-city connections.** Inter-city links are only ever going to be part of a journey. The overall change in accessibility depends on door-to-door journey times so intra-city connections must be adequate.

¹ SIC codes 65 to 745.

Overview of our approach

Our approach is described in **Figure 1**. We have addressed each question in turn, as described below.

Figure 1. Understanding the potential role of inter-city transport connections in enhancing economic performance of the Northern Powerhouse.



1. What are the aspirations for economic performance in the Northern city regions?

Historically, there has been a productivity gap between the North and South of England – particularly when compared to productivity performance in London and the South East. GVA growth in the Northern Powerhouse region² has been below the UK average over the past 10 years, and its productivity (when measured in terms of GVA per worker) is 29% below productivity in London (Centre for Cities 2015).

The Northern Powerhouse policy agenda aims to address the economic performance gap between the North and the South to contribute to a spatial rebalancing of economic activity in the UK (Osborne 2015). More specifically, the aim of Transport for the North (TfN) is “...for economic growth in the North to be at least as high as the rest of the country, to complement and act as a balance to the economic weight of London.” Alongside detailed plans being developed by the Northern city regions, improving transport connections is seen

² For the purposes of our analysis, we assume that the Northern Powerhouse includes the six Northern city regions of Hull, Leeds, Liverpool, Manchester, Newcastle and Sheffield. These are the city regions whose work is being taken forward by TfN.

as one of the important components to achieving this ambition. TfN notes that “...a transformation in connections between the great cities of the North and beyond will enable them to increase their productivity to meet the levels currently only seen in London and the South East.” (Transport for the North 2015a).

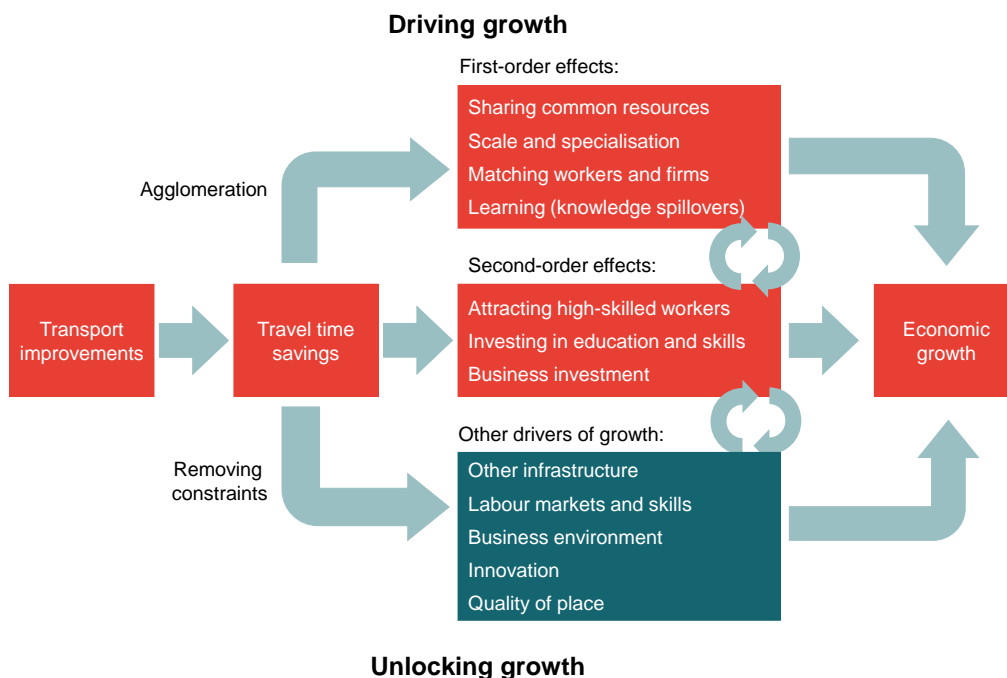
The analysis in this report therefore focuses on the potential contribution of improved inter-city connections in particular. However, as we describe below, **opportunities to boost economic performance can only be fully realised if other drivers of economic performance are adequate and complementary.**

2. What do we know about the drivers of economic performance?

The evidence is clear that there are a range of factors that drive economic performance. Each driver is likely to be necessary, though not sufficient by itself, for fully realising opportunities. The drivers include the labour market and skills, infrastructure, the business environment, innovation and quality of place.

Transport resides in the infrastructure driver. Interventions that enhance transport can create opportunities to improve economic performance in two particular ways, as shown in **Figure 2**.

Figure 2. Transport interventions and economic performance



As **Figure 2** shows, transport has a role in the following:

- **Unlocking growth.** Transport infrastructure can remove bottlenecks and unlock the economic potential of other drivers of growth.
- **Driving growth.** Transport can stimulate the economy by bringing people, firms and places effectively closer together and generate ‘agglomeration benefits’ which directly increase productivity. These are created through:
 - **First-order effects.** Agglomeration increases the productivity of the existing stock of workers and firms, by enabling scale and specialisation, better matching among workers and firms, and learning and knowledge spillovers. First-order effects increase productivity holding the composition of the economy (workers and firms) constant. Therefore, they are not particularly dependent on other drivers of economic performance.³
 - **Second-order effects.** High-skilled workers and investment can be attracted into an area in response to the reduced travel times and associated rise in wages and returns to investment. This changes the economic composition of the area and adds to economic performance.

To realise the potential for inter-city transport connections to contribute to economic performance, there are three critical factors to consider:

- i. **Other growth drivers must be adequate and complementary: transport improvements alone will not be sufficient.** For example, quality housing and amenities are needed to attract high-skilled workers to the area, and a favourable business environment is needed to increase investment.
- ii. **Intra-city transport networks are important to realising the growth opportunity:** improved inter-city travel could increase flows into the city centre. If those central networks become congested then the potential accessibility gains could be eroded.
- iii. **Impacts over time imply movement of businesses and workers.** There is the potential for some areas to gain (if productive workers move in) at the expense of other areas (if productive workers move away), yet there is little evidence to suggest the scale or direction of such changes.

³ However, to the extent that improvements in inter-city transport connectivity increase traffic flows, it may be necessary to invest in intra-city transport networks to ensure that congestion does not occur (because congestion could erode any improvement in door-to-door journey times).

3. Where are the opportunities for inter-city transport improvements to contribute to economic performance likely to be comparatively greater?

The identification of transport corridors that can create greater opportunities for boosting economic performance will depend on how we see the role of transport in promoting economic performance.

- **To unlock growth:** Our analysis of transport performance suggests the following.
 - The links with the highest commuter demand are those between Manchester and Liverpool (road and rail), Manchester and Leeds (for rail only), and Leeds and Sheffield (road and rail). In each case, flows in the morning peak are relatively greater from the smaller to the larger city, reflecting travel to dense employment centres. Lower than expected travel flows along certain corridors may also indicate transport constraints.
 - The greatest pressures on the strategic road network are on the M62 between Liverpool and Manchester, and also between Manchester and Leeds; on the M60 around Manchester; on the M1 near Sheffield; on the M6 leading into Manchester; and, on the A1(M) near Newcastle. On the rail network, the greatest (morning peak) pressures are on services into Manchester and Leeds.
 - Key freight routes, particularly those around ports attracting new investments, such as Liverpool and Hull, are likely to experience significant increases in traffic. The M62 is a critical freight link (freight is around 40% of traffic).
 - Commuter flows between Manchester and Sheffield, and between Manchester and Hull, are significantly lower than expected given the characteristics of the cities and the distance between them. This may indicate the existence of transport constraints.
- **To drive growth:** The greatest comparative opportunity for driving economic performance through inter-city transport improvements is on connections between cities that have the following characteristics:
 - **Large and fast growing cities.** The potential gain in overall earnings is likely to be greater by improving connections between large and fast-growing cities simply because of the volume of workers who would benefit from that boost in productivity. Cities with the largest numbers of jobs are Manchester, Leeds and Newcastle.
 - **High and intermediate skills.** There is considerable evidence that productivity gains associated with improved accessibility are greater for

workers with high, or intermediate, skills levels. Productivity levels in terms of GVA/worker vary across the city regions. For example, Liverpool, Manchester and Leeds (which have the highest levels of productivity) have GVA/worker which is around 11–12% higher than Sheffield (which has the lowest level of productivity).

- **Relatively high shares of sectors for which face-to-face or business-to-business contacts are important.** Producer services (which include finance, insurance, real estate and consulting services)⁴ and transport services are most amenable to gains in accessibility and associated increases in earnings. The Manchester and Leeds city regions have higher proportions of their economies in producer services than the Northern Powerhouse average.
- **Cities already relatively closer together (in terms of travel times).** The benefits of increased accessibility decline rapidly with the travel time from the source, particularly for service sectors. We note that Liverpool–Manchester (fastest time of 32 minutes by rail) and Leeds–Sheffield (fastest time of 40 minutes by rail) are closer together than the connections between the remainder of the six city regions: for example, Manchester–Sheffield, 48 minutes; Hull–Leeds, 55 minutes; Hull–Sheffield, 86 minutes; Newcastle–Leeds, 87 minutes; and Leeds–Manchester, 49 minutes.

4. What scale of opportunity could be created through improved inter-city connectivity in the North?

We have carried out analysis of the changes in access to workers (‘accessibility’) associated with improving rail travel times between the travel to work areas (TTWAs) around major Northern cities⁵. We consider scenarios of improved rail times between four city pairs plus a scenario in which all inter-city rail journey times improve, all in line with TfN aspirations⁶.

Our findings are consistent with the notion that relative gains in earnings are likely to be greater when improving connections between larger and more productive (higher skilled) cities with relatively shorter travel times between them.

⁴ SIC codes 65 to 745.

⁵ The equivalent analysis using road travel times was not possible in the timeframe of this study.

⁶ See Chapter 5 for the detail.

We have compared the gains in accessibility (access to resident workers) for the following scenarios. These were selected because they reflect connections between cities of different sizes, economic compositions and rail travel time proximity, as well as different levels of inter-city commuter flows. They allow a comparative analysis to be carried out. The scenarios are:

- Leeds to Manchester;
- Manchester to Sheffield;
- Liverpool to Manchester;
- Leeds to Hull; and
- All Northern Powerhouse inter-city rail aspirations being achieved.

We find the following.

- Improving the rail travel time between the largest cities (Leeds and Manchester) from 49 minutes to 30 minutes leads to gains in accessibility (i.e. number of workers to whom cities have access) for all six of the largest city regions. Accessibility of Leeds could increase by around 2.8%, Hull by 1.5% and Manchester by 1.3% (the latter increase is relatively lower as it starts from a higher base). This translates to an estimated gain in total earnings for the six Northern city regions (ITWAs) in the order of £30 million per year or £62 million nationally, including the wider northern area.
- Improving other city connections could also result in earnings increases, though of a lower magnitude. For example, improving the rail journey time between Manchester and Sheffield from 48 minutes to 30 minutes could offer a gain in earnings to the six northern city regions (ITWAs) of £18 million a year with a national gain of £41 million per year, including gains to the wider northern region. Improving journey times between Liverpool and Manchester from 32 minutes to 20 minutes could offer an annual gain of around £12 million in earnings to the six city regions (ITWAs) and an annual £18 million nationally, including the wider northern regions.
- Of our scenarios modelled, improving the rail link between Hull and Leeds from 55 minutes to 45 minutes could offer a comparatively smaller gain in earnings. Our analysis suggests a gain in annual earnings of £2 million in the six northern city regions (almost all gain is in Hull) or £3 million per year nationally, including the wider northern area.

These estimated gains in annual earnings are *additional* as they are not captured within the standard approaches to assessing the user benefits of a transport intervention (which largely capture the ability of the intervention to unlock growth and are largely driven by time savings, reductions in collisions or

accidents or reduced overcrowding). Agglomeration impacts would be expected to form *just one part of any assessment of the benefits of a transport intervention*. Investment decisions should be informed by an assessment of all anticipated costs and benefits of an intervention. An assessment of the costs and benefits is beyond the scope of this particular study but any productivity gains would need to be considered alongside other economic impacts, environmental considerations (such as emissions or landscape impacts) and social effects.

This analysis is based on a number of assumptions as described in Chapter 5.

5. What does this suggest for policy makers?

There are some emerging findings that are relevant and important for policy makers as they seek to boost the economic performance of the North. As noted at the start of this summary, our findings are the following:

- Improving inter-city transport connections is able to create an opportunity to boost economic performance, especially where investment is targeted on links where there is scope *both* to unlock transport constraints, and to drive enhanced economic performance (subject to other conditions being in place).
- To unlock the gains in economic performance from improved inter-city connections, investment should be targeted on routes demonstrating signs of current and future congestion and overcrowding; and heavily used by commuters, freight and business travellers.
- The importance of relieving constraints on routes heavily used by freight must be noted given the substantial planned investments in ports (such as Liverpool, Hull and Newcastle) and the importance of surface access to international airports, such as Manchester Airport, and other regional airports.
- The extent to which inter-city transport connections are able to drive economic performance will crucially depend on whether other economic drivers are sufficient and complementary; and if intra-city connections are adequate.
- Policy makers may therefore wish to focus attention on inter-city connections in which the following characteristics are present.
 - Large and fast growing cities.
 - Prevalence of high and intermediate skills.

- Relatively high shares of sectors for which face-to-face or business-to-business contacts are important.
- Cities already relatively closer together (in terms of travel times).
- Adequate intra-city connections.

Chapter 1: The policy context

Chapter overview

In this chapter, we provide an overview of the strategic policy context in Northern England. This forms the backdrop against which investing in improving connectivity between cities in the North can be considered.

In the following sections, we set out the motivations for, and aspirations of, the Northern Powerhouse policy, current economic growth aspirations in Northern cities, aspirations for transport system investment in the North, and the role of devolution. We analyse local economic geography and transport system performance in Northern cities in more detail in later chapters.

1.1 Northern Powerhouse policy

In this section, we set out the motivating factors for developing a Northern Powerhouse, and its aspirations.

Motivation for developing a Northern Powerhouse

Historically, there has been a productivity gap between the North and South of England, particularly when the comparison is with productivity performance in London and the South East. Gross value added (GVA) growth in the Northern Powerhouse region⁷ has been below the UK average over the past 10 years, and its productivity (when measured in terms of GVA per worker) is 29% below productivity in London (Centre for Cities 2015).

The productivity gap is evident across all the large cities in Northern England. The City Growth Commission analysed the largest 15 metro areas in the UK,⁸ which include Greater Manchester, Merseyside, West Yorkshire, South Yorkshire, and Tyne and Wear. It found that, outside London, only the Bristol metro area had higher productivity than the national average.

Alongside this productivity gap, which is expected to continue in the absence of intervention, the population of Northern cities is forecast to continue growing. Across the six Northern city regions we focus on, annual population growth is projected to be 0.89% from 2016 to 2026.⁹ This is more rapid than the 0.77%

⁷ For the purposes of our analysis, we assume that the Northern Powerhouse includes the six Northern city regions of Hull, Leeds, Liverpool, Manchester, Newcastle and Sheffield. These are the city regions whose work is being taken forward by Transport for the North.

⁸ Metro areas are defined as cities with an overall population of over 500,000, including the city centre, suburbs, and surrounding area.

⁹ Estimated using United Nations (2014).

annual population growth projected in London over the same period. The extent of projected population growth differs by city: for example, the population of West Yorkshire is projected to grow by 11.7% in total over the period 2016–2026, while the population of Liverpool is projected to grow 7.4% over the same period.¹⁰

At the same time, populations are ageing: in Northern England, the proportion of the population aged 20–64 is projected to fall from 58% in 2016 to 55% in 2026, and to 52–53% by 2036.¹¹ This is similar to the projected ageing in England overall, where the same figures are projected at 58%, 56% and 54% respectively – i.e. a gradual decline in the proportion of the population that is of working age, which could be offset to some extent by changes such as individuals retiring at a later age.¹² Underlying this is a projected absolute decrease in the population aged 20–64 in the North West and North East, and almost no change in the population aged 20–64 in Yorkshire and the Humber over this period.

The result of historical productivity gaps has been a policy aim for spatial rebalancing of economic activity, under the umbrella of the Northern Powerhouse policy. In the next section, we discuss the growth aspirations developed to achieve this rebalancing. City population growth and a changing age profile (given its implications for the working age population) discussed above are important factors affecting how economic growth aspirations can be achieved – for example, by having an impact on future labour supply.¹³

1.2 Growth aspirations for Northern cities

The overarching Northern Powerhouse growth aspiration is for economic growth in the North to at least equal the national average.¹⁴

Northern cities are developing plans to support increased economic growth. Through Local Enterprise Partnerships (LEPs), Northern cities have developed Strategic Economic Plans and Growth Plans. These plans articulate aspirations for increasing economic growth in city regions, and set out the priorities for achieving this. As we describe in Chapter 2, there are several drivers of economic

¹⁰ Estimated using United Nations (2014).

¹¹ The North East, North West, and Yorkshire and the Humber. See Office for National Statistics, Social Survey Division (2015), 2012-based Subnational Population Projections for Regions in England.

¹² See Office for National Statistics, Social Survey Division (2015), 2012-based Subnational Population Projections for Regions in England.

¹³ We explore the economic geography of Northern cities further in Chapter 3.

¹⁴ See Transport for the North (2015a). Alternative targets have also been used: the City Growth Commission uses a target of reducing the ‘fiscal gap’ between attributable tax revenue for a city and its level of public expenditure.

growth, and to be able to realise full growth potential, the wider policy framework must recognise this. Hence, the plans developed by LEPs include policy actions across the different drivers of economic growth, such as improving skills, or investing in transport infrastructure and housing to attract inward migration of skilled labour.

Economic plans by cities to date have developed forecasts using different horizons, assumptions, and estimation techniques, so their interpretation differs. Some are also subject to further consultation. Although not comparable, these estimates provide an indication of what cities are currently aspiring to. We therefore summarise published employment and economic growth aspirations for Northern cities in **Table 1**.

Table 1. Employment and growth aspirations of Northern cities

City	Employment growth forecasts	GVA growth forecasts
Hull^a	Potential job growth of 20,400 to 27,040 in the Humber sub-region (i.e. broader than Hull), assuming 'game changer' projects go ahead (period not specified).	Potential GVA growth of £5.7–£11.7 billion in the Humber sub-region (i.e. broader than Hull), assuming 'game changer' projects go ahead (period not specified).
Leeds^b	44,600 net additional jobs are forecast to be created in Leeds over 2013 to 2023, representing 32% of net additional jobs forecast over the same period in the Yorkshire and Humber region.	GVA in Leeds is forecast to increase by 27%, from £18.1 billion in 2013 to £22.9 billion in 2023.
Liverpool^c	Potential net employment growth of 100,000 jobs is forecast over 2013 to 2025.	GVA growth of £10 billion is forecast over 2013 to 2025.
Greater Manchester^d	Employment is forecast to grow by 110,000 jobs over 2014 to 2024.	GVA growth is forecast to average 2.8% per year from 2014 to 2024, above the average in the North West.
Newcastle^{*e}	22,000 additional jobs are projected to be created across Newcastle and Gateshead over the period to 2010 to 2030, an increase of approximately 7.3%.	GVA is projected to grow by 55% from 2010 to 2030, from £6.2 billion in 2010 to £9.6 billion in 2030.
Sheffield^f	Net employment growth of 40,700 over 2013 to 2024 is targeted to address the current productivity gap.	Net GVA growth between 2013 and 2024 is targeted at £1.3 billion.

* Forecasts are for Newcastle and Gateshead.

Source: (a) University of Hull (2013); (b) Leeds City Council (2013); (c) Liverpool City Region Skills for Growth (2013); (d) Oxford Economics (2015); (e) Durham Business School for Joint Planning Teams of Newcastle City Council and Gateshead Council (2012); (f) IPPR North, RBL Consulting, and East West Locations (2013).

In addition to the work undertaken by individual cities, an Independent Economic Review has been commissioned by Transport for the North (TfN) to explore future growth aspirations of the North, and the likely sector composition of the economy in Northern England if economic growth aspirations are achieved.

While analysis in this report focuses on improving transport connectivity at current population levels, as our economic framework will show, the wider policy context is also critical. An important change in the policy context to date has

been the devolution of responsibilities from central Government to authorities in Northern cities, which we explore below.

1.3 Governance and policy responsibility in Northern cities

The context within which growth aspirations will be delivered is increasingly devolved, and reflects an increasing focus on cities as the likely source of increased economic growth. TfN has responsibility for developing a transport strategy, and in doing this is working with LEPs, central Government – primarily the Department for Transport and HM Treasury – and national bodies including Highways England, HS2 Ltd and Network Rail.

Alongside this, ‘combined authorities’ have been created: these are public bodies bringing together local authorities and reflecting boundaries of economic activity (typically a city), with responsibilities to deliver devolved economic and transport policy functions. Costs relating to these functions are met by the councils within the combined authorities, with in turn funding from government grants. Combined authorities are responsible for setting economic growth aspirations and planning to meet these, and are also responsible for delivery of an increasing range of public services as a result of Devolution, City, and Growth Deals with central Government. We briefly outline the scope of these deals in the box below.

Devolution Deals

Cities can apply to secure Devolution Deals, which grant devolved or shared powers to Combined Authorities. Devolved responsibilities can include transport, health and social care, skills, business support, planning and employment (see HM Treasury 2015a, and Local Government Association, Devolution Deals¹⁵). To date, Devolution Deals have been secured in Northern England by the Combined Authorities of:

- West Yorkshire;
- Liverpool City Region;
- Greater Manchester;
- Sheffield City Region;
- North East Combined Authority; and
- Tees Valley Combined Authority.

City authorities with devolved powers are encouraged to move to a model of having directly elected mayors – to date, this has been agreed for Greater Manchester only.¹⁶

City and Growth Deals

Devolution Deals were preceded by City Deals and Growth Deals, which devolved powers to cities for specific programmes relating to improving economic performance, along with provision of funding to achieve programme aims. Deals included funding, policy support and formation of partnerships, with projects in areas including skills, transport and city growth.

1.4 Transport investment in Northern England to facilitate local growth aspirations

Improving transport is an important focus of the work underway to meet economic growth aspirations in the Northern Powerhouse area. We discuss the potential role of transport in facilitating and driving economic growth in Chapter

¹⁵ <http://www.local.gov.uk/devolution-deals>

¹⁶ <http://www.local.gov.uk/devolution/directly-elected-mayors>

2. In this section, we set out the context within which Northern transport investment policy is being developed and delivered.

TfN has been established to develop a transformational Northern Transport Strategy. TfN is chaired by John Cridland, and its focus is on understanding and enabling development of the transport system that will be required if the Northern Powerhouse aim, which is to raise economic growth in the North to the national average, is achieved. Transport could support this through improving connections between centres of economic activity, improving commuting access to centres of economic activity, or improving information and ticketing systems to make travel easier.

TfN is a collaborative body bringing together combined authorities and local transport authorities from Northern England. It is due to become a statutory body by 2017, and has responsibility for local roads and rail. TfN is collaborating with Highways England, the Department for Transport and Network Rail, who have responsibility for strategic routes.

TfN has a long-term focus, and work is underway to identify and assess specific transport investment projects to take forward. However, in its report on the Northern Transport Strategy, TfN articulates its priority areas, spanning inter- and intra-city connectivity, air transport, and freight and logistics (Transport for the North 2015a). This includes identifying ‘aspirational’ journey times between Northern cities, which we use to inform our later analysis. We summarise TfN’s priorities across the four main areas in **Table 2**.

Table 2. Priority areas identified by TfN

Priority area	Description
Inter-city connectivity	TfN's vision is to achieve large reductions in rail journey times between cities, and to improve road connectivity. This could include Government commitment to the full High Speed Two (HS2) 'Y' network; a new 'TransNorth' rail system; improving east–west road links; and expanding capacity on major north–south roads.
Intra-city connectivity	TfN prioritises improving connectivity between communities and areas of employment growth. This includes a focus on developing effective onward connectivity from HS2 stations, and working to build in improvements to local rail services through future rail franchises.
Air transport	Priorities include improving rail connectivity between Manchester airport and nearby cities, and increasing the destinations served by the existing network of airports in Northern England.
Freight and logistics	The focus in this area is on improving planning, to coordinate port expansion with development of the distribution network, and similarly to support increased freight movements by improving rail capacity.

Source: Transport for the North (2015a)

In addition, TfN considers the role of 'smart' travel (e.g. integrating ticketing systems across the North), which sits across the above areas. TfN also recognises that transport investment is just one factor required to meet economic growth aspirations, alongside other drivers of economic growth, such as investment in skills, city centre amenities and supporting businesses (Transport for the North 2015a).

In addition to the transformational investment being planned, a large number of incremental road and rail improvements have been made or are being made in the near term in the Northern Powerhouse area. These are mapped in 'A blueprint for connecting the Northern Powerhouse'.¹⁷ The incremental changes will improve aspects of transport such as capacity, journey times and quality of services. Examples include electrification of rail track and improvements to the North Trans-Pennine line, to deliver a greater number of fast trains and shorter

¹⁷ <http://maps.dft.gov.uk/northern-powerhouse/index.html>

journey times between Manchester, Leeds and York; and work to improve traffic flow on the M62, improving journeys between Leeds and Bradford.

Having explored the policy context and emerging transport priorities in the Northern Powerhouse area, we set out an economic framework for analysing inter-city links in Chapter 2.

Chapter 2: Transport and economic performance

Chapter overview

This chapter presents an economic framework for understanding the key drivers of economic performance in cities and other urban areas, and how those drivers interact. We focus on the ways in which transport, in particular improvements to inter-city links, can contribute to the economic performance of a city, along with estimates of the magnitude of the impact based on the latest academic and policy evidence.

The structure of the chapter is as follows.

- Section 2.1 sets out the economic framework through which transport unlocks and drives economic performance, when complemented by other key drivers of economic performance.
- Section 2.2 discusses the types of potential gains from increased transport connectivity, both in terms of the first-order gains to productivity holding the structure of the economy constant, and in terms of the potential second-order responses, which occur over time as workers, firms and investment respond. The latter can fundamentally transform the local economy.
- Section 2.3 presents the latest empirical evidence on the impact of transport interventions, and inter-city transport links in particular, on economic performance. The section contains an overview of the current literature and the gaps in our knowledge, a discussion of the methods used to estimate both first- and second-order effects, estimates of the magnitude of these benefits and the conditions under which they are likely to be stronger.
- Section 2.4 concludes with a few key observations from the literature on transport and economic performance to inform the strategic case.

2.1 The drivers of economic performance in cities

Overview of the key drivers

The urban economics and city growth literature contains a well-established evidence base on how cities, city regions and other urban areas grow. This body

of evidence identifies the key drivers of economic performance at disaggregated spatial levels, with city growth being a primary focus of much of the research.¹⁸

The evidence is clear that there are many factors that drive economic performance, and each driver is likely to be necessary, though not sufficient, to realising growth opportunities.

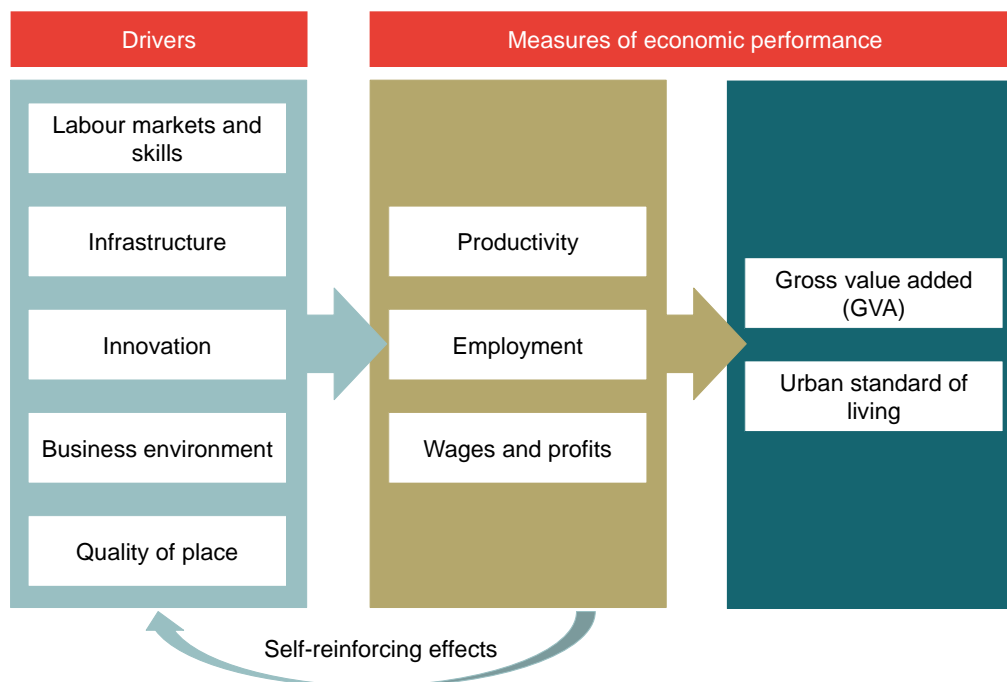
In **Figure 3**, we provide a stylised diagram for understanding the economic performance of cities, drawing on an extensive and well-recognised body of evidence on the key drivers of growth (Aghion et al. 2013, Berube et al. 2006, City Growth Commission 2014, and Gibbons et al. 2009a). The diagram sets out the main high-level drivers of economic performance in cities, which improve output and standards of living by increasing productivity, employment, wages and profits.

It is worth noting that these measures of economic performance are interlinked. For example, Krugman (2005) explains that when we consider countries, a 5% difference in productivity translates into roughly a 5% difference in the standard of living. In a well-functioning economy, workers are paid according to their productivity, so higher labour productivity results in higher wages.¹⁹ There is also evidence that increased productivity at an industry level generates demand, which in turn increases total employment (see, for instance, Nordhaus 2005). In the following discussion, we focus on the effect of transport infrastructure enhancements and other key drivers on productivity.

Each driver of economic performance is described in more detail in the following text.

¹⁸ It is worth noting the definition of ‘economic growth’ in this context. Throughout this chapter, the term ‘economic growth’ refers to changes in the *level* of economic performance – therefore, any measure that improves the level of economic performance can be seen to generate economic growth (in that period). The phrases ‘improving economic performance’ and ‘generating economic growth’ are therefore used interchangeably. This is distinct from ‘increasing in the *rate* of economic growth’, which refers to the percentage increase in output per year.

¹⁹ Under neoclassical assumptions, workers are paid their marginal product of labour.

Figure 3. Key drivers of economic performance in cities

Source: Frontier Economics, adapted from Office of the Deputy Prime Minister (ODPM) 2006, drawing on the LSE Growth Commission 2013 (Aghion et al. 2013), City Growth Commission (2014) and Overman et al (2009)

- **Labour market and skills.** This refers to the education, training and skill level of individuals, which has an impact on their productivity and earnings. Cities can grow both by improving the skill base of residents and by attracting skilled workers from elsewhere.
- **Infrastructure.** Cities rely on infrastructure of various forms, both physical and digital. The quality, capacity, reliability and efficiency of such infrastructure are important for economic performance. National and local governments play a large role in influencing infrastructure, both in terms of direct provision (as is the case for transport networks), and also in the regulation of infrastructure (as is the case with broadband services and land use policy).
- **Business environment.** The business environment refers to the tax regime, regulations and stable policy environment in which businesses make decisions. For example, business rates and labour regulation can affect where, and how much, firms invest.
- **Innovation.** Innovation is the process by which ideas and technologies affect production, either in terms of higher output productivity or new types of goods produced. Cities can play a role in innovation by supporting knowledge generation (e.g. through universities) or business innovation (e.g.

with business innovation grants or capital support for early-stage companies).

- **Quality of place.** The quality and variety of amenities available in cities affect the quality of life, and in turn influence the location decisions of workers and firms. Hospitals, schools, green spaces, cinemas, theatres and other cultural and leisure facilities all affect the quality of place, as do environmental factors such as pollution.

The literature identifies a number of important feedback effects and interdependencies between economic performance and its drivers, such that raising economic performance may rely on making improvements across multiple drivers at the same time. Similarly, improvements in one driver can have knock-on impacts, both positive and negative, on other drivers. For example, an improvement in skills may not be sufficient if growth is constrained by an unfavourable business environment. Alternatively, a favourable business environment may lead firms to invest in up-skilling their workers.

Transport sits within the infrastructure driver, along with other types of infrastructure, such as energy, telecoms and housing. The need for transport improvements to be complemented with other drivers of economic performance is clear. The Eddington Transport Study, conducted nearly a decade ago, argued that ‘whilst transport can play an important role in facilitating productivity growth, transport infrastructure alone does not create economic potential’ (Eddington 2006). However, transport is a unique type of infrastructure in its ability to reduce the effective distance between places and to create the opportunity to drive economic performance, as we describe in the following section.

Role of transport in promoting economic performance

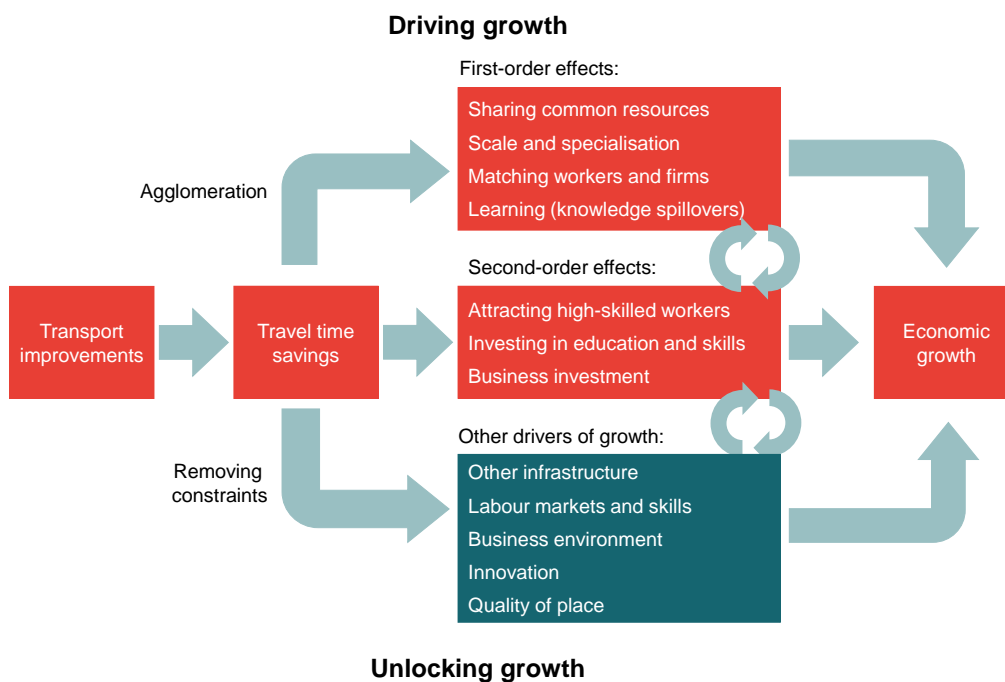
There are two ways of looking at the role of transport in promoting economic performance from a UK perspective (Gibbons 2015, What Works Centre for Local Economic Growth 2015).

- The first is to ensure that transport infrastructure responds to growing demand, so that congestion, travel times and travel costs do not constrain growth, where this growth is generated by other drivers discussed above. This is the traditional role of transport, in which transport acts as a facilitator of growth, *unlocking* the growth potential of other drivers.
- The second is where transport plays a role in stimulating local economies, *driving* growth rather than simply facilitating it. This can be further split into the following two effects.

- By reducing travel times and connecting people, firms and places, transport improvements can generate ‘agglomeration benefits’ that increase productivity (first-order effects).
- Further, the reduction in travel times and the resulting rise in productivity increase wages and returns on investment, which attracts more high-skilled workers, firms and investment to the area over time (second-order effects).

The scale of these benefits, in particular the second-order effects on the local economy, will depend on the extent to which transport improvements are supported or constrained by other drivers of economic performance. The role of transport in promoting performance must therefore be seen in the context of all other drivers of economic performance, as shown in **Figure 4**.

Figure 4. Role of transport in promoting economic growth



Source: Frontier Economics, drawing on Gibbons (2015), What Works Centre for Local Economic Growth (2015) and Laird et al. (2014)

Unlocking growth by removing constraints

We have stated that one way in which transport improvements can promote economic performance is by relaxing the constraints imposed by congestion, long travel times or inhibitive costs of travel. Long travel times imply economic costs because time spent on journeys could be used more productively. Further, long and unreliable journey times raise business costs, which increases prices to consumers and constrains production (Gibbons 2015).

The Eddington Transport Study presents evidence that transport networks under pressure can constrain growth, so unless transport infrastructure keeps pace with investments in other drivers of growth, these investments will not achieve their full potential.

For instance, the Irish economy grew rapidly in recent decades, due to heavy investment in education and skills and to fiscal incentives for FDI. However, transport investment lagged behind the growth of the economy, so that by the mid-2000s, inadequate international connectivity (ports and airports) and congestion around urban areas had become a limiting factor on growth (Eddington 2006). Another example is India, where growth driven by investment in human capital and information technology risked being hindered by inadequate transport infrastructure: in 2006, the World Bank warned that major improvements in the transport sector would be required to support the country's continued economic growth (Eddington 2006).

The Eddington Transport Study estimated that a 5% reduction in travel times nationally would be worth around 0.2% of GDP per year, and argued that transport interventions should be targeted at growing and congested areas and congested strategic inter-city links. These policy priorities were echoed by the recent LSE Growth Commission (Aghion et al. 2013). Unlocking constraints from congestion is a therefore a fundamental benefit of transport improvements.

Driving growth through agglomeration

A second role of transport is to stimulate the economy, that is, to directly drive economic performance rather than just unlocking the growth potential of other drivers. There has been greater interest in this channel in recent years, particularly in the context of reducing inequalities between London and the North of England (Cox and Davies 2013, What Works Centre for Local Economic Growth 2015).

There are two particular effects worth noting.

First, a large body of evidence suggests that connecting people, firms and places more closely generates 'agglomeration benefits'. These refer to first-order benefits from:

- sharing common resources;
- increased specialisation;
- better matching between workers and firms; and
- knowledge spillovers.

The above factors increase productivity *given* the current stock of workers and firms within the economy (i.e. the current economic composition is held constant).

Second, over time, travel time savings and the resulting productivity gains can also produce second-order benefits by attracting more productive resources into the economy, in particular:

- attracting high-skilled workers to the region;
- incentivising local people to invest in education and skills; and
- stimulating business investment.

These effects have the potential to fundamentally *transform* the local economy.

Second-order effects further increase agglomeration (by increasing the number of workers and firms in the cities), which may trigger further second-order effects, and so on.

It is worth noting that the definition of ‘agglomeration benefits’ in the academic literature is broader than the definition used in the Department for Transport’s WebTAG²⁰ appraisal guidance on wider economic impacts, which captures only the first-order effects on productivity. Throughout this report, we refer to the academic definition of agglomeration benefits, which considers both first- and second-order effects.

Whether second-order benefits are realised crucially depends on the other key drivers of economic performance, which may help or hinder the impact of transport improvements. **This is because the mechanisms through which these benefits arise do not depend on transport alone.** Transport interventions can help attract high-skilled workers to the region, but quality housing and amenities are also needed to attract and accommodate these workers, and skilled labour pools in surrounding areas can ensure that high-skilled workers are available. Individuals must have access to high-quality training if they are to invest in education and skills as a result of transport improvements, and a favourable business environment is needed to attract investment. If these drivers are not in place, then the second-order benefits and the self-reinforcing loop between first- and second-order benefits may fail to materialise. **This means that it may be necessary to invest in other drivers of economic performance alongside investments in transport in order to fully realise the potential (second-order) benefits of improved connectivity.**

For example, a recent study found that the expansion of high-tech clusters in Oxford and Cambridge was hindered by planning restrictions, which limited the availability (and increased the cost) of housing, as well as inadequate coverage of ultra-fast broadband (Aghion et al. 2013). A survey of senior executives cited in

²⁰ DfT’s WebTAG web site (<https://www.gov.uk/guidance/transport-analysis-guidance-webtag>) It is worth noting that second order benefits are captured in Land Use Transport Interaction (LUTI) models recommended by WebTAG, however not all transport appraisals use LUTI models.

the Eddington Transport Study indicates that whilst transport infrastructure²¹ featured heavily in the factors influencing business location, the availability of qualified staff, business environment, availability and cost of office space and quality of life in the area were also considered ‘absolutely essential’ for a substantial proportion of respondents.

There is good evidence that when supporting drivers are in place, transport interventions can have a large economic impact, as shown by the Jubilee Line Extension. The impact of this transport scheme on regeneration in the Docklands was boosted by favourable business rates that attracted investment, as well as access to London’s skilled labour pool (Eddington 2006).

In the context of improving transport links between cities, it is also important to consider the interdependencies between inter-city and intra-city connectivity. Inadequate intra-city networks can constrain the impact of any improvements to inter-city transport links, weakening the first- and second-order benefits from agglomeration. This is because most journeys are not city centre to city centre, so the door-to-door experience of travel between cities depends on the quality of transport networks within cities. Congestion is currently a major problem in a number of Northern cities: for example, peak bus speeds within Manchester and Leeds are little better than 5 miles per hour, with peak car speeds around 10 miles per hour. This means that halving the journey time between Leeds City and Manchester Piccadilly would only reduce the journey time between Leeds Beckett University and Manchester University by around a quarter (Mackie et al. 2015). Further, improved transport links may increase traffic volumes within cities. As such, investment in intra-city networks may be required to ensure that this does not result in intra-city congestion, which can offset any reduction in door-to-door journey times resulting from inter-city improvements.

²¹ In terms of ‘easy access to markets’ and ‘inter-city and international links’.

Why must other drivers also be considered in order to realise the full potential of transport investments to drive economic performance?

- **First-order effects** improve productivity holding the state of the economy constant, and are therefore not particularly dependent on non-transport drivers of economic performance. However, improved inter-city transport links could increase traffic volumes within cities, which may lead to intra-city congestion and offset any reduction in door-to-door journey times. If this is the case, then investment in intra-city transport networks may be necessary to realise first-order effects.
- **Second-order effects** depend crucially on other drivers of economic performance, notably housing and a favourable business environment. Without these drivers in place, transport investments may fail to attract productive workers and firms to the area. If this is the case, then it may be necessary to invest in other drivers of growth alongside transport investments to fully realise second-order effects.

Identifying transport corridors that offer the greatest opportunity to unlock or drive economic performance

The two ways of seeing the role of transport in promoting economic performance have different implications for the choice of priority strategic corridors (Gibbons 2015, What Works Centre for Local Economic Growth 2015). On the basis of the first ‘ameliorative’ role of unlocking growth, investment should be targeted at cities where the economy and transport demand are growing, in order to relax the constraints that congestion and travel times impose on growth. This implies that the priority inter-city links will be those between the fastest growing cities in the North, and/or the corridors already facing high levels of congestion.

The second role of directly driving growth implies that transport investment should be targeted at corridors that have the greatest scope for agglomeration benefits. As discussed in the following sections, this depends on:

- the size of the cities being linked;
- current travel times between these cities;
- the quality of their intra-city networks;
- their geographic location in relation to surrounding cities;
- their sector compositions;

- the skills levels of their labour force; as well as
- the extent to which other drivers of growth (in particular housing and a favourable business environment) are in place.

The corridors that are identified as offering relatively larger opportunities to drive economic performance in this view may not match the corridors that currently constrain growth. It is important to consider both perspectives.

In Chapter 3, we provide an overview of the economic geography of the North and the current performance of the Northern transport system. This allows us to identify the corridors that are most likely to unlock growth from other key drivers, and to understand the scope for second-order effects in directly driving growth. We also present bespoke modelling by Professor Stephen Gibbons that simulates the indicative agglomeration benefits that could arise from improving different inter-city links.

Given that the benefits of relieving congestion are well known and captured by transport user benefits,²² in the following sections we focus on the ways in which transport improvements generate agglomeration benefits, and we discuss the latest available evidence on the magnitude of these benefits, including both first- and second-order effects.

2.2 Benefits from improved transport connectivity

Improvements in inter-city transport links reduce the time taken to travel from one city to another. Without any change in geographical location, the cities become effectively closer together. This increase in proximity is often referred to as ‘agglomeration’ and can have important implications for economic performance in cities. It should be noted again that our definition of agglomeration is far wider than that used by the WebTAG guidance on wider economic benefits, and instead follows that of the academic urban economic literature.²³

In this section, we discuss the transmission mechanisms through which transport improvements can increase productivity and economic performance within cities.

²² In the WebTAG guidance issued by the Department for Transport for transport appraisals, transport user benefits to businesses are uplifted by 10% to reflect the wider economic benefits of reducing business costs, arising from imperfect competition.

²³ WebTAG’s framework on the wider economic impacts of transport improvements defines ‘agglomeration benefits’ as only the static impact of agglomeration: increases in output per worker as a result of the increase in accessibility. Second order effects are captured in the Land Use Transport Interaction (LUTI) modelling recommended by WebTAG, however not all transport appraisals use LUTI models.

There are two main mechanisms: ‘first-order effects’, which increase productivity holding the composition of the economy constant, and ‘second-order effects’, which reflect the fact that workers, firms and investment may be attracted to the city as result of reduced travel times and resulting productivity gains. The scale of these effects may depend on the characteristics of individuals and cities, the specific transport scheme and the extent to which there is a supportive policy framework around other drivers of economic performance (such as the business environment).

First- and second-order effects

Greater connectivity increases productivity in any given economy – the *first-order effect*. Over time, this can attract additional workers, firms and investment to the area, changing the structure of the economy – *the second-order effect*. The sources of first- and second-order effects are described below (based on Combes and Gobillon 2015, Gibbons et al. 2009a, Laird et al. 2014, and Puga 2010).

First-order effects

These refer to the following.

- **Sharing common resources.** Firms and individuals close together are able to lower average cost by sharing common goods and services, such as water services or airports.
- **Scale and specialisation.** Larger markets provide firms with economies of scale and greater ability to specialise. These benefits are experienced by the firms themselves, and also shared by those firms and workers who benefit from lower prices.
- **Matching workers and firms.** Reduced travel times make it quicker and easier for workers to find jobs that match their skills. This improves productivity by reducing 'frictional' unemployment (i.e. the time spent unemployed while searching for jobs). Access to wider markets also makes it easier for workers to find jobs that better suit their skill set, past training and experience, which boosts productivity by enabling them to perform better compared with a job that does not quite match their skills.
- **Learning (knowledge spillovers).** Learning and knowledge spillovers are more likely to occur when more people are closer together. For example, younger workers have more interaction with experienced workers, information is transmitted through casual interactions, and firms have more opportunities to experiment and innovate (Gibbons et al. 2009a). Compared with the above mechanisms, learning is distinctive in that it *continues over time* and can be *permanent*. This means that the learning mechanism can increase the growth rate of productivity over time, and further that these productivity gains remain with firms and workers even as they move to areas with lower levels of agglomeration.

Second-order effects

These refer to the following.

- **Attracting high-skilled workers.** High-skilled workers may choose to relocate to areas with improved transport links because of reduced travel times and the first-order productivity benefits available in these areas, that is, the opportunities to find more attractive and highly paid jobs. In the academic literature, this is referred to as the ‘sorting’ effect.
- **Investing in education and skills.** Access to wider employment markets may give individuals an incentive to invest in education and skills, because returns to skills are higher in more agglomerated cities.
- **Business investment.** Firms may also have an incentive to enter or invest in areas benefiting from first-order productivity gains, which in turn increases economic growth in the area. Such investment could come from other local areas (hence there could be a risk of displacement), or it could come from overseas via FDI. This is discussed further below.

Because second-order effects increase agglomeration (by increasing the number of workers and firms in the area), this can lead to a self-reinforcing loop, whereby agglomeration boosts productivity, which further increases agglomeration. Again, the importance of complementary drivers is important to note – for example, increased employment would be expected to increase the demand for housing.

It is worth noting that the theoretical literature on urban economics focuses on how density produces agglomeration effects and the impact that these have on the economic performance of cities. The literature does not directly address the impact of inter-city transport improvements; however, given that these improvements increase the effective density of the affected areas, it is reasonable to expect that agglomeration will occur through the same mechanisms. Indeed, the mechanisms of first-order agglomeration occur through accessibility to markets and people, which should equally be attained by increasing either real or effective density.

Similarly, the literature has not investigated what happens when the effective densities of two areas increase at the same time, which is the case with inter-city transport improvements. As will be discussed below, the first-order effects are expected to be positive for both places; however, the reallocation of resources due to the second-order effects may benefit one place more than another or, indeed, one place and not the other. There is some literature (Puga 2010) discussing the potential for improved accessibility to have harmful effects: not only do firms gain access to better inputs and larger markets, but also rival firms

now gain access to their markets, which increases competition. If firms in the less productive region are unable to compete, this can negatively affect them. This means that our theoretical evidence base for the benefits of inter-city connectivity is stronger for first- than second-order effects; as discussed in Section 2.3, this is also true for the empirical evidence to date.

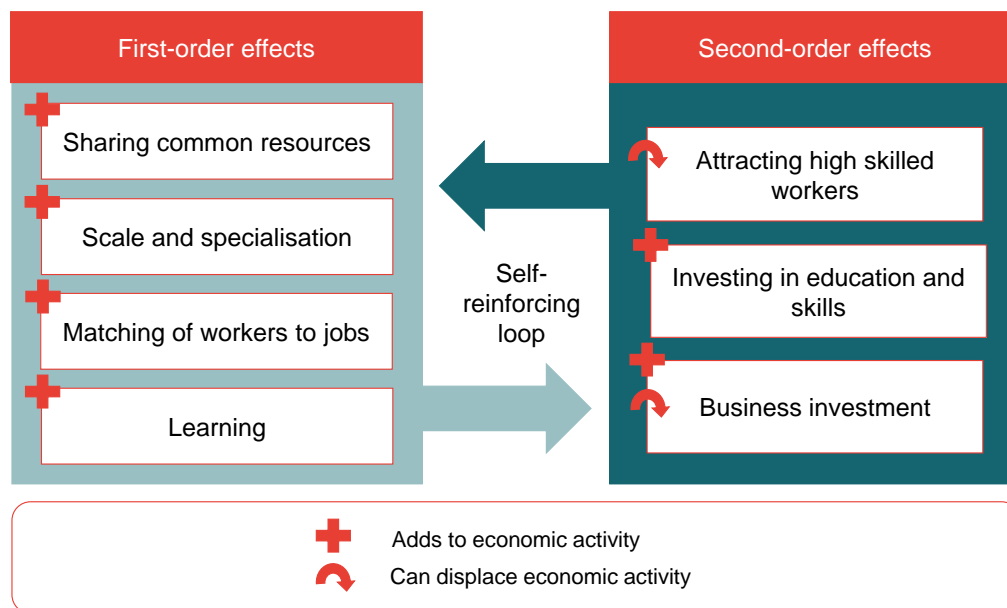
Additional growth v. displacement

First-order effects unambiguously improve economic performance, because they increase productivity holding the current stock of workers and firms constant. That is, growth resulting from first-order benefits can be seen as additional growth. Second-order benefits may either be additional, or displace economic activity in other areas, by drawing productive resources away from those areas.

For example, the movement of high-skilled workers is likely to result in displacement. Improvements in inter-city transport links in the North may attract high-skilled workers from other parts of the UK (e.g. from London to Manchester) or from one Northern city to another (e.g. from Leeds to Manchester). Both these examples will be observed as an increase in Manchester's economic activity, but at the expense of economic growth elsewhere. Investment by firms can also be at the expense of other areas: for instance, transport improvements may lead firms to invest in the North rather than London.

Other types of second-order effects are likely to cause additional economic activity. For instance, to the extent that transport improvements give local people an incentive to invest in education and skills, or attract investment from abroad (FDI) that would not have otherwise been directed at the UK, this should be seen as adding to total economic activity. The different types of first- and second-order effects are summarised in **Figure 5**.

Figure 5. First- and second-order effects of transport connectivity on productivity



Source: Frontier Economics, drawing on Laird et al. (2014) and Puga (2010)

The net impact of second-order effects will depend on the extent to which the benefits displace rather than add to total economic activity. The theoretical literature does not predict the net effect on different areas, nor does it offer any conclusive predictions on the types of areas that are likely to suffer from displacement.²⁴ However, improving inter-city connectivity should unambiguously improve economic performance through first-order effects. This means that whilst certain areas and/or cities may lose out from improved connectivity, the direct impact on individuals (regardless of where they are) is likely to be positive.

Determinants of the nature and scale of benefits

The characteristics of cities, such as their skill and sector composition, are an important determinant of the nature and scale of potential benefits from improved transport connectivity (Gibbons et al. 2009a, Combes and Gobillon 2015). For instance, services that are more reliant on face-to-face interaction may benefit more from learning and knowledge spillovers, whereas manufacturing may benefit more from sharing common resources, scale and specialisation. Workers and businesses that gain more from knowledge, likely high-skilled workers and high-tech firms, may gain more through the learning mechanism.

²⁴ This is because spatial economic models typically involve multiple equilibria, which makes specific ex-ante predictions impossible without knowing the initial conditions in detail.

Agglomeration economies may arise more from ‘urbanisation’ (meaning they extend across all industries) or ‘localisation’ (meaning they occur in narrowly defined industries). This will depend on the extent to which different industries can benefit from sharing the same infrastructure and labour pool. It will similarly be affected by the extent to which learning and knowledge spillovers are most beneficial within or across sectors.

Each mechanism will have an impact at different spatial distances from the centre of the city. The benefits resulting from closer labour markets are more likely to matter within a reasonable commuting distance. However, knowledge spillovers and learning due to face-to-face interactions will be most prevalent within a short radius of the centre. If benefits from agglomeration occur in a narrow radius around the centre, intra-city transport improvements may be more beneficial than inter-city improvements.

The type of transport link will also affect the nature and scale of benefits, depending on the types of firms and workers that use the particular mode of transport. Improving city-to-city rail links may encourage commuting, and therefore produce matching and learning benefits. Alternatively, improvements in roads may benefit freight travel, resulting in resource sharing, scale and specialisation gains for firms. Inter-city links, which improve access to airports, could improve international accessibility with corresponding impacts on FDI and international knowledge spillovers for importing and exporting firms.

The following empirical section will examine in depth the evidence on how agglomeration and city characteristics interact. These will have important consequences for the extent to which inter-city transport improvements can be expected to provide wider economic benefits.

2.3 Evidence of benefits from improved transport connectivity

Having outlined the theoretical types of benefits from improved transport connectivity in the previous section, this section sets out the empirical evidence on these benefits. We first provide an overview of the state of existing evidence and highlight the gaps in our knowledge, especially in terms of the long-term second-order effects and the impact of specific improvements in inter-city transport. We then discuss the most common methods of estimating benefits from transport improvements, noting the methodological limitations of each approach as well as the difficulties in interpreting results.

In this section, we describe the evidence on estimates of the impact of increased access to markets on productivity in the UK. We also summarise the results of recent studies on first-order and total benefits from increased accessibility, including some evidence of displacement from other areas. The next section

considers the conditions under which these benefits are stronger, namely the effect of specific sectors, sector mix (localisation), skills levels and spatial decay on the magnitude of agglomeration benefits. This provides some guidance on the types of cities and transport linkages to target when improving inter-city connectivity in the North.

Overview of available evidence

Most of the available evidence examines the impact of access to markets ('accessibility' in short) on wages, used as a proxy for labour productivity. However, whilst we have relatively reliable estimates of the first-order effect of accessibility on productivity, holding the rest of the economy constant, little is currently known about the second-order effects that result from the behaviour over time of workers, firms and investment in response to these effects. Further, there is a lack of evidence on the economic impact of transport schemes in particular (as opposed to accessibility in general). It is assumed in the academic literature that the benefits of accessibility can be replicated by improving transport links between cities (see, for instance, D'Costa et al. 2009).

Specific transport interventions v. accessibility

The bulk of research on agglomeration effects examines the effect of city size, density or accessibility on productivity (Combes and Gobillon 2015). Of these, accessibility is the most relevant metric for assessing the impact of inter-city transport links. It has variously been called 'market access', 'market potential', 'effective density' or 'closeness centrality' in the literature (D'Costa et al. 2009). The accessibility of a city is measured by the sum of 'economic mass' (typically employment) that can be accessed from that city, discounted by the cost of accessing these areas (in terms of generalised transport costs,²⁵ travel times or distance). This means that a reduction in travel times to a given city, or an increase in employment in surrounding areas, would result in an increase in its accessibility. Some studies use econometric techniques to isolate the change in accessibility resulting from changes in travel times (as opposed to changes in employment in surrounding areas), so that estimated benefits can plausibly be attributed to transport improvements.

In contrast, there is very little existing evidence on the economic impact of specific transport interventions. In part, this results from a lack of rigour in transport evaluations, particularly in defining what would have happened in the absence of the transport scheme. The What Works Centre for Local Economic Growth (2015) reviewed around 2,300 policy evaluations from the UK and other

²⁵ Generalised transport costs refer to the sum of financial travel costs (cost of fuel, fare, vehicle maintenance, etc.), plus the value of the person's travel time (including journey time and time spent waiting for public transport). The value of time is higher for business travel than for leisure.

OECD countries, and found fewer than 30 robust studies, mostly on interstate highways and light rail lines in the US.

Aside from the lack of reliable evidence, there is a problem with generalising the findings of these studies to the UK context. For instance, the impact of widening a highway in California is not directly informative of the likely benefits of improving rail links between Manchester and Leeds. However, the savings in travel time from such a scheme could be translated into an increase in accessibility. The benefits to productivity from this increase in accessibility could then be estimated and projected to the UK context in a relatively straightforward way. In our evidence review below, we therefore focus on estimates of the impact of accessibility on productivity in the UK, drawing on evidence on specific transport interventions where relevant.

Measures of productivity

There are two widely used measures of productivity in the literature: labour productivity and total factor productivity (TFP; Gibbons et al. 2009a). TFP is the more rigorous measure, as it captures the efficiency with which all inputs are combined to produce output, not just the efficiency of the labour force. However, it is not observable and must be estimated. There are a number of ways to estimate TFP, and the appropriateness of these methods is a subject of ongoing debate (Gibbons et al. 2009a). Partly because of this, most studies on the impact of agglomeration on productivity focus on the effect on labour productivity, which can be easily measured or approximated using wages.²⁶ This is not without problems, as labour productivity also depends on the extent to which other inputs are substituted for labour, as well as the relative bargaining power of workers and firms. However, given the evidence available, we focus on the impact of accessibility on wages, supplementing the evidence with occasional studies on TFP. Wages are also a policy priority in their own right, as they directly affect individuals' standards of living.

Knowledge gaps

Despite considerable advances in recent years, the study of spatial economics remains a relatively new field, and there are still large gaps in our knowledge of the wider economic benefits of transport improvements. First, whilst econometric techniques have been used to estimate the first-order effect of agglomeration on productivity, very little is known about the second-order feedback mechanisms between transport improvements and the behaviour of individuals, firms and investment in response to these improvements. This is complicated by the fact that, as time goes on after a transport improvement, it

²⁶ Under neoclassical assumptions, workers are paid their marginal product of labour, so high wages in an area can be interpreted as reflecting high labour productivity.

becomes less and less clear what can be attributed to the transport scheme, and any second-order effects will necessarily take a long time to feed through. Certain transport models (such as LUTI models²⁷ used in some transport appraisals) do attempt to simulate these interactions; however, the predictions of these models have never been validated against actual outcomes.

We therefore have relatively reliable estimates of the first-order effect of agglomeration, holding the rest of the economy constant, but – as explained in the following subsection – we have at most an estimate of the upper bound on the total impact of transport improvements, taking second-order effects into account. Further, no systematic studies to date have been undertaken on the nature and extent of displacement, which means that policy makers have focused on the benefits of improved connectivity with little understanding of the full range of potential costs.

Second, most of the reliable evidence captures the effect of accessibility in general, rather than the effect of transport improvements in particular. As explained above, accessibility depends on a number of things, such as the size, density and physical proximity of cities, in addition to the number and quality of transport links between and within cities. This means that in some cases, the derived estimates may reflect the impact of city size or density more generally and a historical density–productivity relationship that has evolved over time, rather than the causal effect of changes in transport infrastructure. Even when econometric techniques are used to isolate the impact of transport improvements, it is unclear that all of the estimated benefits will accrue to inter-city (as opposed to intra-city) connectivity, given the rapid spatial decay of agglomeration effects.²⁸ The academic literature assumes that we can replicate the estimated benefits of accessibility by improving transport links between cities (see, for instance, D’Costa et al. 2009).

Methods for estimating the effect of transport connectivity

As explained in the previous subsection, improving inter-city connectivity has two types of effects: a first-order effect resulting from closer proximity of existing firms and workers, and a second-order effect of attracting more productive resources into the area, in particular high-skilled workers, firms and investment. This distinction is important when thinking about the wider economic benefits of improving linkages between two cities. Whilst first-order

²⁷ Land use transport interaction models. These seek to model a local economy and how market agents respond to changes in transport costs over time. They assume that labour is mobile within a particular defined area and that businesses and trade respond to find a new equilibrium following a transport intervention. As with most transport appraisal models, they compare outcomes following the intervention to what would have happened in the absence of the intervention.

²⁸ Spatial decay is exponential in nature, which implies that a given reduction in travel times will have more impact where travel times are currently shorter.

effects are likely to accrue to both cities, second-order effects may benefit one city at the expense of the other. Put simply, if productive workers and firms move from one city to another as a result of increased connectivity between the two cities, the destination city gains from second-order effects whilst the city of origin loses out from second-order effects (though any losses may be offset by gains from first-order effects). Further, increased accessibility in both cities as a result of the transport scheme may draw productive resources away from other cities that have not been directly affected by the scheme. Ideally, we would want to separately identify first-order and second-order effects, including any displacement effects on areas that experience negative sorting. Here, we outline the most common methods of estimating the effects of transport connectivity, noting the methodological limitations and difficulties in interpretation.

First-order effect

To identify the first-order effect, we would need to compare the productivity of individuals who are otherwise identical, but live in cities with different levels of accessibility. Recent studies have attempted to do this by tracking individuals as they move from one city to another, whilst controlling for observable changes²⁹ in their characteristics, such as education levels or years of work experience (Combes and Gobillon 2015). Provided that there are no changes in ability or motivation (that cannot be observed by the researcher) over time, this approach ensures that if a particular individual earns more in cities that are more accessible, we can plausibly attribute the wage difference to first-order effects.

In the absence of randomly allocating individuals between cities, this is the best approach available for identifying first-order agglomeration effects. However, it is worth noting that we cannot rule out the possibility that individuals' unobserved characteristics change over time, or that something unobserved happens to individuals that both affects their wage and induces them to move cities. Further, this approach captures the general impact of accessibility on productivity, and not the specific impact of transport interventions. It is simply assumed that these productivity differences can be replicated by improving transport links.

Another issue with this methodology is that it does not capture the permanent effects of learning: skills gained working in large cities cannot be distinguished from individual characteristics such as underlying ability. To capture both city-based and permanent learning effects, some studies have included measures of the time spent in different types of cities in their analysis (see, for instance, Puga and De la Roca 2012, and D'Costa and Overman 2014). However, this is a very new field (with the first paper published in 2012), so this area of research is still in its infancy.

²⁹ This refers to changes that are observable to the researcher, for instance measurable qualifications.

Second-order effect and displacement

The separate identification of second-order effects (including displacement) is more difficult. Studies do not estimate second-order effects directly; instead, some estimate the overall impact of accessibility by comparing more and less accessible cities, sometimes controlling for industry structure (see, for instance, D'Costa et al. 2009). The difference between this aggregate estimate and the estimate of first-order effects (as above) is then attributed to second-order effects. In the context of estimating the wider economic benefits of improving inter-city connectivity, key to note here is that this aggregate estimate represents the correlation between accessibility and productivity across all cities, not the incremental gain that we would expect from increasing accessibility to any particular city. This correlation is likely to capture a historical density–productivity relationship that has evolved over time, owing to other drivers of economic performance (notably skills), in addition to any causal impact of accessibility. Put simply, if we are to directly apply estimates derived in this way to changes in inter-city connectivity, we must believe that *all* of (for example) London's productivity advantages can be replicated with inter-city transport links alone. Further, the estimate does not capture potential displacement effects, either on the cities being connected or on other areas not directly affected by the scheme. At most, estimates derived through cross-city comparisons can be seen as the upper bound on the long-term benefit of accessibility, including both first- and second-order effects.

Another issue is that the government may focus transport connectivity projects on high-performing cities with congested transport links, in which case estimates based on cross-city comparisons would capture the causal effect of productivity on accessibility, rather than the impact of accessibility on productivity that we are after.³⁰ If transport interventions are targeted at areas due to their underlying productivity, this will create biased estimates of the impact of accessibility on productivity – this is called 'selection bias' or more specifically 'endogenous policy targeting' in the economic literature. Some studies attempt to use econometric techniques³¹ to eliminate selection bias; however, the results are inconclusive (Combes and Gobillon 2015). Because transport investments have traditionally been aimed at relieving constraints on growth, and therefore targeted at high-performing cities, estimates based on cross-city comparisons are likely to be biased upward. This reinforces our view that such estimates should be seen as the upper bound on the total effect of accessibility.

³⁰ Theoretically, it is also possible that transport projects are deliberately targeted at low-productivity areas as a way of improving their economic performance (D'Costa et al. 2009).

³¹ In particular, historical values of population or density and geological features have been used as instrumental variables.

Given the difficulty of separating out positive dynamic effects, displacement and selection bias, in the following summary of the literature we present estimates of the total effect of accessibility, noting the difficulties in interpretation. We also discuss the qualitative results of other studies on specific transport interventions, as well as some indicative evidence of displacement.

Estimated effect of transport connectivity

Estimates from recent academic literature and policy reports suggest that increasing accessibility to a city by 10% (for instance by reducing generalised transport costs from that city to *all* other cities by 10%³²) would increase wages³³ in that city by 0.3–0.7% through first-order agglomeration effects (see sources in **Table 3**). Whilst these figures look modest, it is worth noting that labour productivity in the North has remained essentially unchanged since 2000 (Office for National Statistics 2015a).³⁴ The range of 0.3–0.7% would imply an increase in earnings of £75–£175 per person per year in the North.³⁵

The total impact on wages of a 10% increase in accessibility, including first- and second-order effects, is up to 1.1–2.6% (see sources in **Table 4**). However, these values are likely to be overestimating the contribution of transport to economic performance as they capture the impact of *all* drivers, not just transport. Therefore, one would effectively have to believe that all improvements ever observed in a city's productivity had been the result of the transport intervention (and not other drivers).

Furthermore, there is also some tentative evidence of displacement, which means that projects to improve connectivity could negatively affect some cities. This means that it is difficult to predict the impact of increasing inter-city transport connectivity on particular cities, though the effect on individuals (regardless of where they are) is likely to be positive due to first-order effects.

It is also important to note that these elasticity figures represent *average* UK-wide estimates, across all sectors, cities and individuals. In reality, the actual impact will be highly location-specific, so that similar accessibility improvements in different areas may lead to wildly different results. This is partly due to the interdependencies between transport infrastructure and other drivers of economic performance, as discussed in the final subsection, and partly due to the

³² This is based on a measure of accessibility based on inverse weighting of generalised transport costs, as is standard in the literature (see D'Costa et al. 2009). Alternatively, if accessibility is based on travel times alone, a 10% fall in travel times to *all* other cities would produce a 10% increase in accessibility.

³³ Throughout the report, 'wages' refer to pre-tax wages.

³⁴ Based on nominal GVA per hour in North East, North West, and Yorkshire and the Humber.

³⁵ Based on median annual earnings of £25,035 in the North East, North West, and Yorkshire and the Humber in 2014 (simple average across the three regions).

fact that the magnitude of benefits varies according to individual and city characteristics. Some of the conditions under which benefits to accessibility are more pronounced are discussed below.

First-order effect

Based on recent studies in the UK, increasing accessibility by 10% would lead to a 0.3–0.7% increase in wages as a result of first-order effects, holding the composition of the economy constant (see sources in **Table 3**). Permanent learning effects in the UK appear relatively weak, although further investigation is needed to produce conclusive results.

A recent study by D’Costa et al. (2009) estimates that reducing generalised transport costs for train travel by 10% (by reducing wait times, travel times or ticket fares), whilst holding existing road infrastructure as is, would increase wages by 0.3–0.5% on average through first-order effects. Conversely, reducing generalised transport costs for road travel by 10% (by reducing travel times or fuel costs), whilst holding train connectivity as is, would increase wages by 0.7%.

These estimates are similar to previous estimates of first-order effects in the UK, of 0.4–0.6%, derived using comparable but slightly different methodologies. A related study by Gibbons et al. (2009b) looks at the change in TFP of firms in response to changes in accessibility, holding the skills composition of the area fixed, and finds that a 10% increase in accessibility increases TFP by 0.4%.³⁶ The results from this study underpin the UK Department for Transport’s appraisal guidance (WebTAG), which provides underlying assumptions for estimating the wider economic benefits of transport interventions.

The estimates are also in line with, if higher than, estimates of the first-order effect of accessibility in other European countries, which place the increase in wages due to a 10% rise in accessibility at 0.1–0.5%.

³⁶ The measure of accessibility used in this paper is based on distances, rather than generalised transport costs. However, to the extent that improved transport links reduce ‘effective’ distances, the results can be applied to transport improvements.

Table 3. Estimates of first-order impact of accessibility improvement on wages

Author(s)	Country	Estimated elasticity
D'Costa et al. (2009)	UK	0.03–0.05 trains 0.07 roads
Graham and Melo (2009)	UK	0.04–0.06
Gibbons et al. (2009b)	UK	0.04*
Fingleton (2008)	UK	0.04–0.06
Andersson et al. (2014)	Sweden	0.01
Puga and De la Roca (2012)	Spain	0.02
Mion and Naticchioni (2009)	Italy	0.01
Combes et al. (2008a)	France	0.02
Combes et al. (2008b)	France	0.02–0.05

*Based on TFP rather than wages (labour productivity).

Research on permanent learning effects is sparse, and there is only one study on the topic in the UK. D'Costa and Overman (2014) explore both city-based and permanent effects of agglomeration by considering the effect of city experience. They find that permanent effects are relatively weak, and further that gains disappear after the first year in a city. Because of the method used in this study (measuring wage growth rather than wages, city population rather than accessibility, and discrete categories of city size rather than a continuous measure of accessibility), it is difficult to generalise their findings to the elasticities presented above. However, Puga and De la Roca (2012) find that when permanent learning effects are captured in Spain, a 10% increase in accessibility results in a 0.5% increase in wage levels through first-order effects, more than double the effect (0.2%) when only city-based effects are considered. This indicates that there is value in further investigating the impact of permanent learning effects in the UK.

Total effect (including first- and second-order effects)

Table 4 presents estimates of the total effect of accessibility on productivity in the UK, based on cross-city comparisons as described above. Estimates vary widely, largely due to methodological differences between studies. In particular, studies differ in the factors that they hold constant, which means that the derived estimates are not entirely comparable. Overall, the estimated total effect of

increasing accessibility by 10% on wages is between 1.1% and 2.6% (see sources in **Table 4**).

The study by D'Costa et al. (2009) discussed above estimates that reducing generalised travel times for train travel by 10%, holding the cost of road transport constant, is associated with a 2.6% increase in wages within that area. In contrast, reducing generalised travel times for road travel, holding train infrastructure constant, is not associated with any significant change in wages.³⁷ Another recent study by Gibbons et al. (2012) estimates that a 10% reduction in travel times is associated with a 2.4% increase in wages at the firm level, and a rise in employment in the area by 2.5–3.5%. This study uses econometric techniques to pick up only those changes in accessibility that result from improvements in road infrastructure, and to reduce selection bias,³⁸ so that the estimated benefit can plausibly be attributed to improved inter- and/or intra-city transport links. Three older studies of connectivity in the UK produced lower estimates of the total effect of accessibility on productivity, which may be partly due to methodological differences.³⁹ The evidence indicates that connectivity improvements can have a substantial positive impact on target cities; however, as discussed above, the estimates are likely to overstate the potential of inter-city transport and do not consider displacement from other cities.

³⁷ Combined with the positive individual-level effect explained above, this implies that road connectivity is negatively associated with skills, perhaps because of road infrastructure projects being targeted at areas with low levels of productivity (selection bias).

³⁸ As explained in the previous subsection, this refers to the bias caused by the fact that transport interventions are not randomly allocated but may be targeted at areas with high or low productivity.

³⁹ KPMG (2010) uses additional assumptions on firms' catchment areas and workers' willingness to travel rather than a simple accessibility indicator. Fingleton (2008) uses a short-run equilibrium model to derive accessibility indicators. Graham (2006) considers the effect of distance rather than generalised transport costs; the estimated effect increases significantly when generalised transport costs are used, although the precise figure is not reported.

Table 4. Estimates of total impact of accessibility improvement on wages

Author(s)	Country	Estimated elasticity
Gibbons et al. (2012)	UK	0.24
D'Costa et al. (2009)	UK	0.26 trains 0 roads
KPMG (2010)	UK	0.11
Fingleton (2008)	UK	0.16
Graham (2006)	UK	0.13*

*Based on distances rather than generalised transport costs. A chart in the report suggests that when generalised transport costs are used, the elasticity is around 0.2.

Research on specific transport interventions (instead of accessibility in general) has mostly produced positive total effects. A study by Duranton and Turner (2011) found that a 10% increase in the number of kilometres of interstate highways leads to a 1.5% rise in employment within a 20-year period. A large number of other studies have been thoroughly reviewed by the What Works Centre for Local Economic Growth (2015), which shows that many evaluations have found positive impacts of road and rail projects on wages, employment and property prices. However, a significant minority of studies have found no effect, or mixed effects on different communities. As discussed above, it is difficult to generalise from these studies to the context of improving connectivity in the North.

Overall, it is worth noting that relatively few recent studies focus on the total effects of accessibility; most focus on estimating first-order effects, presenting total effects as a potential sensitivity, if at all. This is because the derived estimates do not have a straightforward interpretation. **As discussed, to take the above estimates at face value, we would need to believe that productivity differences between cities are *solely* the result of differences in transport connectivity.** Further, even if we accept this (clearly unreasonable) premise, we still cannot conclude from the above estimates that increasing accessibility to a city by 10% would increase wages in that city by 1.1–2.6% due to potential displacement effects. For example, we cannot conclude that a scheme that improves connectivity between Manchester and Leeds (thereby increasing accessibility in both cities) would lead to increased wages in Leeds, because the scheme may in fact draw productive workers and firms to Manchester away from Leeds, to the detriment of its economy. This may or may not be offset by positive first round agglomeration effects in Leeds, or by the sorting of productive workers and firms into Leeds from outside areas.

Displacement

There are no general estimates of displacement as a result of changes in accessibility. However, evaluations of individual transport interventions provide some tentative evidence of strong displacement effects. The evidence supports the focus on first-order effects in the empirical literature, as these do not rely on drawing resources away from other areas.

For instance, a study of interstate highways in rural regions in the US found that highway construction raises total earnings by 6–8% in the counties that the highways pass directly through, but draws economic activity away from adjacent counties, reducing total earnings in these areas by 1–3%. Summing over all counties in the region, the net effect on regional growth is found to be essentially zero (Chandra and Thompson 2000). However the result may be particular to the non-metropolitan areas considered. Chalermpong (2000) studies the construction of a particular new interstate highway in the US, and finds that employment in areas along the highway corridor increased by 200%, compared with a 10% increase in employment in other areas. The author argues that the magnitude of this effect suggests severe displacement from areas at greater distance from the highway; certainly, this appears more likely than the construction of the highway incrementally increasing employment growth by 190 percentage points.

Another example of displacement comes from Hanson (1997), who studies the effect of trade reform in Mexico in the 1980s, which dramatically increased accessibility for cities along the US–Mexico border. The results show that this increased the number of firms along the border, at the expense of economic activity in Mexico City, which is located far from the border. Basile (2004) also finds that whilst agglomeration in Italian cities increases FDI, it has a negative effect on FDI in adjacent provinces, indicating displacement effects. The evidence of potentially strong displacement effects implies that estimates of the total effect of accessibility should be treated with caution, as they rely on (but do not capture) displacement from other areas. Because of this, our modelling in Chapter 5 focuses on first-order effects, to which displacement does not apply.

Conditions under which benefits from improved inter-city connectivity are likely to be stronger

The previous subsection presents estimates of the average effect of increasing accessibility, across a wide range of cities, sectors and individuals. In reality, the impact of improved connectivity may diverge substantially from the average. This is partly due to the interaction between transport and other drivers of economic performance, which may help or hinder the realisation of second-order benefits, as discussed above. In addition, the magnitude of benefits also depends on the nature of the transport intervention and the characteristics of the targeted locations (Combes and Gobillon 2015). Here, we discuss some of the factors that

affect the potential size of effects, and consider their implications on the strategic case.

Because we are concerned with relative impacts rather than exact estimates, and owing to the relative lack of evidence available, we have reviewed studies on all types of benefits, including both first- and second-order effects, based on city size and population density as well as accessibility. **The evidence suggests that service sectors and relatively high-skilled individuals are more likely to benefit from agglomeration.** There is evidence of strong spatial decay, which means that benefits are likely to be local (for instance, inter-city rail links will mostly benefit the city centre), and further that **improving links between cities that are already close by may have a larger effect than connecting far away locations.** Creating clusters of firms in any particular sector is unlikely to have an effect over and above general agglomeration benefits for most sectors, with the exception of a few high-tech and high-skilled sectors.

The importance of sector characteristics

Meta-analysis by Melo et al. (2009) shows that on average, across a large number of countries and time periods, agglomeration effects tend to be stronger in service industries than in manufacturing industries. This result is supported by research on the UK, in terms of both first-order agglomeration effects and long-term aggregate effects. Because the UK studies employ a range of methodologies and capture different outcomes (employment, wages and TFP), we present estimated sector-specific effects in **Table 5** as multiples of overall benefits, estimated across the whole economy, rather than the estimates themselves. This provides indicative evidence of the relative gain from increased accessibility in different sectors.

The evidence suggests that services gain strongly from improvements in accessibility, whilst the gain to the manufacturing sector is relatively limited. **In particular, producer services (which include finance, insurance, real estate and consulting services)⁴⁰ benefit up to two times more from increased accessibility than average, and two to four times more than manufacturing industries.⁴¹** Unsurprisingly, transport services also benefit from accessibility improvements, up to 30% more than average. The impact on consumer services (including wholesale and retail, hotels and restaurants and telecommunications)⁴² and construction industries is relatively smaller, but still higher than the impact on manufacturing.

⁴⁰ SIC codes 65 to 745.

⁴¹ SIC codes 15 to 35.

⁴² SIC codes 50 to 55 and 64.

Table 5. Agglomeration effects across sectors as multiple of overall effect

	Gibbons et al. (2014)*	Gibbons et al. (2009a)**	Gibbons et al. (2009b)	Graham (2006)
Manufacturing	0.6	0	0.5	0.6
Construction	0.6	0	0.8	1.5
Transport	1.3	1.3	–	
Consumer services	0.6–1.1	0	0.6	1.6
Producer services	1.7	2.4	1.9	
Others	0–4.7	0–1.7	–	0–2.3

*Consumer services based on retail, wholesale and tourism; producer services based on finance and professional services and other business services.

**Based on specification (5) on ward level employment.

The importance of sector mix

As discussed above, the transmission mechanism may operate through two channels: urbanisation, which refers to the benefits of accessibility to workers and firms in all sectors, and localisation, which refers to the benefits of accessibility to workers and firms within the same sector. The concept of localisation relates to the idea of industrial clusters (from Silicon Roundabout in East London to Media City), which have become popular among policy makers. The argument for creating clusters relies on the assumption that sharing, specialisation, matching and learning are more likely between workers and firms within the same sector.

There is little evidence that ‘clustering’ has a substantial effect on productivity, over and above the effect of accessibility in general. Studies by Mion and Naticchioni (2009) and Combes et al. (2008b) find that the impact of localisation is small or insignificant once general accessibility is controlled for, in Italy and France respectively. Gibbons et al. (2009a) find similar results for the UK economy as a whole; however, when looking at individual sectors separately they find evidence of additional gains to localisation in some sectors. Five sectors appear to experience benefits to ‘clustering’ in addition to general agglomeration benefits: aviation; creative/digital/new media; engineering; financial and professional services; ICT digital communications. In five other sectors (wholesale, sport, energy, automotive and the catch-all ‘other’), they find benefits to localisation in the absence of general agglomeration benefits, but note that the

sector classification used is quite broad, so we should be careful about drawing conclusions from these results.

Overall, the benefits of general improvements in accessibility appear more important than clustering at the sector level, although some individual sectors do experience additional benefits from clustering. Combined with the above result on service sectors gaining more from agglomeration than manufacturing, this means that in most cases it does not matter whether transport improvements take place between two cities with large shares of services *in general*, or between two cities that share *particular services*.

The importance of skill levels

There is considerable evidence that gains from accessibility are greater for workers with higher skills levels. Gould (2007) finds that first-order benefits are present for white-collar workers but not for blue-collar workers in the US, whilst Andersson et al. (2014) find that only non-routine jobs benefit from agglomeration in Sweden. These results are supported by Matano and Naticchioni (2012), who find that first-order benefits in Italy appear to strengthen along the wage distribution.

However, D'Costa et al. (2009) estimate that **in the UK, the first-order effect of accessibility on wages is largest for intermediate-skilled workers**. In particular, train accessibility (based on train journey times and ticket prices) has a positive effect on intermediate-skilled workers, but little or no effect on high-skilled workers (corporate managers and professionals) and low-skilled workers in elementary occupations. The effect of road accessibility (based on road journey times and fuel prices) is also largest for intermediate-skill workers, and slightly larger for high-skilled than low-skilled workers, though the difference is not pronounced. Given the lack of other research on skills-based effects in the UK, it is unclear whether the difference between UK and European results is due to differences in skills classifications, or to fundamental differences in the use of transport infrastructure among socio-economic classes.

The importance of spatial decay

Research on spatial decay shows that **the benefits of agglomeration decline rapidly with distance from source; for instance, the construction of an inter-city rail link between two cities will benefit the city centres much more than areas far from the train stations, which take relatively longer to reach**. Gibbons et al. (2009b) have produced estimates for the extent to which benefits decline with distance in the UK, which are used in the WebTAG guidance on transport appraisals. In the context of improving transport connectivity, spatial decay should be interpreted in terms of 'effective distance' (travel times) rather than physical distance.

Estimates for the UK economy as a whole, as well as for specific sector groups, are shown in **Table 6**. A larger parameter estimate implies a faster rate of spatial decay. A parameter estimate of 1.7 implies that a 1 hour reduction in travel times on a journey that currently takes 10 hours has 7 times the effect of a 1 hour on journey that currently takes 20 hours. To aid interpretation, we have added the equivalent figures for the sector-specific estimates. An alternative way of interpreting the distance decay parameter is that changes in economic mass (employment) close by have a much larger effect on accessibility than changes in economic mass far away (in terms of travel times). For example, a given increase in economic mass in a market 10 hours away has one fiftieth (1/50) the effect as the same change in a market 1 hour away.

The estimates show that **spatial decay is substantially more rapid in service sectors than in the manufacturing sector, which is likely to reflect the importance of face-to-face interaction in service sectors**. It is worth noting that these estimates are rather high (the wider literature on travel, trade and other flows generally uses a decay parameter of 1), but the differences in the relative speed of decay across sectors is significant

Table 6. Spatial decay estimates across sectors

	Parameter estimate	Effect of 1h reduction in journey taking 10h as factor of journey taking 20h
All	1.7	7.0
Manufacturing	1.1	4.5
Construction	1.6	6.5
Consumer services	1.8	7.5
Producer services	1.7	7.0

Previous research supports the finding of rapid spatial decay. Rice et al. (2006) find that for UK regions, markets located 40–80 minutes away have one-quarter the effect of those located less than 40 minutes away, whilst markets located more than 80 minutes away have no significant impact on local wages and productivity.

In the context of inter-city connectivity in the North, this implies that benefits to increased accessibility may be highly localised. Further, spatial decay is exponential, which means that any given reduction in travel times will have a larger effect on routes where current travel times are relatively short, than on

routes with long travel times. **The quality of intra-city transport networks is important, because the relevant travel time applies to the door-to-door journey: if intra-city networks are congested, an improvement in inter-city connectivity may only have a small effect on the door-to-door travel time.** The fact that spatial decay is more rapid for services than for manufacturing, coupled with the fact that services experience greater agglomeration benefits, suggests that inter-city links should focus on cities with large service sectors that are already relatively quick to travel between.

2.4 Implications for the strategic corridors that offer the greatest opportunity

Based on the evidence above, the opportunity for productivity gains from improved inter-city links will depend on:

- the size of cities being linked;
- current travel times between these cities;
- the quality of their intra-city networks;
- their geographic location in relation to surrounding cities;
- their sector composition; and
- the skills levels of their labour force.

The extent to which other drivers of growth are in place (in particular housing availability and a favourable business environment) will also affect the potential for second-order benefits from improved connectivity.

In Chapter 3 (on the economic geography of key Northern cities) and Chapter 4 (on the performance of transport systems between and within these cities respectively), we examine each of these factors in turn to identify the corridors with the greatest scope for driving growth.

Chapter 3: Local economic geography

Chapter overview

To build the strategic case for assessing improved connectivity in the Northern Powerhouse, it is critical to understand the local economic geography. It helps us to identify which inter-city connections could have the most potential for unlocking or driving future improvements in economic performance.

We saw in Chapter 2 that the role of transport connectivity in economic performance depends on the characteristics of the cities being linked. Improving connections between large and growing cities would be likely to offer the greatest opportunity for the productivity benefits that can result from agglomeration effects. Realising these benefits does, however, also depend on the composition of the economy and the skills mix of the workforce. In this chapter, we discuss each of these characteristics in turn.

The structure of this chapter is as follows.

- First, we outline the characteristics of the Northern Powerhouse city regions taken as a whole, making comparisons with the UK and London where relevant.
- Second, we compare the city regions within the Northern Powerhouse. We outline recent trends in populations and economic growth, we assess sector compositions and we consider the productivity and skills of the workforce.
- Finally, we conclude with several key observations to inform the strategic case, linking the evidence on the local economic geography to the role of transport connectivity in economic growth outlined in Chapter 2.

There has been a growing body of research on the economy of the Northern Powerhouse city regions in recent years. We therefore draw on this to support our analysis where relevant, particularly utilising research from the Centre for Cities.⁴³

3.1 The Northern Powerhouse

This section outlines the characteristics of the Northern Powerhouse as a whole, considering the six city regions⁴⁴ collectively. We focus on the size of the

⁴³ <http://www.centreforcities.org/>

⁴⁴ As will be detailed later, these are Liverpool, Manchester, Sheffield, Leeds, Hull and Newcastle.

Northern Powerhouse, its economic composition and the skill mix of the workforce, making comparisons with the UK and London where relevant.

Population and economy

The size of the Northern Powerhouse, taking the six city regions together, is comparable to that of London. It has a population of 10.8 million people, around 17% of the UK's population. The annual economic contribution of the Northern Powerhouse is £209 billion of GVA. However, its 13% share of UK GVA is around half that of London's 25% (as shown in **Table 7**).

Table 7. Populations and economies of the Northern Powerhouse and London

		Northern Powerhouse	London [*]
Population	millions	10.8	9.8
	% of UK	17%	15%
	Average annual growth (2001–14)	0.5%	1.2%
GVA	£ billions	209	399
	% of UK	13%	25%
	Average annual growth (2001–14) ^{**}	1.4%	2.9%

* Note that the London population refers to the London urban area, which is larger than the Greater London Authority area.

** Real growth rate, adjusted for inflation using ONS regional GVA indices up to 2013, and national GDP deflator for 2014 due to data limitations.

Source: ONS Population Estimates (2014 data), ONS Regional Accounts (2014 data), London estimates from Centre for Cities data tool (2014 data)

Average population growth in Northern Powerhouse cities was around 0.5% per year over 2001–14⁴⁵. This is forecast to increase to an average of 0.9% per year

⁴⁵ ONS Population Estimates, Nomis (<https://www.nomisweb.co.uk/>).

out to 2030, based on demographic projections (United Nations 2014)⁴⁶. This equates to an increase of around 90,000 people per year in the population of the Northern Powerhouse city regions, or around 1.4 million in total between 2015 and 2030.

The Northern Powerhouse economy (as measured by GVA) grew at an average of around 1.4% per year over 2001–2014, compared with 2.9% in London. This reflects both lower population growth and productivity compared with London. An ambition for future economic growth to at least match the national average growth rate by 2020 is one of the key stated aims for the Northern Powerhouse (HM Treasury 2015b). Annual growth in the UK economy is forecast to be 2.3% in 2020 by the Office for Budget Responsibility (2015). Higher employment and/or productivity growth than past trends will therefore be needed to achieve this aim.

Economic composition

The composition of the Northern Powerhouse economy is important for understanding which sectors are already more prevalent and where the relative potential to improve economic performance through improved inter-city connectivity could be greatest.

The overall economic composition of the Northern Powerhouse is broadly similar to the UK average, as might be expected when considering a large geographic area. As with the UK average, a significant proportion of the economy is in a variety of service sectors. As discussed in Chapter 2, these sectors are particularly likely to benefit from the productivity gains that can result from increased transport connectivity. Services in general may benefit relatively more than other sectors because they tend to be more reliant on face-to-face interaction, leading to learning and knowledge spillovers. Knowledge-based services, such as financial and insurance activities, tend to particularly benefit because of their relatively high reliance on skilled workers.

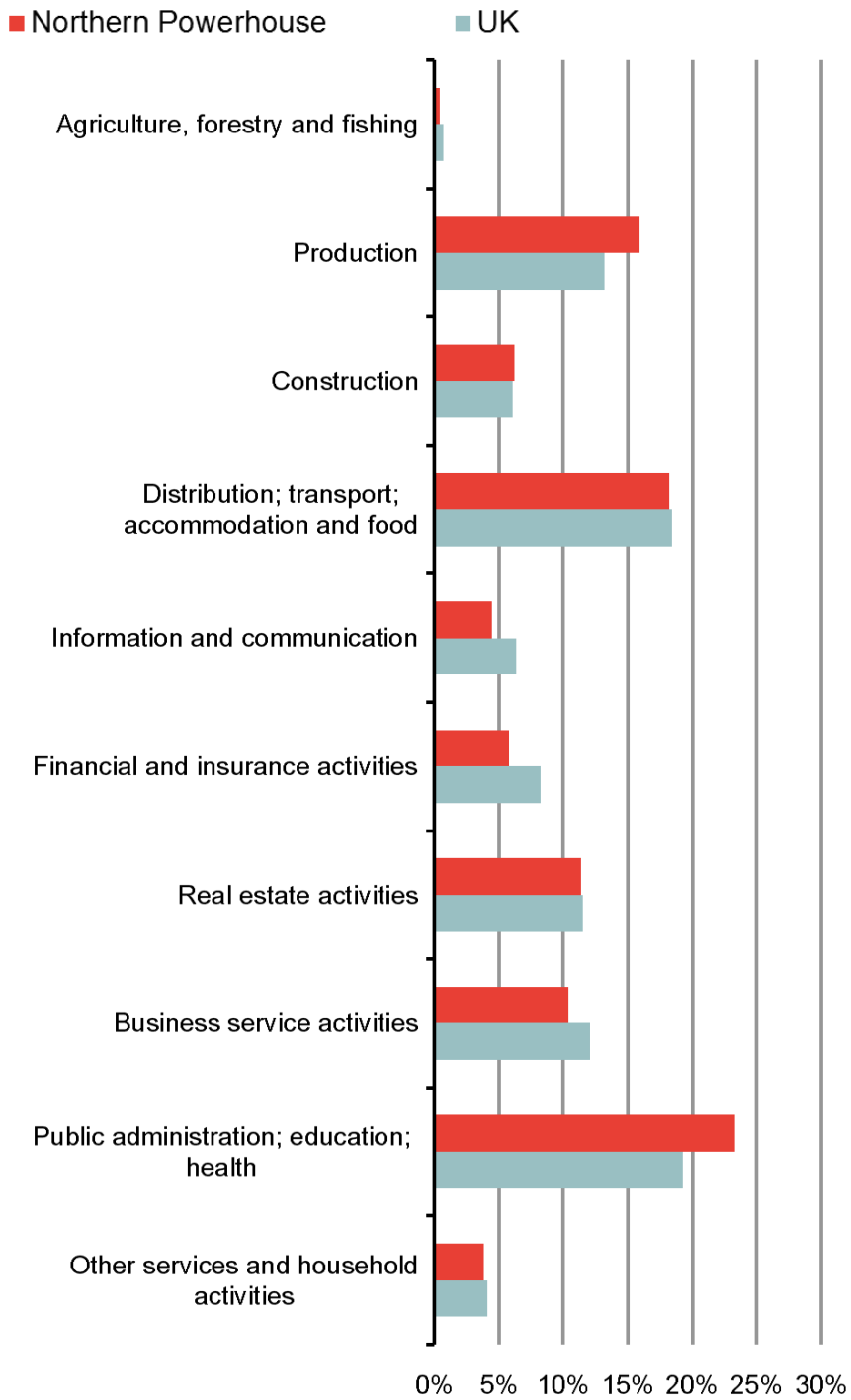
As shown in **Figure 6**, the proportion of GVA in the Northern Powerhouse accounted for by such knowledge-based service sectors is relatively lower than the national average. This is mainly because of the prominence of the public administration, education and health sectors.

Production, which includes manufacturing, also accounts for a higher proportion of the economy within the Northern Powerhouse compared with the rest of the UK. The evidence discussed in Chapter 2 suggests that the potential for

⁴⁶ Note this forecast uses slightly different geographic definitions to the city regions referred to elsewhere. The areas included are United Nations urban area definitions for: Liverpool, Manchester, Sheffield, Kingston upon Hull, Newcastle upon Tyne, Sunderland and West Yorkshire.

agglomeration benefits is generally relatively lower in the manufacturing sector, but this also depends on the skill mix within those sectors locally.

Figure 6. Proportion of GVA by industry



Source: Nomis, ONS Regional Accounts (2012 data)

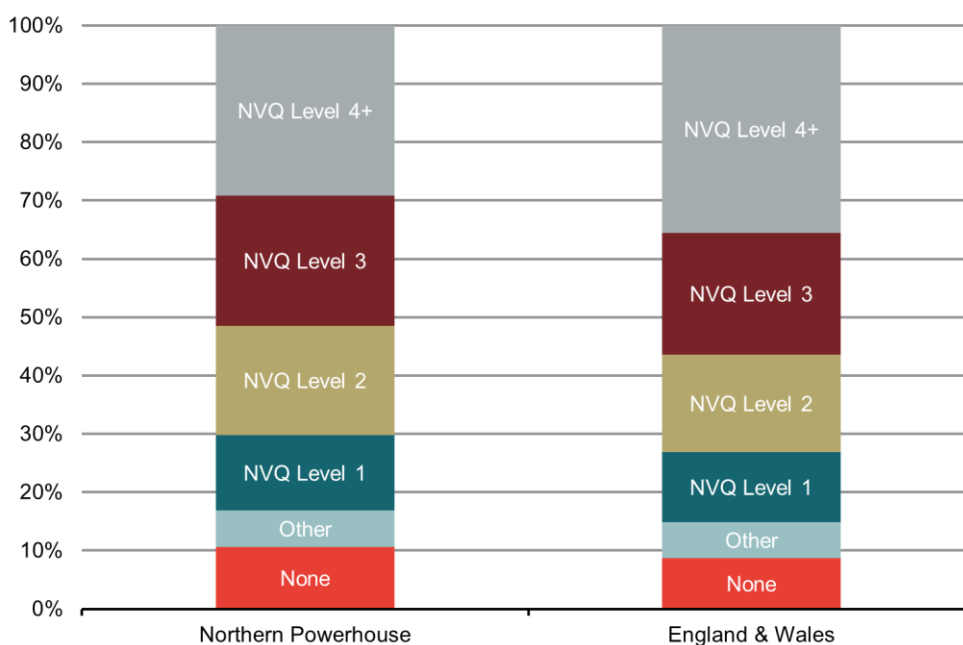
Productivity and skills

The availability of skilled workers is an important driver of economic performance. Whilst the distribution of skills in the workforce is difficult to measure directly, it can be assessed through consideration of qualifications and overall labour productivity.

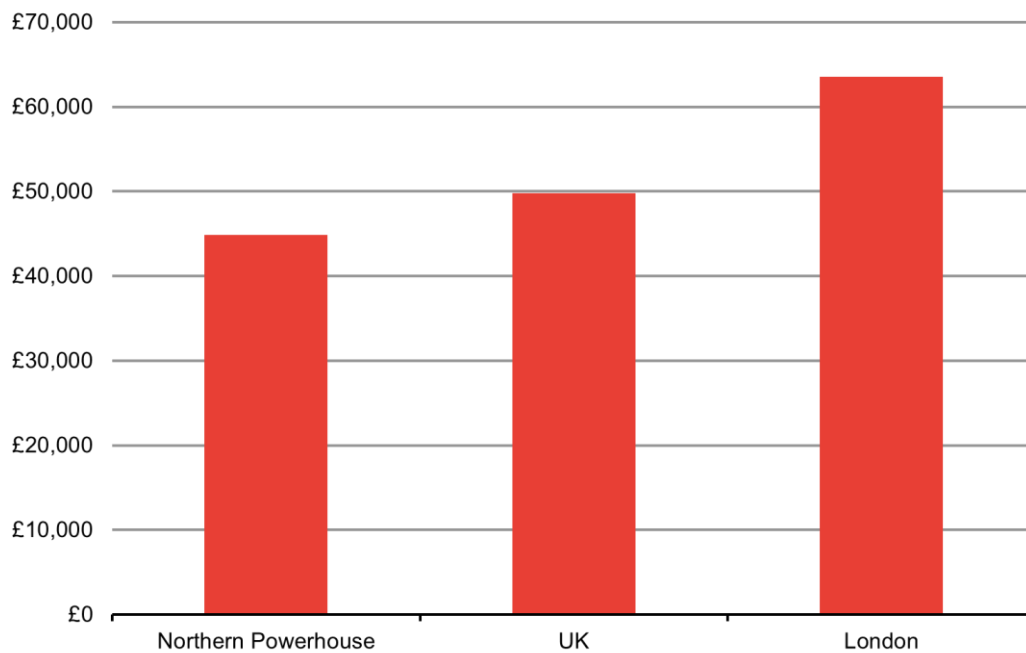
Qualification levels of the working age population in the Northern Powerhouse are shown in **Figure 7**, compared with those of England and Wales. A smaller proportion of the Northern Powerhouse population (29%) has qualifications of NVQ level 4 or above compared with the average for England and Wales (36%). A larger proportion has no qualifications: 11% in the Northern Powerhouse, compared with 9% in England and Wales.

Labour productivity is also below the national average in the Northern Powerhouse, with £44,850 GVA per worker, compared with £49,800 for the UK average (**Figure 8**). The difference compared with London's £63,500 is greater still.

Figure 7. Highest level of qualification – % of working age population



Source: Nomis, ONS, Annual Population Survey (2014 data)

Figure 8. Labour productivity – GVA per worker

Source: Centre for Cities (2015) and ONS, Business Register and Employment Survey (BRES) (2013 data)

Summary

Taken together, the Northern Powerhouse city regions have a population comparable with that of London. They make a significant contribution to the economy, but have a much smaller proportion of UK GVA than London. The population and economy of the Northern Powerhouse have been growing at steady rates, around half that of London's growth.

The composition of the Northern Powerhouse economy is broadly similar to the national average. Qualification levels and productivity data both suggest that skill levels in the workforce are somewhat below the national average.

We explore city differences in the next section.

3.2 Comparison of the city regions

This section compares the local economic geography of the city regions within the Northern Powerhouse, focusing on population, the economy, economic composition, jobs, productivity and skills. We find that the Manchester city region is the largest in terms of its population and economy, followed by the city regions of Leeds and then Newcastle. The city regions are generally more similar to one another in terms of economic composition, productivity and skills.

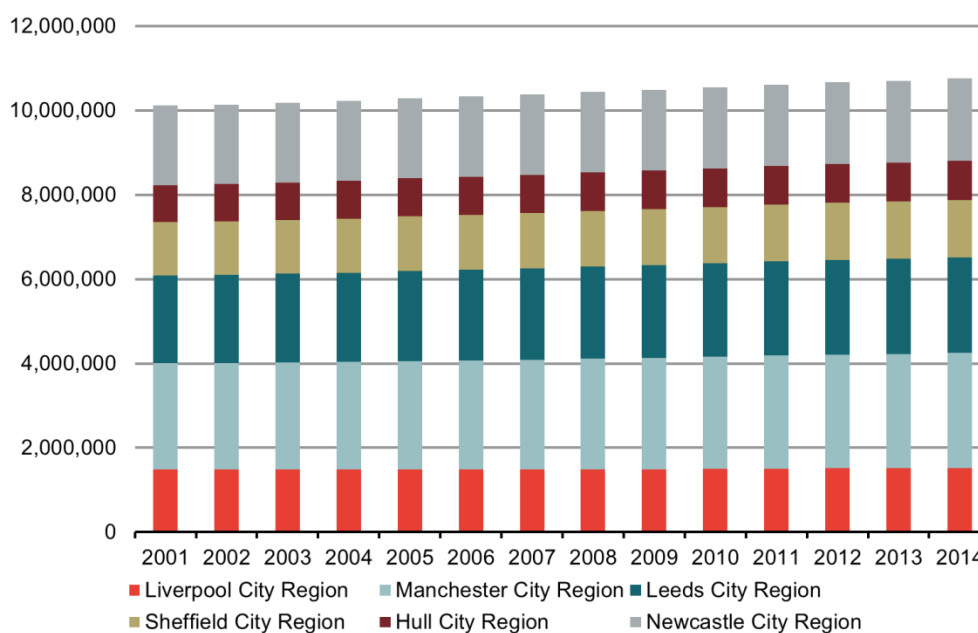
Further details on each individual city region are also outlined in the Annex.

Population

City scale is one of the important factors in determining the potential productivity gains from agglomeration that could result from improving inter-city transport connections. A simple comparison of populations in the city regions can therefore be a useful indicator.

The Northern Powerhouse city regions together have a population of 10.8 million people, around 17% of the UK. Manchester city region is the largest (2.7 million), followed by Leeds (2.3 million) and Newcastle (2.0 million). The two largest city regions, Manchester and Leeds, have seen the fastest growth from 2001 to 2014 and now account for 46% of the Northern Powerhouse population between them (**Figure 9**).

Figure 9. Populations of city regions over time



Source: ONS Population Estimates

Economy

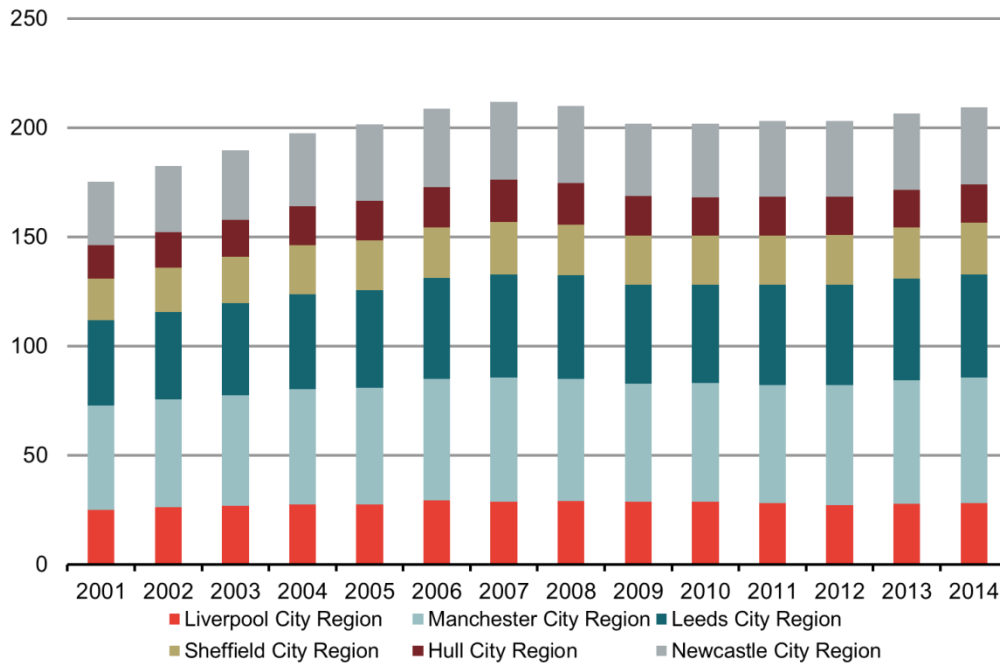
As with populations, the existing scale of economic activity can be an important factor in determining the potential benefit from improved inter-city connectivity.

The economic contribution of the Northern Powerhouse city regions (**Figure 10**) together is £209 billion GVA, some 13% of the UK total. All of the city regions were growing rapidly in the years prior to the recession, with the Sheffield and

Hull city regions showing the strongest growth. The Manchester city region has grown the most rapidly over the past three years, following the recession, with the Liverpool and Sheffield city regions also showing strong recent economic recovery.

The Manchester city region is the largest economy in terms of GVA (£57.4 billion), followed by Leeds (£47.1 billion) and Newcastle (£35.4 billion). The GVA of the Manchester city region is second only to London (among the proposed UK city regions⁴⁷). The Manchester and Leeds city regions are the only two with a share of GVA that exceeds their share of population in the Northern Powerhouse, with 50% of the Northern Powerhouse GVA between them (compared with 46% of the population). This may imply higher productivity than the Northern Powerhouse average.

Figure 10. Economic performance of city regions over time (GVA, £bn)

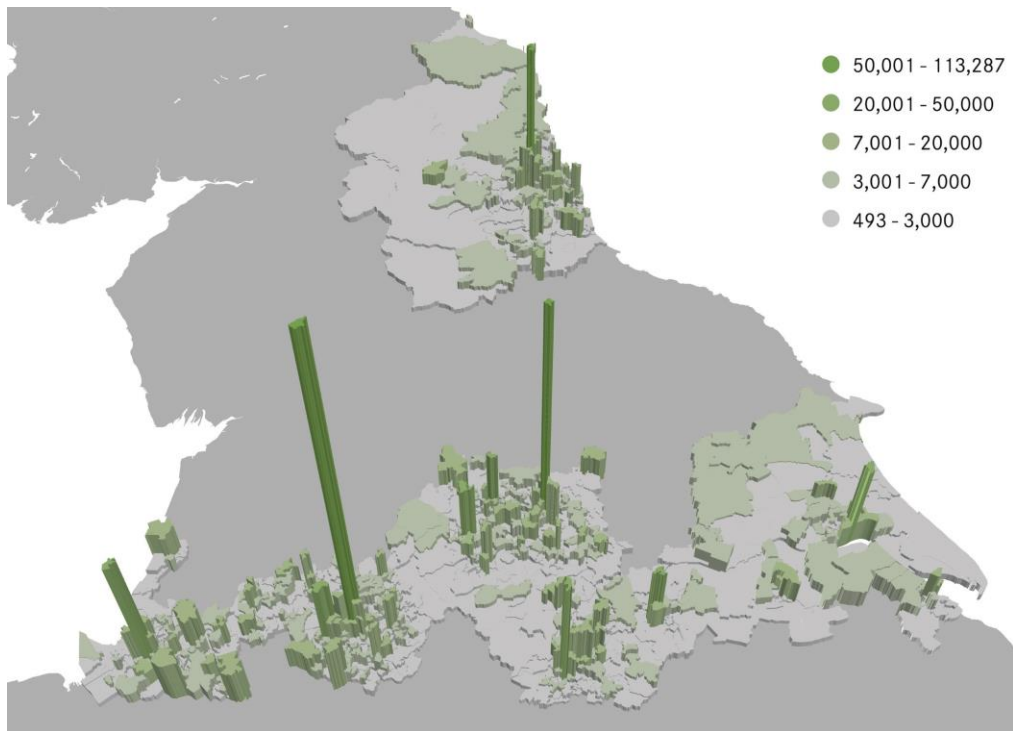


Source: ONS Regional Accounts, adjusted to 2014 prices using GVA and GDP deflators

Employment levels across the Northern Powerhouse (**Figure 11**) also demonstrate the relative economic scale of the city regions. Employment follows a similar pattern to the scale of economic activity. The biggest city regions have the highest employment (numbers of jobs), particularly Manchester, Leeds and Newcastle. This suggests higher employment density in these areas, with jobs appearing somewhat more spread out in other city regions.

⁴⁷ Office for National Statistics (2015b), and ONS Regional Accounts (2015c).

In terms of total job numbers, the Manchester city region has the most, followed by the Leeds and Newcastle city regions (**Table 8**).

Figure 11. Distribution of jobs across city regions

Source: Centre for Cities (2015) (2011 Census data)

Table 8. Number of jobs in city regions (2013)

Region	Number of Jobs
Liverpool City Region	594,872
Manchester City Region	1,207,529
Leeds City Region	993,830
Sheffield City Region	531,897
Hull City Region	365,737
Newcastle City Region	770,771

Source: Centre for Cities (2015) and ONS, Nomis, BRES (2013 data)

Economic composition

The economic composition of the city regions within the Northern Powerhouse is generally quite uniform. **Figure 10** shows the percentage point difference in

industry share compared with the Northern Powerhouse average, where 0% implies an economic sector share that is the same as the average.

The most notable difference is the Hull city region, which has approaching 12 percentage points more of its economy in production than is the case, on average, in the Northern Powerhouse. The Liverpool, Sheffield and Newcastle city regions have greater proportions of their economies in public administration, education and health than the average.

The Manchester and Leeds city regions have a higher proportion of their economies in producer services (which include finance, insurance, real estate and business services⁴⁸), which we have seen are likely to particularly benefit from agglomeration effects. These sectors together contribute 5 percentage points more of GVA in the Manchester city region than the Northern Powerhouse average, and 3 percentage points more in the Leeds city region.

Further details on economic composition by city region are provided in the Annex.

⁴⁸ Also includes professional services, which may be spread across the categories in Figure 10. See OECD definition, <https://stats.oecd.org/glossary>.

Figure 12. Difference in industries compared to Northern Powerhouse average



Productivity and skills

The distribution of skilled workers across the Northern Powerhouse can provide an important indication of economic potential. This is true in terms of both the role of skills in agglomeration benefits and also the direct role of skills in economic performance more generally.

The availability of high-skilled workers can be compared across city regions using information on the proportion of the working age population with qualifications of NVQ level 4 or above (**Figure 13**). The Manchester city region has the highest proportion of people in this category, with 32%. All the other city regions have proportions ranging between 27% and 29%, showing relatively small differences in the availability of skilled workers.

Extending this analysis to also consider more intermediate skills, which can also benefit from agglomeration benefits, shows a similar story. The proportion of the population with NVQ level 3 or above ranges from 49% to 53% across the city regions; Manchester city region has the greatest proportion of such workers (**Table 9**).

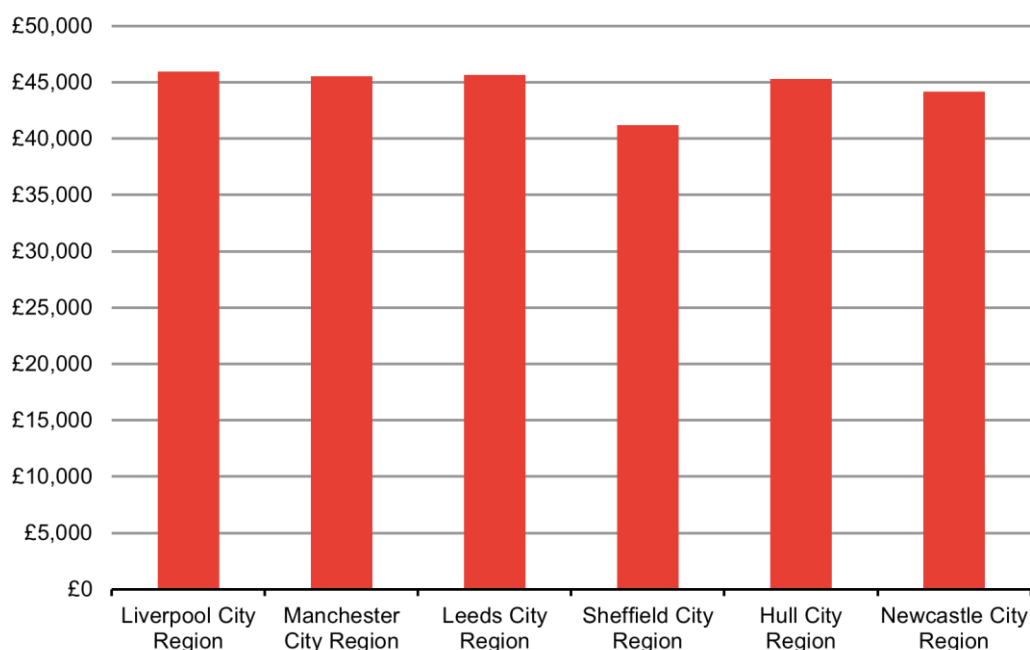
Productivity, measured in terms of GVA per worker, shows very similar levels across the city regions (**Figure 14**), with the Liverpool city region showing the highest, just above the Leeds, Manchester and Hull city regions. This again suggests broadly similar skill distributions at the local level.

Figure 13. Proportion of working age population qualified NVQ level 4 or above



Source: Nomis, and Office for National Statistics, Social Survey Division (2015)

Figure 14. Labour productivity by city region – GVA per worker



Source: Centre for Cities (2015), ONS Regional Accounts (2013 data) and BRES (2013 data).

Summary

Key data on each of the city regions from the discussion above are summarised in **Table 9**. The key points are the following.

- Manchester is the largest city region in terms of population and economic activity, followed by the Leeds and Newcastle city regions.
- Manchester city region has the highest proportion of working age people with qualifications of NVQ level 4 or above, with 32%. All the other city regions have proportions ranging between 27% and 29%, showing relatively small differences in the availability of skilled workers.
- Labour productivity levels are very similar across the city regions, apart from Sheffield, which is around 10% lower than Manchester and 7% lower than the second to least lowest productivity city, Newcastle. The highest productivity city is Liverpool at £45,950 GVA/worker.

It is worth noting also that Sheffield, despite its relatively low productivity, is the fastest growing city region of all in the Northern Powerhouse. Its annual growth over 2001–2014 was 1.77% compared with the next fastest, Newcastle, at 1.59%.

Table 9. Summary of city region characteristics

Region	Population		GVA		Jobs 2013, million	Productivity £ GVA/ worker	NVQ 4+	NVQ 3+
	2014, million	2001– 14, Average annual growth	2014, £ billion	2001–14, Average annual growth				
Liverpool city region	1.5	0.16%	28.3	1.01%	0.59	45,950	27%	49%
Manchester city region	2.7	0.64%	57.4	1.43%	1.21	45,550	32%	53%
Leeds city region	2.3	0.64%	47.1	1.49%	0.99	45,650	29%	51%
Sheffield city region	1.4	0.58%	23.9	1.77%	0.53	41,200	28%	51%
Hull city region	0.9	0.41%	17.5	1.07%	0.37	45,300	27%	50%
Newcastle city region	2.0	0.26%	35.4	1.59%	0.77	44,150	29%	52%
Northern Powerhouse	10.8	0.47%	209.5	1.41%	4.46	44,850	29%	51%

Sources: See Tables 7 and 8.

3.3 Key observations to inform the strategic case

This section concludes our discussion of local economic geography with a few key observations to inform the strategic case. Here we link the evidence on the local economic geography to the role of inter-city transport connectivity in driving and unlocking economic performance.

In Chapter 2, we outlined evidence from the academic literature on the role of transport investment in economic performance.

- **Unlocking growth.** Investment should be targeted at cities where the economy and transport demand are growing and capacity constraints are beginning to have an effect. This implies that the priority inter-city

links will be those between the fastest growing cities in the North, and/or the corridors already facing high levels of congestion.

- **Driving growth.** Investment should be targeted at corridors that are able to facilitate agglomeration through enhanced accessibility to economic mass (i.e. workforce). This depends on the size of the cities being linked, the distance between these cities, the quality of their intra-city networks, their geographic location in relation to surrounding cities, as well as their sector compositions and, importantly, the wider drivers of economic performance.

In the remainder of this section, we discuss the local economic geography of the Northern Powerhouse in this context.

Unlocking growth

The most promising inter-city links for unlocking growth are expected to be those between the fastest growing cities in the North, and/or the corridors already facing high levels of congestion. We discuss the former here, while Chapter 4 outlines congestion across the city regions.

- The Northern Powerhouse has a growing population, with growth having averaged 0.5% per year from 2001 to 2014 and forecasts showing continued growth out to 2030.
- The city regions that have shown the fastest population growth are Manchester, Leeds and Sheffield. Each showed population growth averaging around 0.6% per year from 2001 to 2014.

Driving growth

Of the factors affecting how transport connections can drive growth, we discuss evidence from the economic geography evidence above for the following in turn: the size of the cities being linked, their sector compositions and the quality of their labour force. The remaining factors, relating to geographic location, the distance between cities and intra-city networks, are discussed in Chapter 4.

- **Size of the cities.** The opportunity for productivity benefits from agglomeration is usually greatest for larger cities, with higher employment density. The largest city region in the Northern Powerhouse is Manchester, in terms of population (2.7 million), the economy (£57 billion) and jobs (1.2 million). This is followed by the Leeds and Newcastle city regions. The city centres of Manchester, Leeds and Newcastle also appear to have particularly high employment densities.

- **Sector composition.** Those sectors that would be expected to benefit most from agglomeration tend to be service sectors. This reflects that they are generally more reliant on face-to-face interaction, leading to learning and knowledge spillovers, and that producer services in particular tend to need access to high-skilled workers. Manufacturing industries tend to show lower potential for agglomeration benefits in general. The industry composition of the Northern Powerhouse is broadly similar to the UK average, but with a degree of specialisation in individual regions. The Manchester and Leeds city regions have higher proportions of their economies in producer services than the Northern Powerhouse average, suggesting higher potential gains in economic performance from increasing accessibility to these cities.

Meanwhile, those regions that are more reliant on manufacturing, such as the Hull city region, suggest comparatively lower – though still positive – potential gains from agglomeration, but this also depends on the skill mix within those sectors locally.

- **Quality of labour.** Skill levels are particularly important for considering the potential for increased accessibility to drive economic performance – the greatest gains are likely by increasing accessibility to skilled workers. The proportion of skilled workers appears fairly similar in each of the city regions. The Manchester city region has the highest proportion of people qualified NVQ level 4 or above, but the differences between the city regions are modest; and labour productivity levels are very similar across the city regions, apart from Sheffield (which is 10% lower than Manchester).

Taken together, average skill levels in the Northern Powerhouse appear somewhat below the national average. This suggests that wider policies are also important for increasing the overall pool of skilled workers available within the Northern Powerhouse as a whole, either from up-skilling within the region or attracting skilled workers from elsewhere.

The economic geography therefore suggests a prominent role from improving inter-city transport connectivity to/from the Manchester city region, with the Leeds city region also appearing particularly important, given its relatively large population, its comparatively high productivity and the fact that it has among the highest level of skills in the Northern Powerhouse.

Chapter 4: Overview of the Strategic Transport Network in the North

Chapter overview

The economic framework (Chapter 2) highlighted the fact that transport improvements can both unlock and drive improvements in economic performance. To understand which inter-city corridors may have the highest potential to do so, it is important that we examine the performance of the Northern Powerhouse's transport system.

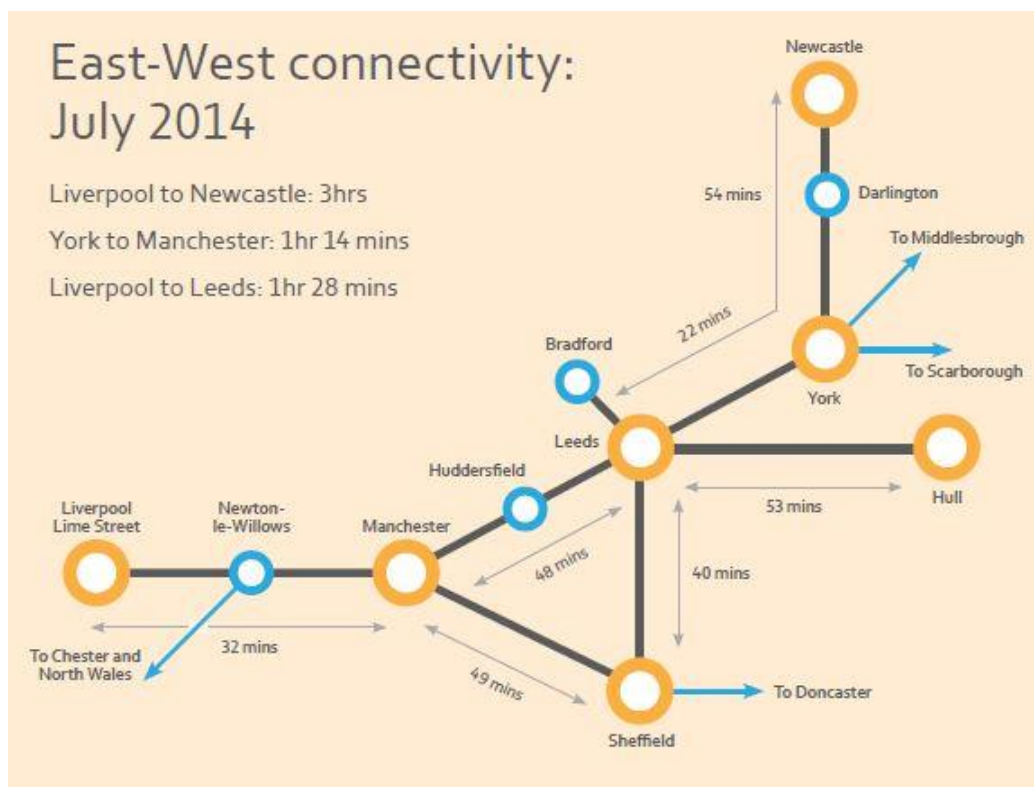
This chapter will address the following.

- First, we provide an overview of the current rail and road network in the north.
- We then examine the main differences in demand and performance of the northern strategic rail and road networks.
- Next, we look at how the freight industry interacts with the current transport system, and identify freight-related constraints and opportunities in the north.
- We then highlight some of the gaps in our knowledge, the data limitations and some further analysis that could be insightful should the data become available.
- Finally, we conclude with a few key observations.

4.1 Overview of the current strategic rail network in the Northern Powerhouse

Overview of the main northern strategic rail corridors

Northern inter-city rail connectivity is focused upon a central east-to-west route spanning from Liverpool on the west coast to Hull on the east coast. Newcastle joins the network from the North at Leeds, while Sheffield connects in from the South, at both Leeds and Manchester. This is shown in **Figure 15**.

Figure 15. Northern inter-city train routes and journey times

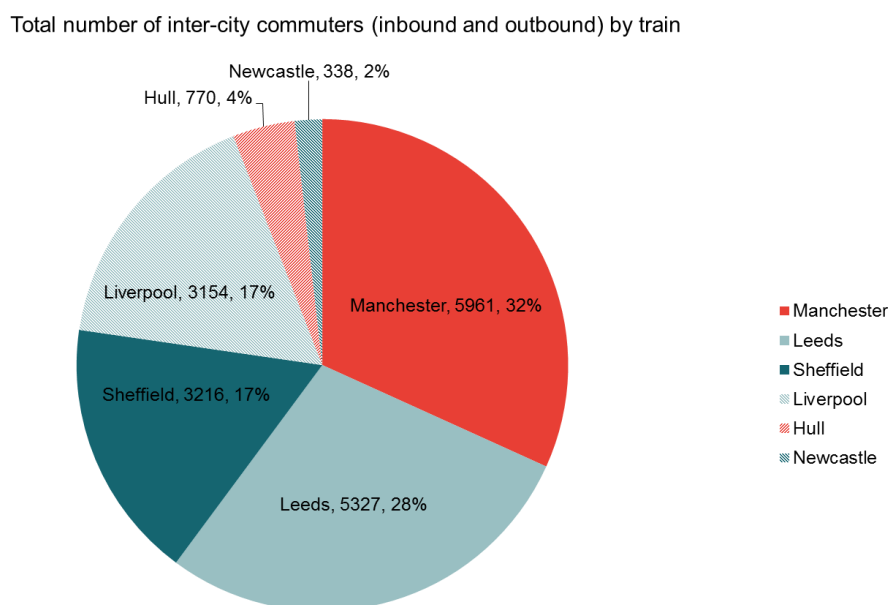
Source: High Speed Two Limited (2014)

Figure 15 illustrates how Leeds and Manchester are important nodes in the network: Manchester connects directly to both Liverpool and Sheffield; and Leeds connects directly to the eastern cities Newcastle, Hull and Sheffield. The Manchester–Leeds trans-Pennine link is critical because it provides the principal route for rail services from the western cities (Liverpool and Manchester) to get to any of the eastern cities (Leeds, Newcastle and Hull), and vice versa.

Demand for inter-city strategic rail in the north

The centrality of the Leeds and Manchester nodes is reiterated in **Figure 16**, which shows the number of inter-city rail commuters for each city (inbound and outbound commuters combined). These two cities are the origin or destination for 60% of all inter-city commuters. Liverpool and Sheffield account for another large share (34%) while Hull and Newcastle make up the remaining 6%.

Figure 16. Northern inter-city commuting by rail: number of people who commute by city (inbound and outbound commuters combined)

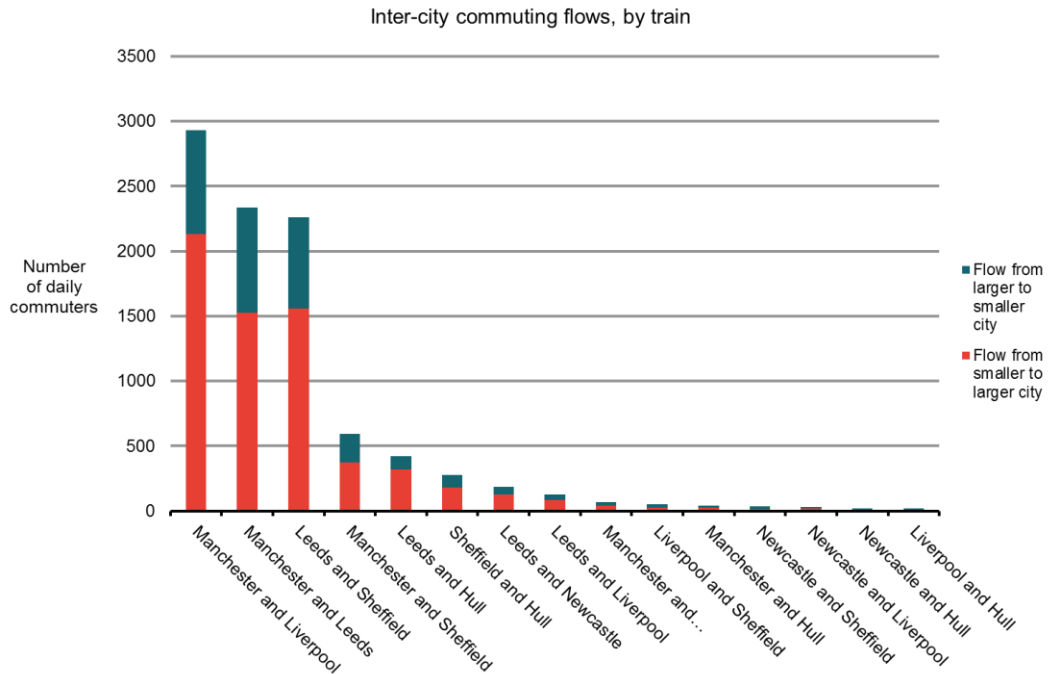


Source: Office for National Statistics (2011), Travel to Work Area (TTWA) data

Note: This graph shows the number of people who live in a TTWA in one city, and commute to work in a TTWA in a different city; for example, Manchester represents all those who commute out of Manchester to any other city and into Manchester from all other cities.

When looking deeper at the patterns of commuting across northern cities – by rail – we observe some corridors that have significantly higher commuter flows than any of the other corridors. This is shown in **Figure 17**. This analysis is based on census data in which respondents reported whether they travelled to a different city for work and by which means of transport. As such, these data capture both city-centre to city-centre rail travel and also rail commuting from the broader city region to anywhere in the destination city region. However, given that the busiest rail stations are in city centres, as shown in **Table 10**, it is likely that many of these rail commuters finish their journey in the city centre.

Figure 17. Northern inter-city commuting by rail: number of people who live in one city and commute to a different city



Source: Office for National Statistics (2011), TTWA data

Note: This graph shows the number of people who live in a TTWA in one city, and commute by rail to work in a different TTWA. Each city pair is named 'larger city and smaller city', based on population. For example, the red bar for Manchester–Liverpool represents the number of people who live in Liverpool and commute to work in Manchester.

Rail commuting patterns between northern cities, as illustrated in **Figure 16** and **Figure 17**, show three striking patterns:

- there are three busy corridors: Manchester–Liverpool, Manchester–Leeds and Leeds–Sheffield;
- there are greater flows between cities that are in close proximity to each other: Newcastle, which is located further from the other cities, has negligible intercity commuter flows; and
- in each of these corridors, the flow is approximately twice as high from the smaller to the larger city, than it is in the other direction.

After the three busiest routes, inter-city commuter flows are far lower for the remaining routes; for instance, Manchester–Sheffield has roughly one-quarter of the number of daily rail commuters of Leeds–Sheffield (500 compared to 2000, approximately).

While these commuter figures provide a strong indication of rail demand in the peak, it should be noted that they do not capture all journey purposes. The

figures capture all commuters who live within one of the northern city regions and travel to work in a different city region.⁴⁹ They do not include business travel, leisure travel, or travel to schools or universities, for example. Despite these limitations, it is justifiable to focus on commuter flows because they provide an indication of how mobile the labour market is, and how far businesses and workers are reaching out to find suitable jobs. They also indicate the demand for inter-city rail travel given current services and travel times: workers are willing to travel 48 minutes (Manchester–Leeds) to work in a different city if the job pays sufficiently, while they do not generally seem willing to travel over an hour for work (very few travel to or from Newcastle, for example).

Table 10 shows the busiest stations in the Northern Powerhouse cities, based upon the total passengers entering and exiting the stations in 2014–2015. They include all passenger types, thus including both intra- and inter-city rail passengers. This lends further evidence that Leeds, Manchester and Liverpool (which all have combined passengers in excess of 28 million per year) have the highest demand for rail travel. Sheffield and Newcastle have eight million and nine million passengers, respectively, while Hull has two million passengers enter and exit its station annually. There has been considerable growth in rail passengers over the past five years: Leeds (31%), Manchester (24%), Sheffield (21%) and Newcastle (21%).⁵⁰

⁴⁹ We use the definition of city regions from Office for National Statistics (2015b). As this does not include a definition for Hull, we take it to be the ‘East Yorkshire and Northern Lincolnshire’ NUTS level 2 region.

⁵⁰ Liverpool’s Lime Street station’s passenger numbers increased by 34%, although numbers fell in Liverpool’s other stations (Liverpool Central and Liverpool James Street). The overall change was approximately a 2.5% increase in passenger numbers across the three Liverpool stations.

Table 10. Busiest stations in Northern Powerhouse cities, by number of entries and exits in 2014–15

Station name	Total number of entries and exits in 2014–15	Percentage change between 2009–10 and 2014–15
Leeds	28,847,648	31%
Manchester Piccadilly	24,614,970	24%
Liverpool Central	15,272,837	-17%*
Liverpool Lime Street	14,870,920	37%
Sheffield	9,112,726	21%
York	8,586,056	25%
Newcastle	8,053,112	12%
Manchester Oxford Road	7,598,295	24%
Manchester Victoria	7,282,062	24%
Manchester Airport	3,460,854	32%
Liverpool James Street	3,215,334	-4%
Hull	2,199,092	2%

* Liverpool Central was closed for four months for refurbishments in 2012, which coincides with the time during which a large fall in passenger numbers occurred – passenger numbers fell from 18 million to 13.5 million between 2010–11 and 2012–13. While passenger numbers have increased since then, they have not yet reached the previous level. See BBC (2011).

Source: Office of Rail and Road (2015)

Note: This table includes the eight busiest northern stations, by entries and exits in 2014-15, alongside some other important stations for the Northern Powerhouse cities: Manchester Airport; and city centre stations such as Liverpool James Street.

Performance of inter-city strategic rail

This subsection explores the performance of the strategic rail network in the north by considering journey times, speed, frequency and congestion of each route.

Journey times

Journey times are important for users because these, along with cost, determine the extent to which users are prepared to make a particular trip. Distance, per se,

is typically less relevant to the decision. In terms of journey times, **Figure 18** illustrates the quickest journey times by rail between each of the six largest northern cities we are focusing on. An illustrative breakdown of the journey times provides three categories:

- less than 40 minutes (Liverpool–Manchester and Leeds–Sheffield⁵¹);
- between 41 and 50 minutes (Manchester–Leeds and Manchester–Sheffield);
- longer than 50 minutes (Newcastle–Leeds, Leeds–Hull and all indirect⁵² routes such as Newcastle–Sheffield and Liverpool–Leeds).

The Manchester–Leeds link (48 minutes), which most of the indirect trains use, takes longer than the Leeds–Sheffield link (40 minutes), which is a similar distance. The longest journey times, as expected, are typically those that cover most geographical distance, either directly or indirectly.

It is also interesting but perhaps unsurprising to note that the routes with highest demand each have the shortest direct journey times. The shortest is Liverpool–Manchester and, as we saw in **Figure 15**, this is also the link with the highest commuter flows.

The Manchester–Sheffield route is a notable exception: its journey time is 49 minutes, yet the number of people commuting by rail is significantly below the three other corridors with journey times less than 50 minutes (Liverpool–Manchester; Leeds–Sheffield and Manchester–Leeds). This highlights an important point, that a route will not have high demand just because of its journey time. This is because transport is a means to an end, not an end in itself. As such, demand will be driven by whether people can derive a benefit from using that transport link, which exceeds the total cost to them of making the trip (time and money), for instance by providing access to work, education or leisure. Quicker journey times will only increase demand in so far as they allow people to gain quicker access to locations or activities from which they can derive a sufficient benefit.

Speed and frequency

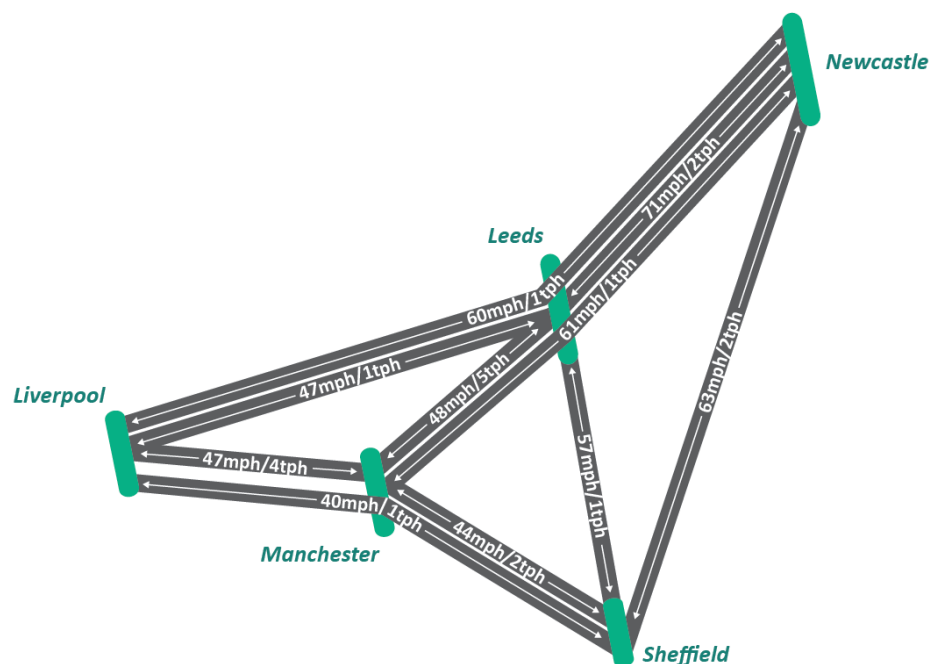
While journey times are useful, speed provides a further indicator of the service performance. **Figure 18** indicates that the four rail links services with highest

⁵¹ Leeds–York is also within this category, but we focus our discussion on the cities discussed in Transport for the North (2015a), which includes Liverpool, Manchester, Leeds, Sheffield, Newcastle and Hull.

⁵² We consider routes to be indirect if they have to pass through a different city along the way to their destination city. For instance, Liverpool–Manchester services are direct, but Liverpool–Leeds services must go indirectly through Manchester.

commuter demand also tend to be the slowest: of these four, only Leeds–Sheffield services have speeds in excess of 50 mph, whereas trains to Newcastle travel at 71 mph.

Figure 18. Northern inter-city rail routes: speed and frequency of fast trains



Source: Re-produced from One North (2014)

These speeds may not, however, be directly comparable for numerous reasons, such as: the constraints associated with the average and maximum speeds of the trains and track; congestion on the track; the distance between stations and the number of stations at which trains stop. Indeed, the topography of the route may mean that faster trains are not possible, at least without considerable cost. However, for illustration, we can try comparing performance against similar international examples. One North (2014) highlights Randstad⁵³ and Rhein-Ruhr⁵⁴, in the Netherlands and Germany respectively, as regions with similarly

⁵³ The Randstad region consists of Amsterdam, Rotterdam, Den Haag and Utrecht. It has a population of 7 million. Excluding Amsterdam, their per capita GDP ranges between approximately €35,000 and €40,000, which is higher than the approximate €25,000–€35,000 range of the northern cities. City to city distances are between 30 and 50 miles.

⁵⁴ The Rhein-Ruhr region of Germany consists of Cologne, Düsseldorf, Duisburg, Essen and Dortmund, alongside 10 other smaller cities. It has a population of 10 million and, excluding Dusseldorf, has a per capita GDP that ranges from less than €30,000 to €45,000, approximately. Several of the city distances are in the 30–50 mile range.

sized and spatially located cities. All of the Rhein-Ruhr cities have speeds in excess of 63 mph, compared to 40–57 mph on all the shorter distance English routes.⁵⁵ While the Randstad has some slower trains, relative to northern England, they are substantially more frequent. Indeed, only two out of seven of the North's routes have four or more services per hour (Liverpool–Manchester and Manchester–Leeds), compared to 11 out of the 13 services on the European routes examined.

One North (2014) highlights that these European region's services are better timed to support quick connections at key interchanges. There is no readily available evidence on this particular issue within the Northern Powerhouse, but further analysis may be justified if it can identify places where better connection times have the potential to reduce travel times, without incurring network improvement costs.

Crowding

Table 11 illustrates how crowded trains are when arriving into each station during peak morning times, and indicates that trains arriving at Manchester are the most crowded of the Northern Powerhouse cities. On average, these trains have an overcapacity of 6% and 20% of passengers are standing. It is notable that the crowding on trains into Manchester is approaching the level in London (an overcapacity of 7%), which has the highest level of crowding in the UK. Unfortunately, there is no available breakdown of where these crowded trains originate, or at what point along their route they become overcrowded. As such, it is not possible to conclude which corridors are more overcrowded than others. Levels of crowding on services into key stations at Manchester and Leeds are in line with the previous evidence that most commuting occurs into Manchester (from Liverpool and Leeds) and into Leeds (from Sheffield). Further analysis of route level data would be needed to identify whether these inter-city routes are the most overcrowded.

⁵⁵ The longer routes English routes to Newcastle can reach up to 71 mph.

Table 11. Demand, excess demand and passengers standing, at peak morning times, by city of arrival⁵⁶

Station	Total passengers arriving in morning peak hours*	Passengers in excess of capacity (1 hour peak)**	Percentage of passengers standing (1 hour peak)***
Manchester	30,907	5.7%	20.3%
Leeds	25,897	2.5%	14.9%
Liverpool	20,155	0.0%	5.5%
Sheffield	7,224	2.3%	7.8%
Newcastle	4,447	2.2%	9.2%
London	563,354	7.2%	27.9%

* Total passenger numbers include both inter- and intra-city passengers arriving into these stations. As such, the figures shown here are considerably larger than the inter-city passenger numbers in **Figure 16**. Numbers are for 3 hour AM peak.

** Passengers in excess of capacity and percentage of passengers standing are calculated by the Department for Transport as a percentage of the critical load. The critical load is the highest number of standard class passenger on a service on arrival at (AM peak) or on departure from (PM peak) a city. However, these values are of the same order of magnitude as if they were calculated as a percentage of the total number of passengers arriving. Numbers given are for 1 hour AM peak (3 hour peak data shows a similar pattern, but with slightly lower congestion).

***Percentage of passengers standing numbers are for 1 hour AM peak (3 hour peak data shows a similar pattern, but with slightly lower congestion).

Source: Department for Transport (2014a).

4.2 Overview of the current strategic road network in the Northern Powerhouse

Overview of the northern strategic road network

The strategic road network linking the northern cities is similar in structure to that of the rail network, as shown in **Figure 19**.

⁵⁶ Hull is excluded due to lack of data availability.

Figure 19. Map of the main motorway network of northern England



Source: Reproduced from Highways England (2015)

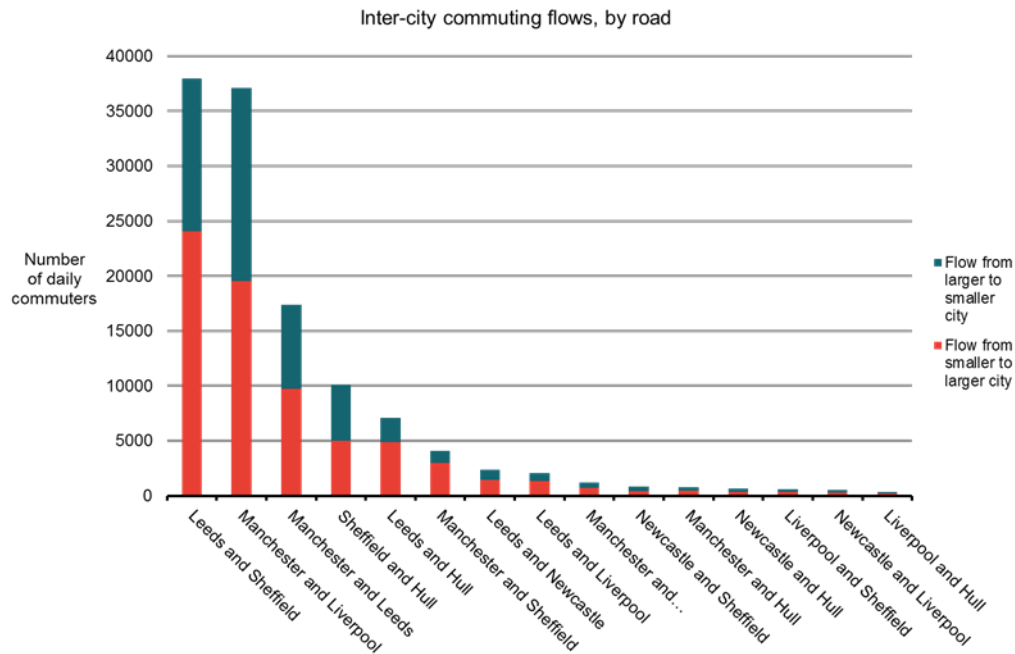
The major corridor is the M62, which spans west-to-east from Liverpool to Hull, passing through Manchester and Leeds. Manchester is surrounded by the M60 ring-road motorway, which feeds into the M62 in both directions. The M1 links Sheffield northwards to Leeds and continues on to Newcastle.⁵⁷ Sheffield to Manchester does not have a motorway link, but is served by the A57. As was the case with rail, the Manchester–Leeds trans-Pennine link is critical because it provides the principal route for traffic from the western cities to get to any of the eastern cities, and vice versa.

Demand for inter-city strategic roads

The inter-city commuting flows by road are shown in **Figure 20**. While the most popular corridors are similarly ranked, there are some important differences from rail commuting flows. As for our analysis above for inter-city rail commuting flows, we draw on the latest census data for commuting travel between TTWAs. It is likely that the final destinations of road commuters are more dispersed than would be the case for inter-city rail travel.

⁵⁷ The link between Leeds and Newcastle is not shown to the map. North of Leeds, the M1 is known as A1(M) as only parts have been upgraded to full motorway status.

Figure 20. Northern inter-city commuting by road: number of people who live in one city and commute to a different city



Source: Office for National Statistics (2011), TTWA data

Note: this graph shows the number of people who live in a TTWA in one city, and commute – by road – to work in a TTWA in a different city. Each city pair is named 'larger city and smaller city', based on population. For example, the red bar for Leeds–Sheffield represents the number of people who live in Sheffield and commute to work in Leeds.

The notable patterns are:

- ten-fold more commuters travel inter-city by car than by rail, highlighting the importance of car travel for commuting in northern England;
- as with rail commuting, there are larger flows from the smaller city to the larger city, than vice versa;
- there are two major commuter links with more than 35,000 commuters: Leeds–Sheffield and Manchester–Liverpool;
- Manchester–Leeds (17,000 commuters per day) and Sheffield–Hull (10,000 commuters per day) also have a large number of commuters, albeit fewer than half the number of the top two commuting links noted above;
- Leeds–Hull (7,000 daily commuters) and Manchester–Sheffield (4,000 daily commuters) have relatively low levels of commuting; and

- the remaining city pairs, which have greater geographical distances between them, have a very low level of commuting (less than 2,500 daily commuters).

Unlike rail commuting where three inter-city links stand out, there are only two inter-city strategic road links that have significant commuting: Leeds–Sheffield (46 miles) and Manchester–Liverpool (34 miles). Manchester–Leeds (about 44 miles), which was highlighted above as an important link for rail commuters, has fewer than half the number of road commuters as the leading two inter-city strategic road links.

The number of people commuting by car is much larger than the number commuting by rail. This indicates the relative importance of car travel as a means to access work in northern cities. As these commuting data account for commuters who live in one city region and travel to another city region for work, the reliance on the car for commuting could reflect the fact that many car journeys do not enter the city centre (unlike rail) but instead travel to destinations for work in the wider city region.

In general, these commuting data provide evidence of demand for different inter-city road travel and are an indicator of how mobile the northern labour force is.

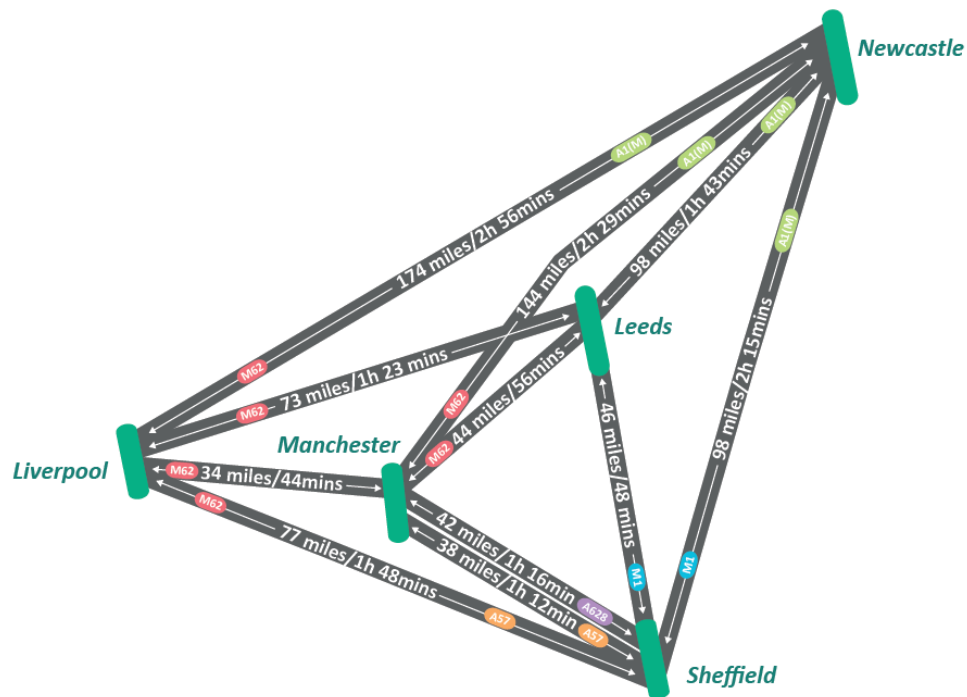
Performance of the strategic road network

This subsection will analyse the performance of the road network based on journey times and congestion.

Journey Times

Journey times by road, as shown in **Figure 21**, are typically quickest between those cities that are located close to each other: Manchester–Liverpool (44 minutes), Manchester–Leeds (56 minutes) and Leeds–Sheffield (48 minutes); whereas journeys to Newcastle and indirect journeys, such as Liverpool to Leeds, take over an hour.

One notable exception is the Manchester–Sheffield link, where journeys are over an hour despite the fact that the distance is shorter than both the Manchester–Leeds and Leeds–Sheffield links. This is due to the lack of a direct motorway link between Manchester and Sheffield. The geography, consisting of a national park and the Pennines, between Sheffield and Manchester has restricted the improvement of this link. However, Department for Transport (2015) have recently proposed some improvements, such as a new dual carriageway link, to improve journey times on this route.

Figure 21. Northern inter-city road routes: distance and journey times⁵⁸

Source: One North (2014)

Congestion

Figure 22 highlights that there is currently high congestion⁵⁹ on the M62 between Liverpool and Manchester, and also between Manchester and Leeds; on the M60 around Manchester; on the M1 near Sheffield; on the M6 leading into Manchester; and, on the A1(M) near Newcastle. High congestion on the Leeds–Manchester M62 link is particularly notable, given the strategic importance of this link at the centre of the west-to-east corridor.

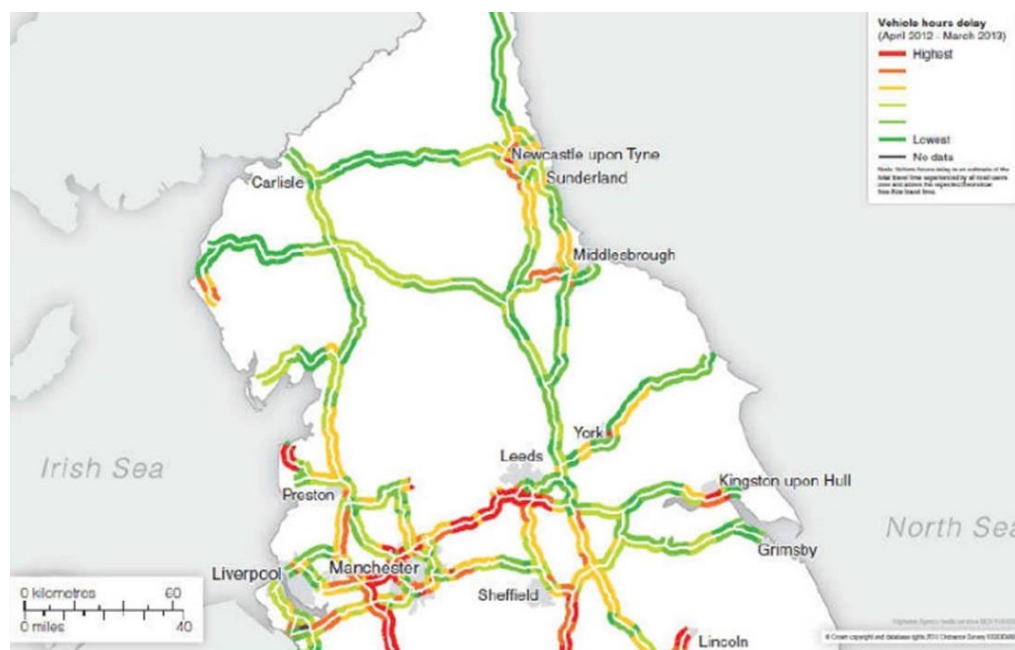
It may not always be the case that the inter-city strategic roads with the highest volumes of commuters are the most congested because other factors need to be taken into account, such as capacity of the road, use of the road by other

⁵⁸ One North (2015) does not define whether these journeys are average journeys or free flowing traffic journey times. Based on AA Route Finder (2015), they seem consistent with free flowing traffic journey times.

⁵⁹ This is the Highways Agency's categorisation, based on vehicle hour's delay, which is an estimate of the total travel time experienced by all road users over and above the expected theoretical free-flow travel time.

travellers (freight, business travellers and leisure travellers) and time of day over which congestion is measured.

Figure 22. Current congestion on the strategic road corridors in the north of England, 2012–2013



Source: Highways Agency reported in Steer Davies Gleave (2014)

The analysis by High Speed Two (2014) of Department for Transport data suggests that congestion will increase over the coming years in similar areas to those already highlighted; as well as increasing on the M1 between Sheffield and Leeds, which is important given the fact that this is the corridor with highest current demand for road commuting.

4.3 Comparison of the strategic road and rail networks in the Northern Powerhouse

This section analyses the differences in the demand and performance of the road and rail networks in the Northern Powerhouse.

Comparison of **Figure 15** and **Figure 21** reveals that inter-city rail journey times are often faster than the equivalent road journey. This is particularly true for longer journeys such as Leeds to Newcastle, where rail can take approximately an hour and 16 minutes, while road journeys are almost 30 minutes longer. In this sense, rail has an advantage over roads, but the onward journey when arriving in the city at the end of the rail trip should also be accounted for. Intra-city

congestion could dampen some of these benefits, depending on the final location.

Figure 17 and **Figure 20** highlight the big difference in commuting patterns for the strategic rail and road networks: there are approximately ten-fold more inter-city road commuters than rail commuters. While road is by far the most commonly used mode for travelling between city regions for work, high demand for both road and rail (evidenced by crowding seen on both networks) suggests that they complement each other and both play an important role in supporting economic activity in the north of England. As noted above, it is likely that rail journeys are primarily used to travel into city centres, while road travel has many potential destinations. Important road and rail routes going into the largest cities in the north are showing clear signs of being under pressure from congestion and crowding.

To contribute to the evidence base on commuting patterns and the extent to which they are at the levels that would be expected given the characteristics of the cities, we have carried out our own analysis in the form of ‘gravity modelling’, as described in the box below.

Actual commuting flows versus expected commuting flows

Another way of thinking about the extent to which the transport network is constraining economic activity is to consider whether flows between certain cities are lower than expected, given the characteristics of the cities and the distance between them. **If flows between certain cities are significantly lower than expected, this could imply that constraints on inter-city connections exist.**

To compare actual and expected flows between cities in the North, we adopt a 'gravity' modelling approach. We follow the methodology used in the Northern Way report (D'Costa et al. 2009), which analyses commuting flows between Manchester to Leeds, and extend this to commuting between the six largest Northern Powerhouse cities. Gravity models explain commuter flows between two areas based on the observable characteristics of the origin and destination areas (wages and employment), the geographic distance between the areas, and any other characteristics of the origin and destination areas not observed by the researcher. The aim is to identify which, if any, inter-city corridors between the six Northern cities have significantly lower commuter flows than predicted by the gravity model, compared to inter-city flows between cities in the South of England, Scotland and Wales.⁶⁰ This could then indicate transport constraints between the two cities – indeed, the Northern Way report (D'Costa et al. 2009) found that the 40% lower than expected commuter travel flows between Manchester and Leeds under one model variation (explained below) were fully explained by lengthy travel times.

Unobserved characteristics in the modelling may capture culture or quality of place, but they may also reflect transport-related factors such as connectivity or congestion. To the extent that they capture the latter, controlling for unobserved characteristics may bias results, if our aim is to explore which corridors have low flows *due* to congested transport networks. We therefore consider 3 different specifications (model variations), which control for unobserved characteristics to different extents. Details of the modelling and results are presented in the Annex.

The inter-city corridors that have significantly lower than expected commuter flows based on *all* 3 specifications are Manchester-Sheffield, Liverpool-Sheffield, Liverpool-Leeds and Hull-Manchester.⁶¹ Of these, low commuter flows between

⁶⁰ The cities considered are: Birmingham, Bristol, London, Nottingham, Oxford in the South; Edinburgh, Glasgow and Aberdeen in Scotland; and Cardiff and Swansea in Wales. The models inter-city LA-LA flows between cities in the North to inter-city LA-LA flows in the South, Scotland and Wales. Cities are defined as city regions, based on existing and proposed city regions and the definitions used in the Northern Way report (D'Costa et al. 2009).

⁶¹ Leeds-Manchester, Hull-Newcastle, Liverpool-Newcastle and Leeds-Newcastle are also significantly lower in one of the three specifications. Leeds-Manchester is significant under the specification controlling for unobserved characteristics, but not others – this is consistent with the findings of the Northern Way report (D'Costa et al. 2009).

Liverpool and Leeds, and between Liverpool and Sheffield, are easily explained by the fact that Manchester lies between these cities (the modelling cannot account for the spatial configuration of cities). Therefore, **the modelling indicates that transport constraints may exist on the Hull-Manchester and Manchester-Sheffield corridors. Flows between these city pairs are at least 25% and 38% lower than expected respectively.**

Indeed, currently commuters between Hull and Manchester tend to travel through Leeds, which means that travel times are higher than the geographic distance suggests.

It is worth noting that unlike the Northern Way report (D'Costa et al. 2009), our analysis does not identify commuting along the Manchester-Leeds corridor to be significantly lower than expected. This is due to two reasons. First, we take into account a larger number of comparator inter-city links, as well as all corridors between the 6 Northern Powerhouse cities, which brings down average commuter flows. Second, we report only those corridors that are significantly negative based on *all* 3 specifications, whilst the Northern Way report obtains a significantly negative result for Manchester-Leeds only under one specification (controlling for all unobserved origin and destination characteristics). In our modelling, flows between Manchester and Leeds are also significantly lower than expected under this particular specification, although the gap is smaller (8% compared to 40%) due to the inclusion of a wider range of comparator inter-city links.

4.4 Road and rail data limitations

This section summarises the gaps in our knowledge due to a current lack of evidence and data.

- Our analysis has looked at commuting patterns by road and rail as this indicates workers' propensity to travel from one city to another to find a job they prefer. To gain a richer understanding of which routes commuters use (i.e. between which stations rail passengers travel and between which areas of the city regions road users travel), it would be beneficial to examine data on the usage of individual road and rail routes. It has not been possible to obtain these data in the time available for this study.
- Our data on rail crowding are based on services arriving into stations, rather than crowding on particular train routes or services. As such, we cannot infer which particular services are more crowded than others. To further understand the extent to which pressures on the transport system constrain

economic performance, it would be useful to examine data on rail overcrowding on individual links. This data was not available for this study.

- To understand the economic geography of the area in more depth and how this affects the labour market, it would be useful to know which jobs workers are willing to travel to other cities for. This would indicate, for example, the extent to which workers travel from one city to another for low- or intermediate-skilled jobs, as well as high-skilled jobs.
- Although the focus of this study is inter-city travel, it is important to recognise that intra-city transport performance (alongside other drivers of economic performance) is critical to whether the opportunities associated with improved inter-city connectivity can be realised. This has not been assessed within this Chapter.
- Travel costs have not been assessed in this Chapter but these are likely to play an important role in determining the extent to which there is inter-city travel by rail and road, and the choice of mode.

4.5 Overview of freight activity in the Northern Powerhouse

Freight movements by rail and road are a significant consideration for inter-city connectivity in the Northern Powerhouse. This section provides a high-level outline of key freight routes in the Northern Powerhouse. We find that there is strong existing freight activity, and this is likely to increase in the future, particularly in light of significant upcoming port investments.

Freight activity across the Northern Powerhouse

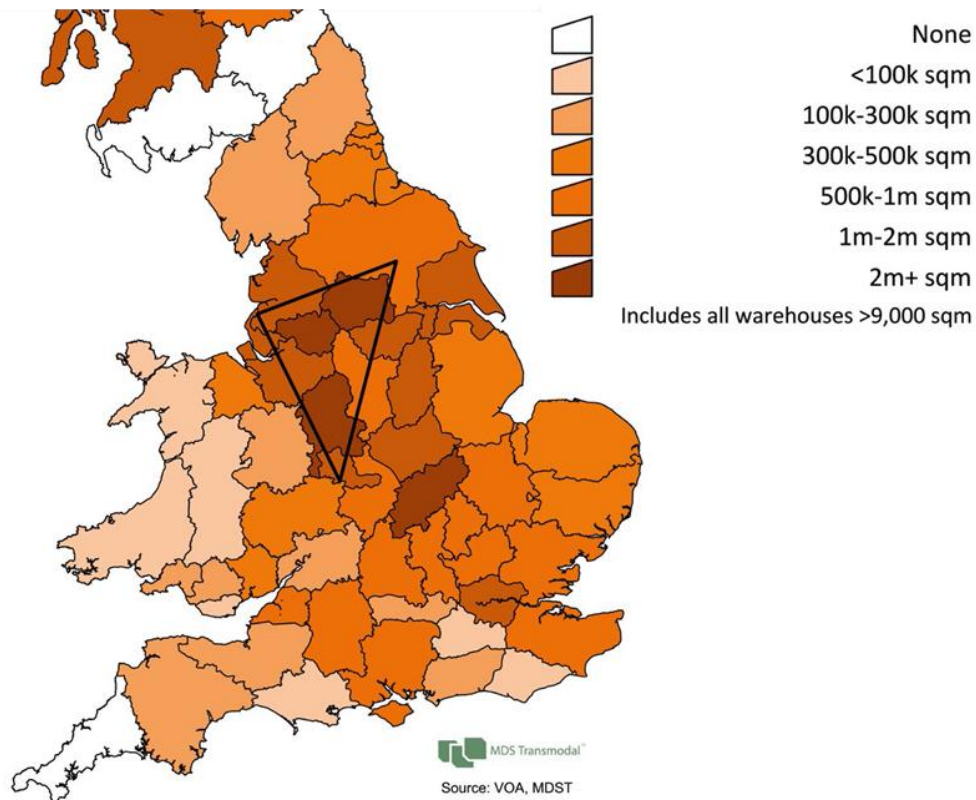
Freight activity is an important aspect of transport performance because of its impact on the wider economy. Freight costs form an element of the final price of goods to consumers. In some cases, these costs can even exceed the cost of the production process – excluding raw materials (Independent Transport Commission 2014). Similarly, freight costs are also a direct cost to businesses, affecting UK competitiveness in an increasingly globalised market. Freight can also have impacts on other road users, affecting congestion, noise and air quality.

The Northern Powerhouse city regions are at the centre of the freight and distribution industry in the north, as demonstrated by a high concentration of warehousing density. Northern England has 14 million square-metres of large warehouses (One North 2014). Transport for the North describe a ‘golden

triangle' of freight and distribution centres, encompassing a number of the Northern Powerhouse city regions and spreading further south into the West Midlands (**Figure 23**).

This has important implications for transport connectivity in the Northern Powerhouse, for road and rail, and their linkages to ports.

Figure 23. Warehousing density in the North (2012)



Source: Re-produced from Transport for the North, Valuation Office Agency, MDS Transmodal

Road freight

Road transport accounts for around 88% of inland good movements in the UK (Eurostat 2012). Some 30% of goods transported by domestic road freight originate from the North West, North East, and the Yorkshire and Humber regions (Department for Transport 2014b).

Freight accounts for a significant proportion of traffic along key routes in the Northern Powerhouse. Freight makes up around 40% of traffic on the M62 route (One North 2014) that stretches from Liverpool in the west to Hull in the east. The M18 and M1 also play a significant role alongside the M62 in providing important links to the Humber ports. Warehouse space is concentrated along the M62 corridor on both sides of the Pennines, in South Yorkshire, where the M18

connects to the Doncaster logistics sector, and around the major ports (One North 2014).

Rail freight

Rail freight accounts for around 12% of national inland good movements in the UK (Eurostat 2013). Rail freight has increased by around 50% over the last decade and is forecast to grow further (Network Rail 2015). There are key freight sites in each of the Northern Powerhouse city regions, including important intermodal hubs, such as the port of Liverpool.

Port freight

The Northern Powerhouse is home to a number of major international ports that support the UK freight and logistics sector, including: Workington, Heysham, Fleetwood, Liverpool, Garston, Manchester, Blyth, Tyne, Sunderland, Seaham, Tees/Hartlepool, Goole, Hull and Grimsby/Immingham (Department for Transport 2014c). This port network places additional demand on transport connections across the north, which can be expected to increase with approaching a billion pounds of investments in northern ports planned over the next few years (Transport for the North 2015a).

The UK handles 500 million tonnes of goods per year at ports, the second highest in Europe after the Netherlands (Eurostat 2013). The ports on both coasts of the Northern Powerhouse play a major role in this industry. Ports in Lancashire and Cumbria, Humber and the North East handled 175 million tonnes of goods in 2014, some 35% of the UK total (Department for Transport 2014d).

Major private sector investment in ports in the north could approach one billion pounds over the next few years. Developments are planned at locations across the north, including the Liverpool, Manchester, Hull and Newcastle city regions. This can be expected to increase freight activity on road and rail connections. For example, the £300 million Peel Ports investment in the Port of Liverpool will create a major terminal capable of accommodating 95% of global container vessels, and is being supported by development of the 'Liverpool Superport' freight and logistics hub (Transport for the North 2015b).

4.6 Key observations for the strategic case

In this section, we offer several observations to inform the strategic case. We link the evidence back to our economic framework of Chapter 2.

In Chapter 2, we outlined evidence from the academic literature on the role of transport connectivity in economic performance.

- **Unlocking growth.** Investment should be targeted at cities where the economy and transport demand are growing and capacity constraints are beginning to have an effect. This implies that the priority inter-city links will be those between the fastest growing cities in the North, and/or the corridors already facing high levels of congestion.
- **Driving growth.** Investment should be targeted at corridors that are able to facilitate agglomeration through enhanced accessibility to economic mass (i.e. workforce). This depends on the size of the cities being linked, the distance between these cities, the quality of their intra-city networks, their geographic location in relation to surrounding cities, as well as their sector compositions and the quality of their labour force.

In the remainder of this section, we discuss the transport performance of the Northern Powerhouse in this context.

Unlocking growth

The most promising inter-city links for unlocking growth will be those between the fastest growing cities in the North, and/or the corridors already facing high levels of congestion. As such, this is a key consideration for our discussion of transport performance.

- With commuting by rail, we have seen that the links with the highest commuter demand are those between Manchester and Liverpool, Manchester and Leeds, and Leeds and Sheffield. In each case, the flows in the morning peak are higher into the larger city. We have seen that trains travelling into Manchester are the most prone to having passengers in excess of capacity. Manchester and Leeds have particularly high proportions of passengers standing, at 20% and 15% respectively in the morning peak hour. This suggests that improvements to these rail routes could be important for unlocking economic performance.
- With commuting by road, we have seen that the links with the highest commuter demand are those between Leeds and Sheffield, and Manchester and Liverpool. The most congested routes are the M62 between Liverpool and Manchester, and also between Manchester and Leeds; on the M60 around Manchester; on the M1 near Sheffield; on the M6 leading into Manchester; and, on the A1(M) near Newcastle. Routes between Leeds and Sheffield are also forecast to experience significant congestion in future. This suggests that improvements to these road routes could be important for unlocking economic performance.
- Analysis of actual versus predicted levels of commuting between the Leeds and Manchester city regions has shown that commuting levels are around

40% lower than expected, which appears to be mostly explained by high travel costs and times. This further highlights the potential importance of transport performance on key commuting routes.

- Economic performance could also be enhanced through improving links heavily used by freight transport, as this would reduce congestion and hence costs to consumers and businesses alike. Warehouse space is focused around the M62, the M1 in South Yorkshire, and the major ports. Key freight routes, particularly those around ports attracting new investments such as Liverpool, are likely to experience significant increases in traffic. Importantly, freight shares infrastructure with passenger rail and car traffic so the interactions of these modes must be considered, because growth in freight and passenger demand implies rising pressure on the system, particularly around cities and ports.
- As we saw in Chapter 3, the populations of the Northern Powerhouse city regions have been growing and are forecast to grow further going forward. This can be expected to further increase demands on the transport network, which, if left unchecked, would be likely to affect its performance. Other changes to the wider network may also have an impact, such as potential increases in travelling between north and south as a result of High Speed 2.
- Overall, the evidence on transport performance suggests that improvements to inter-city connectivity may play an important role in unlocking economic performance, with signs of current capacity constraints affecting both road and rail. There is particular overcrowding on trains into Manchester and Leeds, and road routes around Leeds, Manchester and Sheffield are showing the highest congestion levels. These may therefore be particularly important routes for targeting network improvements.

Driving growth

By referring back to our economic framework in Chapter 2 and drawing on the evidence on the performance of the strategic transport network, we can consider what this means for the potential for inter-city connections to drive economic performance.

It is first worth highlighting that the potential for inter-city transport enhancements to drive economic performance relates strongly to city characteristics and whether accompanying policy is adequately supportive, not just the transport system. For example, we saw in Chapter 2 that whilst improved travel times facilitate access to skilled workers, other factors, such as quality of place, also come into play to determine whether the opportunities from accessibility are realised.

We saw in Chapter 2 that accessibility improvements are relatively greater when travel times between larger cities (with high employment density) are improved and when those cities are relatively closer together (in terms of travel times). Indeed, we have seen that commuter flows are currently relatively greater between cities that are effectively closer together (Manchester–Liverpool, Leeds–Sheffield and Manchester–Leeds). This indicates a greater potential for these routes to be important in driving economic performance.

Chapter 5: Estimating the productivity gains from improving inter-city rail connectivity in the north

Chapter overview

In this Chapter we explore the potential productivity gains associated with achieving the inter-city rail travel times aspired to by TfN. We first set out the objectives and approach to the modelling, before describing the results of the analysis and their implications. Further detail on the methodology and input assumptions is provided in the Annex.

We are grateful to Professor Stephen Gibbons (Director of the Spatial Economic Research Centre, LSE) and Stephen Law (The Bartlett Space Syntax Laboratory, University College London) for their work in leading the analysis presented in this Chapter.

5.1 Objective of the modelling analysis

The objective of the modelling in this Chapter is to assess the extent to which reductions in inter-city rail journey times aspired to in Northern Powerhouse plans could lead to improvements in access to markets, and in turn, potential improvements in output and productivity⁶². We are therefore focusing on the role of inter-city connectivity as a ‘driver’ of economic performance, rather than ‘unlocking’ it.

We focus only on first order effects of changes in accessibility (for example, those resulting from learning and knowledge spillovers or improved matching of workers and firms), rather than second order effects (which could for example include attracting high-skilled workers to a city). As noted in Chapter 2, the first order impacts are the externalities generated by improved connections between places, keeping the spatial distribution of the population and workforce across cities as it currently stands.

The method draws on the empirical literature on agglomeration economies (see Combes and Gobillon 2015) and the application of these ideas to transport appraisal (Department for Transport WebTAG guidance 2014). The intention is to provide indicative estimates of the extent to which achieving the inter-city travel time reductions between northern cities that are envisaged by TfN might create the opportunity to raise productivity.

⁶² The focus on rail in this analysis is because of the availability of rail travel times in the time available for this study; similar analysis would be possible for strategic road travel using road journey times.

This analysis is seeking to explore where the potential opportunity is comparatively greater when considering different scenarios. The analysis does not constitute a full appraisal of the potential benefits of investment in transport – instead we focus on an externality of transport investment: the productivity impacts of increasing agglomeration. Our estimates of potential earnings gains are therefore over and above the transport user benefits that would reflect the gains from ‘unlocking’ growth, such as the value of time savings that would typically be considered in a transport investment appraisal. Some approximations are made, given data availability and the short (five weeks) time period for this study. Estimates are intended to provide an indication of the order of magnitude of potential impacts, rather than to be considered as precise and accurate point estimates.

There are two main measures that we model to explore the potential impacts of improved inter-city rail connectivity, as follows.

- **Improvements in access to markets.** Improved transport connectivity within and between cities increases the economic ‘mass’ (i.e. economic activity measured by the population, number of workers, number of firms or other indicators) that is accessible within a given travel time from a given city. We therefore model changes in economic mass (referred to as changes in accessibility⁶³) resulting from reduced inter-city rail travel times. In particular, the key unit of measurement (accessibility) throughout the analysis reflects changes in the number of workers to whom firms and workers in a city have access when travel times improve.
- **Improvements in output and productivity.** Increasing accessible economic mass is generally understood to improve productivity and create more output (either output per worker, or output for a given level of inputs into the production process).⁶⁴ Prediction of the likely changes in productivity arising through this channel requires the following:
 - prediction of how proposed transport improvements change the level of access to economic mass (i.e. as set out above);
 - estimates of productivity levels before the transport improvement (measured, for example, by wages or firm value-added); and

⁶³ We note that changes to economic mass are referred to in the literature with various names, such as market potential, effective density, accessibility and market access.

⁶⁴ The theoretical mechanisms by which access to economic mass (e.g. city regions) affects productivity are outlined elsewhere in this report.

- estimates of the elasticity of productivity with respect to economic mass (i.e. the percentage change in productivity for a given percentage change in the economic mass which can be accessed).

Section 5.2 sets out the assumptions used in the modelling, and Section 5.3 presents the results using these measures.

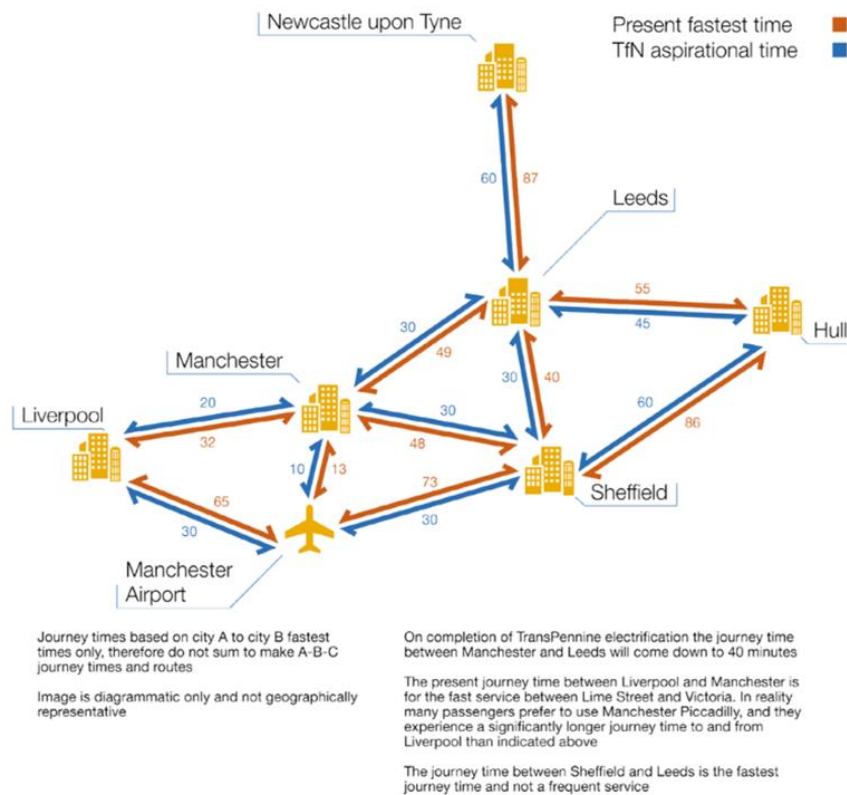
We do not model changes to road travel times because of not having access to the data required to do this. However, we note that there is likely to be some read across from the high-level results of our rail modelling to the potential gains from improving road transport connectivity.

Scenarios

Our analysis explores five illustrative scenarios of rail connectivity improvements between Northern city pairs. The scenarios have been chosen to provide an illustration of the potential impacts of improving inter-city connectivity in the North. They include scenarios that improve travel times between city pairs with different absolute and relative employment sizes, productivity levels, and distances between them. The choice of scenarios does not imply anything about policy preferences.

The improvements in travel times that we model are based on aspirational rail journey times set out by TfN, which we reproduce in Figure 24. This illustrates travel time improvements between seven key stations. We adapt the aspirational journey times to reflect differences between the current journey time reported by TfN (which is the fastest time to make a particular journey), and the current journey time in our dataset which reflects the average travel time for a particular journey (see the Annex for details).

Figure 24. Aspirational rail journey times between Northern cities



Current and Aspirational Journey Times

Source: National Rail timetable correct at time of publication

Source: Reproduced from Transport for the North (2015a)

The four city-pair scenarios that we model using TfN aspirational journey times are as follows.

1. **Leeds – Manchester.** This scenario explores improving the rail links between the two largest cities in Northern England, which are around 45 miles apart. Manchester is the largest Northern city by population. It has experienced rapid economic growth, has relatively high skills compared to Northern England as a whole, and has a diverse economy. Leeds is the second largest city in Northern England by population. It has more financial services activity than Manchester, and slightly lower productivity levels.
2. **Manchester – Sheffield.** This improves links between the largest city in the north and Sheffield which is a relatively small but fast growing economy with a heavy public sector presence and relatively low skills. The distance between Manchester and Sheffield is around 40 miles.

3. **Liverpool – Manchester.** This scenario improves the travel times between the largest of the northern cities (Manchester) and a city half its size in terms of GVA and the number of jobs, Liverpool. The distance is around 35 miles.
4. **Hull – Leeds.** The final city-pair scenario explores improving links between Leeds and Hull. The former is the smallest, most production focused Northern city, and has the lowest skill levels. The distance is around 60 miles.

Alongside the city-pair scenarios, we model one further comparator to these, consisting of the following.

5. **All Northern Powerhouse inter-city rail aspirations being achieved.** This assumes that *all* aspirational rail journey times between the six cities (Hull, Leeds, Liverpool, Manchester, Newcastle and Sheffield) are achieved.

5.2 Modelling approach

In this section, we outline key elements of our approach, including their implications for how the results can be interpreted. In particular, we focus on estimating the following:

- journey times;
- accessibility improvements; and
- potential productivity gains.

Further detail on the assumptions and methodology is provided in the Annex. Our analysis is intended to be illustrative – it is based only on rail journey times and does not map actual or forecast travel demand, rail journey fares, or any of the planned or committed transport capacity improvements (such as investment in High Speed 2). This is as a result of data availability and the time available to carry out the analysis. In addition, it reflects that we are interested in illustrating how accessible Northern cities are currently, and how changes in Northern cities' accessibility might affect their economic performance. On that basis, our focus on travel times only is reasonable for giving indicative estimates.

The unit of analysis corresponding to 'cities' in the modelling analysis is Travel to Work Areas (TTWAs using definitions based on 2011 census data). TTWAs are defined according to containment rules which ensure that at least 75% of the population that work in a TTWA also live there and 75% of the people who live

in a TTWA also work there.⁶⁵ TTWAs have therefore been used to overcome concerns regarding the distinction between access to residential populations and workplace populations.

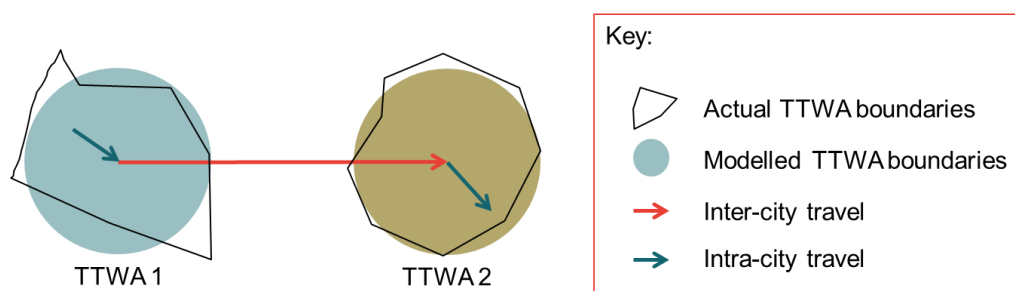
5.2.1 Estimating journey times

To model changes in accessibility, we must first estimate journey times. To reflect the fact that inter-city rail journeys are typically not directly from the origin to the final destination, we estimate total journey times between two TTWAs (TTWA 1 and TTWA 2) as the sum of:

- intra-city travel time in TTWA 1;
- inter-city travel time between TTWA 1 and TTWA 2; and
- intra-city travel time in TTWA 2.

This is shown in Figure 25, where the entire journey between TTWA 1 and TTWA 2 is represented by the three arrows, and the estimated journey time is therefore the time taken to complete these three steps.

Figure 25. Modelling total journey times



Source: Analysis for this study

Intra-city journey times

Intra-city journey times are estimated by constructing a circle of equivalent land area to the TTWA. The average distance of travel from a random point within the TTWA circle to the centre of the circle is then estimated. Each intra-city travel time is then calculated as the time taken to travel the estimated intra-city distance at 40 km per hour (the mean vehicle speed on morning peak A road journeys in Great Britain⁶⁶), plus a 10 minute assumed connection time to allow

⁶⁵ <http://www.ons.gov.uk/ons/guide-method/geography/beginner-s-guide/other/travel-to-work-areas/index.html>

⁶⁶ Based on 2010-11 data, reported in Department for Transport *Transport Statistics Great Britain*: 2011.

for transfers and waiting. This results in the estimated journey times set out in Table 12.

Table 12. Estimated intra-city journey times (minutes)

City region (TTWA)	Assumed connection/ waiting time (minutes)	Estimated travel time from random point to TTWA centre (minutes)	Total baseline intra-city journey time (minutes)
Hull	10.0	22.7	32.7
Leeds	10.0	14.3	24.3
Liverpool	10.0	13.9	23.9
Manchester	10.0	24.2	34.2
Newcastle	10.0	20.0	30.0
Sheffield	10.0	15.5	25.5

As set out in the Annex, we use this modelled approach as our dataset does not provide full coverage of all stations within cities, or contain data on onward road journeys from city centres. Our assumption is that travel is from a random place within the TTWA circle, rather than the expected location of a resident or business within the circle (as this is not known). This approach will therefore exaggerate the average intra-TTWA travel time in a predominantly rural TTWA relative to a predominantly urban one, though our average intra-city journey time (28 minutes) is consistent with the average journey time in England (29 minutes)⁶⁷. For example, the estimated intra-TTWA journey time in Hull is the highest of the six Northern city region TTWAs because of its geographical scale, despite Hull being the smallest city in economic and population terms. This is a limit of the TTWA definitions: they are commuting areas that may be broader than the geographic area (city) within which economic activity is concentrated⁶⁸.

⁶⁷ Department of Transport, 2015, National Travel Survey: England 2014, available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/457752/nts2014-01.pdf

⁶⁸ National Travel Survey (NTS) data on average commuting times in England provides an external cross-check of our estimates of average intra-TTWA journey times. Given the definition of TTWAs, NTS commuting times are likely to be mostly for intra-TTWA travel. In 2014, the average commuting time in England was estimated at 29 minutes which is in line with our estimates of intra-TTWA journey times shown above. As a further sensitivity test, we estimated accessibility gains if intra-TTWA travel times were reduced by 10 minutes in the origin and destination city of each journey

Inter-city journey times

We use the Rail Usage Drivers Dataset (RUDD) supplied by DfT to estimate inter-city journey times. RUDD data contains station-to-station journey times and are derived from timetable information. The data represent around 80% of rail journeys in Great Britain. We match RUDD data to TTWAs using a RUDD station to TTWA lookup dataset, to estimate minimum station to station origin-TTWA to destination-TTWA journey times. The resulting baseline inter-city rail travel times are shown in Table 13.

Table 13. Estimated baseline inter-city journey times (minutes)

Origin	Destination	Baseline rail journey time (minutes)
Hull	Leeds	62.9
Hull	Liverpool	168.4
Hull	Manchester	121.4
Hull	Newcastle	124.8
Hull	Sheffield	80.8
Leeds	Liverpool	114.7
Leeds	Manchester	68.0
Leeds	Newcastle	92.4
Leeds	Sheffield	52.0
Liverpool	Manchester	62.5
Liverpool	Newcastle	196.6
Liverpool	Sheffield	111.3
Manchester	Newcastle	152.6
Manchester	Sheffield	61.5
Newcastle	Sheffield	113.8

(i.e. a reduction in the total journey time of 20 minutes). This is a substantial reduction, given that the average intra-TTWA journey time that we estimate above is 28 minutes. This adjustment did not substantially affect the results that we present below: the overall pattern was similar, with accessibility changes increasing slightly (by around 1%) in TTWAs starting from a lower base in terms of their access to workers.

Source: Analysis based on RUDD data

Note: Our estimates of baseline journey times between Liverpool and Manchester (as well as between Manchester and Manchester Airport, not reported here) are significantly higher than the estimates set out in Transport for the North (2015a). This is likely to be because the times reported in Transport for the North (2015a) are estimates of fastest current rail journey times, rather than average journey times between the stations. Our estimates use RUDD data, and are weighted for service frequency (as set out in the Annex). So, for consistency, using RUDD data we scale our estimates down by the same amount as the TfN aspiration figures to estimate journey times after connectivity improvements.

To construct improved TTWA–TTWA journey times, the TfN aspirational inter-city rail journey times are applied to the links between the main stations in the corresponding Northern Powerhouse TTWAs (Hull, Leeds, Liverpool, Newcastle, Manchester, Sheffield).⁶⁹ The entire station–station origin destination minimum travel time matrix is then recomputed to allow for the fact that these new links may reduce the travel times between stations throughout the network (for example, some journey travel times may rely on the improved link for at least part of the journey).

In a few cases, a TTWA contains no station in the RUDD data, and so is missing from the analysis (it is infeasible to compute a travel time change when there is no station present). These TTWAs are shown on the maps in Section 5.3 as uncoloured. These areas are remote, rural and with small populations, so will not affect the analysis substantively.

Total journey times

Total journey times are estimated by summing inter-city journey times with the two corresponding intra-city journey times. This results in the baseline and improved journey times shown in Table 14.

⁶⁹ So that our baseline is consistent with aspirational journey times, we scale the aspirational journey times to account for differences between RUDD baseline journey time estimates and TfN reported baseline journey times.

Table 14. Estimated baseline journey times (minutes)

Origin	Destination	Baseline rail journey time (minutes)	Improved rail journey time (minutes)
Hull	Leeds	120.0	112.3
Hull	Liverpool	225.1	181.3
Hull	Manchester	188.3	159.9
Hull	Newcastle	187.5	175.6
Hull	Sheffield	139.0	126.0
Leeds	Liverpool	162.9	126.7
Leeds	Manchester	126.5	105.5
Leeds	Newcastle	146.8	121.9
Leeds	Sheffield	101.8	92.4
Liverpool	Manchester	120.6	105.4
Liverpool	Newcastle	250.5	191.5
Liverpool	Sheffield	160.7	126.2
Manchester	Newcastle	216.8	170.3
Manchester	Sheffield	121.2	103.8
Newcastle	Sheffield	169.3	156.4

Source: Analysis based on RUDD data

Estimating accessibility changes

Changes in accessibility are the changes to the economic mass (measured as employment) that can be accessed when journey times are improved between cities. Put simply, the accessibility of a TTWA (or city region) is measured by the number of people in other TTWAs, each weighted according to the length of the journey time to those TTWAs. A reduction in the journey time to a particular TTWA will increase the weight that is given to it, thereby increasing the number of workers in that TTWA who can access the city region of interest, and in turn

the level of accessibility of that city region. We provide a technical description of this approach below.

We define the accessibility of economic mass by rail from an origin TTWA i using a standard form of effective density/accessibility index:

$$(1) A_i = \sum_j \frac{E_j}{time_{ij}^\alpha}$$

Here, E_j is a variable capturing economic activity at destination TTWA j , and $time_{ij}$ is the minimum travel time by rail between TTWA i and TTWA j . These accessibility indices are calculated for each TTWA from measures of employment in Great Britain derived from the 2011 UK census and from rail travel times estimated as above.

Accessibility for the baseline period is estimated using present day travel times, which are set out in the previous section. Post-policy (i.e. with the improvement in inter-city travel times) accessibility is estimated using the inter-TTWA travel time scenarios described above, which reflect the TfN inter-city rail journey time aspirations.

The difference between the natural log of the accessibility index post-policy and in the baseline then gives the approximate proportionate changes in accessibility. We hold employment in the accessibility indices constant at 2011 levels.

Our analysis measures the increase in accessibility to workers from each city as a result of improved rail connectivity. This is not a zero sum game; this is because the workers to whom one city now gains access could also be the same workers to whom another city gains access as a result of improved rail connectivity. Those workers cannot be employed in both cities – instead, the cities gain from having the option and ability to attract employees from a wider labour pool.

Increased accessibility could result in productivity benefits, in a number of different ways, for example:

- it could simply be that workers in Leeds engage in more interaction, business travel and face to face communication during the course of their work with people in Manchester as a result of improved rail connectivity, generating productivity gains due to learning effects; or
- workers in Leeds could swap to jobs in Manchester for which they are better matched and the workers in Manchester swap to jobs in Leeds to which they are better matched, generating productivity gains for both cities due to better matching.

Estimating potential productivity gains

Having estimated accessibility changes, we can then apply an agglomeration elasticity parameter to that change in accessibility to estimate potential first order

productivity gains. Put another way, we saw from Chapter 2 that the evidence finds that a 10% change in accessibility could result in anywhere between a 0.1% and 0.7% first-order change in productivity, depending on the context of the study. By applying this percentage change to the estimated increase in accessibility found above, we can estimate the potential productivity gains. The agglomeration elasticity represents the percentage change in mean earnings from a percentage change in accessibility. We consider only first-order effects as the evidence on second-order effects is very limited, as we discuss below.

The choice of elasticity is therefore critical to estimating productivity gains. There are a number of elasticities that have been generated in the literature. We use an elasticity estimate of 0.03, taken from (D’Costa et al 2009), because that study provides an estimate of the effects of rail-specific accessibility changes on wages using micro data on British workers, and holding the road network constant. It also uses an accessibility index of the same form as equation (1), and is the most directly relevant study. The estimate of the impact on earnings means that the accessibility changes can be translated into potential earnings increases in each TTWA and in Great Britain as a whole.

Estimates of the aggregate impact on earnings in each TTWA and in the country overall are calculated from TTWA workplace-based mean wages and TTWA worker numbers. Mean wages (gross annual earnings, all workers) are taken from Annual Survey of Hours and Earnings data⁷⁰.

We take the existing skills base and its distribution as given, and any second-order up-skilling effects incentivised by increased accessibility are not captured in our analysis. In practice, second-order effects incentivised by transport investment may require additional investment (e.g. in further infrastructure, or in education and training), so would not be likely to be directly attributable to the transport investment itself.

The evidence we have reviewed for this study (in Chapter 2) suggests that a higher elasticity of productivity has been estimated by some studies in a bid to reflect total – i.e. first order and second order – effects. D’Costa et al. (2009) discussed above estimates that a reduction of generalised travel times for rail travel by 10%, holding the cost of road transport constant, is associated with a 2.6% increase in wages within that area (i.e. elasticity of 0.26).

The 0.26 figure reflects the impact on the place (rather than people) of accessibility changes – this is because it captures all aspects about the city that make it as productive as it is (i.e. previous investments in other infrastructure, skills, movement of businesses, density etc.). If we used it in our analysis, we

⁷⁰ Given the size of TTWAs, we would expect wages to vary within them, with the highest wages in the city centres, for example. However, we use average TTWA earnings here to be consistent with our unit of analysis which is TTWAs and not just the city centres.

would be attributing all of that gain in productivity to the particular transport intervention that led to the change in accessibility, and we would need to believe that productivity differences between cities are *solely* the result of differences in transport connectivity. Further, even if we accept this (clearly unreasonable) premise, we still cannot conclude from the above estimates that increasing accessibility to a city by 10% would increase wages in that city by 2.6%, because there could be displacement effects. We note that while the 0.26 estimate is not appropriate to use in our analysis, this does not mean that we expect second-order effects not to exist – we just do not have the evidence to estimate their size. We therefore believe 0.03 reflects a reasonable elasticity to use for this analysis, but note that it is likely to be conservative as it does not capture second-order effects.

5.3 Results

In this section, we set out the results of our analysis, for each of the city-pair and comparator scenarios in turn:

- Leeds – Manchester;
- Manchester – Sheffield;
- Liverpool – Manchester;
- Hull – Leeds; and
- All Northern Powerhouse inter-city rail aspirations being achieved.

We present maps showing the distribution and size of the potential changes in accessibility and productivity for each scenario. **Table 15** summarises the results across all the scenarios, which we then discuss in detail.

Table 15. Scenario analysis results

City (TTWA)	Baseline		Leeds-Manchester		Manchester-Sheffield		Liverpool-Manchester		Leeds-Hull		Achieving all NPH rail aims	
	Mean pay (£)	No. of employees	Change in access (%)	Potential earnings gain	Change in access (%)	Potential earnings gain	Change in access (%)	Potential earnings gain	Change in access (%)	Potential earnings gain	Change in access (%)	Potential earnings gain
Hull	£22,456	231,000	1.5%	£2,300,000	0.1%	£200,000	0.2%	£300,000	1.0%	£1,600,000	4.6%	£7,200,000
Leeds	£25,944	420,000	2.8%	£9,200,000	0.0%	£0	0.2%	£700,000	0.1%	£300,000	5.2%	£17,200,000
Liverpool	£24,063	438,000	0.9%	£2,900,000	0.6%	£2,000,000	2.0%	£6,400,000	0.0%	£100,000	4.2%	£13,400,000
Manchester	£25,148	1,239,000	1.3%	£12,400,000	1.2%	£10,800,000	0.4%	£3,500,000	0.0%	£300,000	3.2%	£30,100,000
Newcastle	£24,394	474,000	1.0%	£3,400,000	0.0%	£0	0.1%	£400,000	0.0%	£0	4.9%	£17,100,000
Sheffield	£23,244	372,000	0.0%	£0	2.0%	£5,100,000	0.2%	£600,000	0.0%	£0	3.2%	£8,300,000
Estimated annual earnings increase across the six city TTWAs				£30,000,000		£18,000,000		£12,000,000		£2,000,000		£93,000,000
Estimated annual earnings increase across GB				£62,000,000		£41,000,000		£18,000,000		£3,000,000		£189,000,000

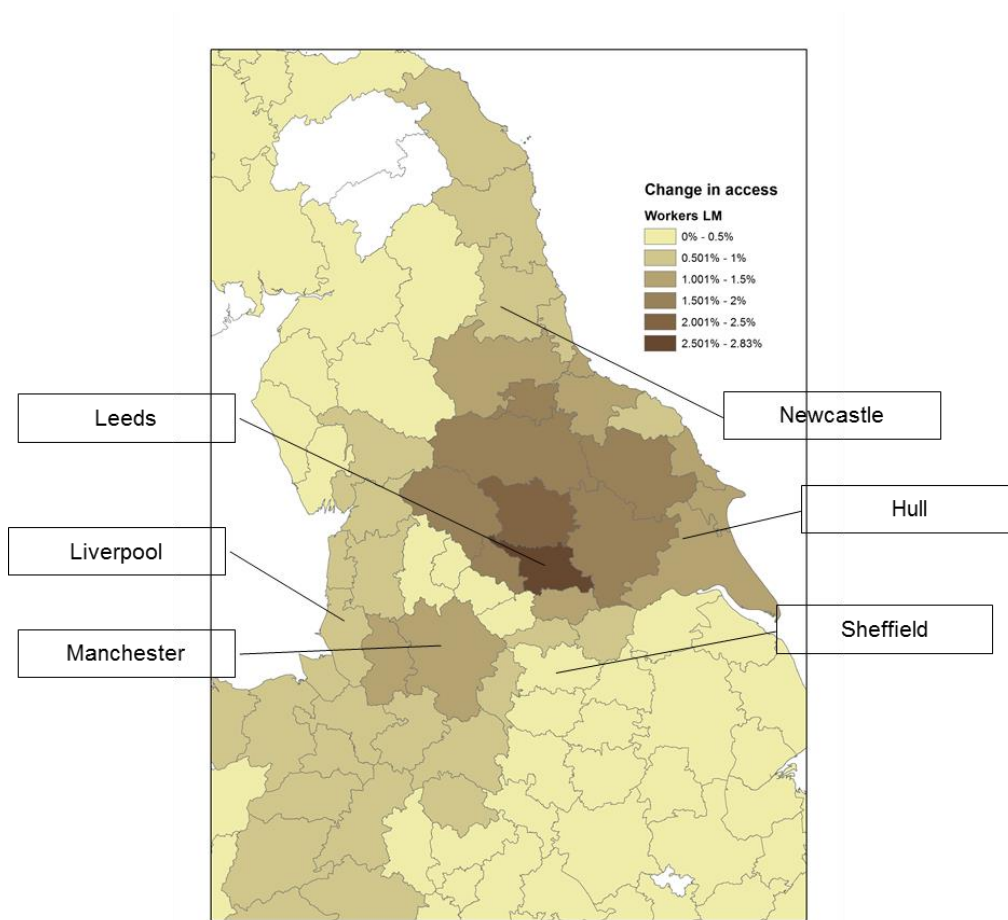
Notes: Table reports initial mean pay (ASHE), worker count (TTWA definition table), plus % change in access index (difference in logs) and aggregate implied increase in earnings per year using assumed elasticity of earnings w.r.t access = 0.03.

Leeds–Manchester scenario

The accessibility impacts of improving rail connectivity between the largest Northern cities (Leeds and Manchester) are shown in Figure 26. Of the city-pair scenarios we consider, this scenario results in the greatest gains in accessibility (i.e. the number of workers to whom cities have access). The access to workers of Leeds could increase by around 2.8%, Hull by 1.5% and Manchester by 1.3%. The increase in Manchester is relatively lower, as it starts from a higher base in terms of transport connectivity and accessibility. Five of the six Northern city regions gain in terms of accessibility under this scenario, with the exception being Sheffield (implying that inter-city rail travel to Sheffield is not improved by reducing the travel time between Leeds and Manchester).

The accessibility impacts for this scenario are high relative to the other inter-city scenarios due to a number of factors. These include their existing connectivity (with these cities having relatively more connections to a range of different cities already), and the greater reduction in travel times which TfN aspire to in this corridor.

Figure 26. Percentage change in accessibility to workers, Leeds – Manchester scenario



Source: Analysis for this study

Note: In this and following maps, areas shaded in white are those without a rail station.

The improved rail connectivity improves access to both skilled and unskilled labour (defined as whether employees have degrees or not). However, the analysis finds that the increase in the number of unskilled workers that the cities can access is relatively higher than the increase in the number of skilled workers. As a result, the share of skilled workers as a proportion of all workers now accessible decreases by a small amount following improved rail connectivity between Leeds and Manchester. This finding applies across the scenarios that we have analysed. This reflects the distribution of skills across the North.

Using the agglomeration elasticity estimate of 0.03, we estimate a potential increase in total aggregate earnings by some £62 million per year across Great

Britain (or £30 million in the six Northern city TTWAs) associated with reducing the Leeds-Manchester rail travel time.⁷¹ The difference between the estimated national (Great Britain) potential earnings gain and potential earnings gains in the six Northern city-regions includes potential gains to the wider northern region.

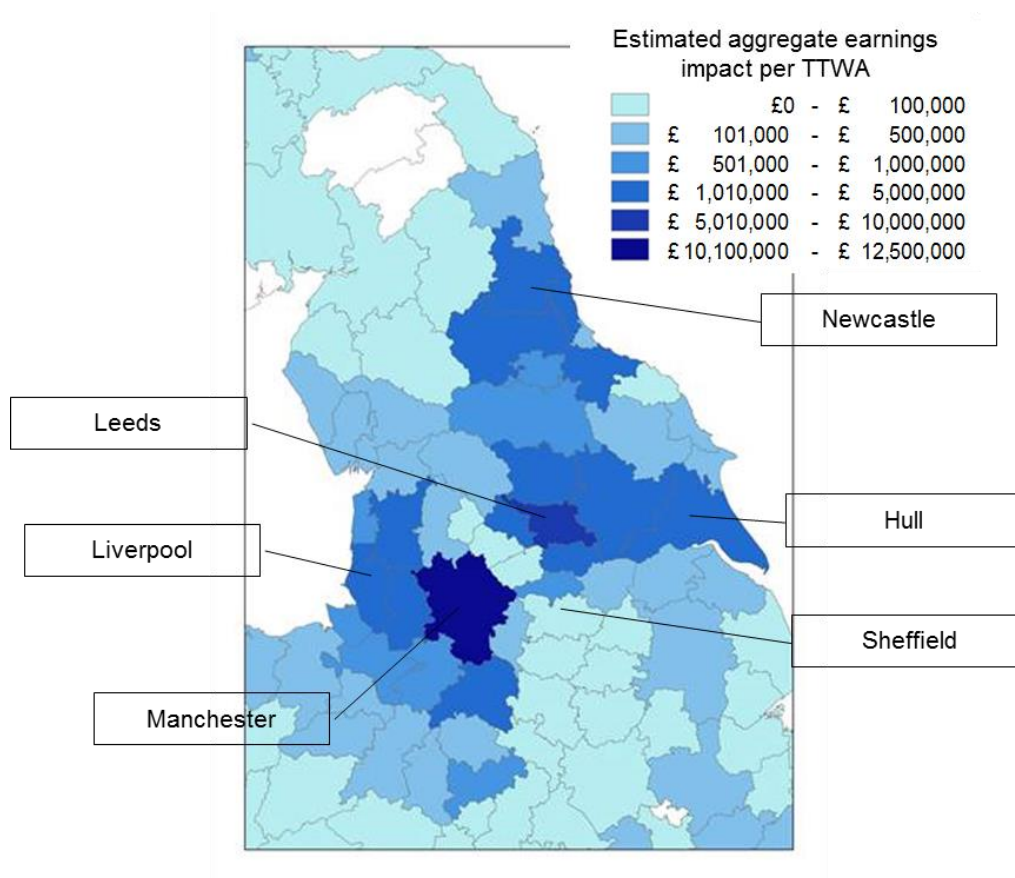
The estimated gain in earnings for each of the six city regions is equivalent to small per worker annual earnings gains:⁷² at £22 per annum in Leeds, and £10 per annum in Hull and Manchester. However, the aggregate monetary gain is considerably greater because the improved connectivity affects so many people, and would accrue over the lifetime of the improved transport infrastructure.

The distribution of productivity impacts is shown in Figure 27. This shows that both Leeds and Manchester show the highest potential increase in earnings as a result of the improvement – by £9 million in Leeds and £12 million in Manchester. This reflects the total size of the cities (Manchester has larger baseline employment than Leeds), their respective baseline productivity levels (again, productivity levels are higher in Manchester than Leeds in the baseline), and the fact that the Leeds–Manchester connectivity improvement would primarily benefit journeys between these two city regions (rather than other journeys between TTWAs that use this link).

⁷¹ Estimates are rounded to the nearest £1 million.

⁷² These are estimated using initial employee numbers in the corresponding city, excluding accessibility increases, to avoid double counting.

Figure 27. Implied aggregate change in earnings at TTWA level: Leeds–Manchester cities only linked



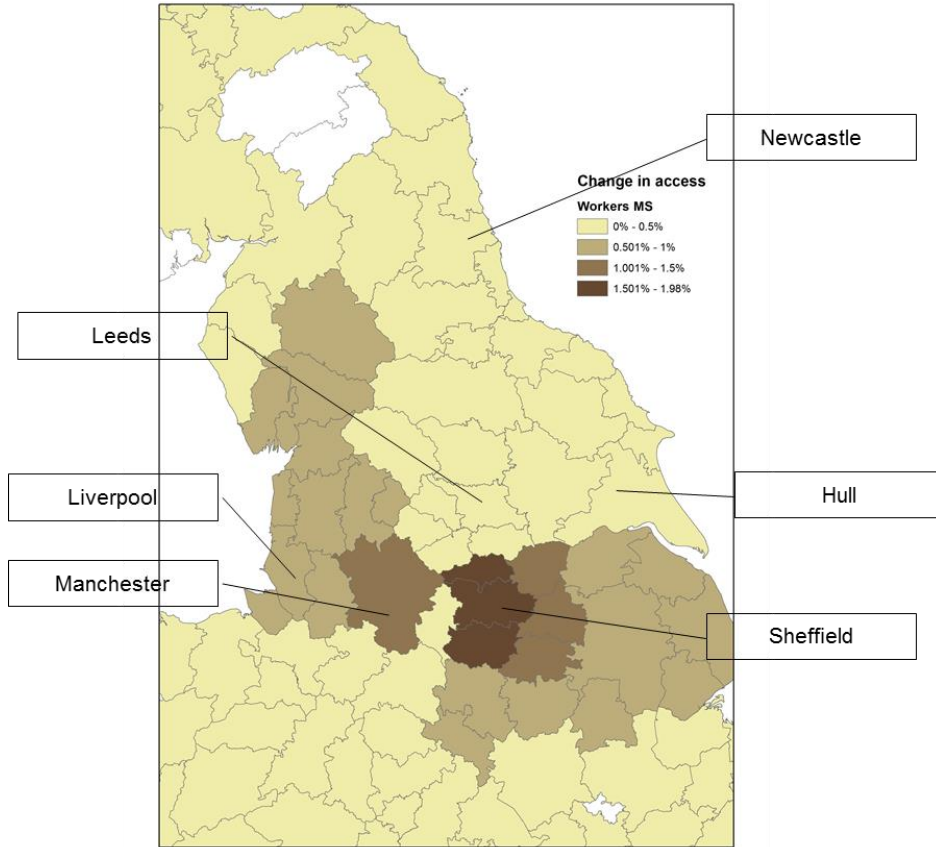
Source: Analysis for this study

Note: Estimated earnings brackets are continuous, but have been rounded in the key above.

Manchester–Sheffield scenario

An improved Manchester – Sheffield link could increase accessibility by 2.0% in Sheffield, 1.2% in Manchester, 0.6% in Liverpool, but minimally in other city regions. This is shown in **Figure 28**.

Figure 28. Percentage change in accessibility to workers: Manchester–Sheffield scenario



Source: Analysis for this study

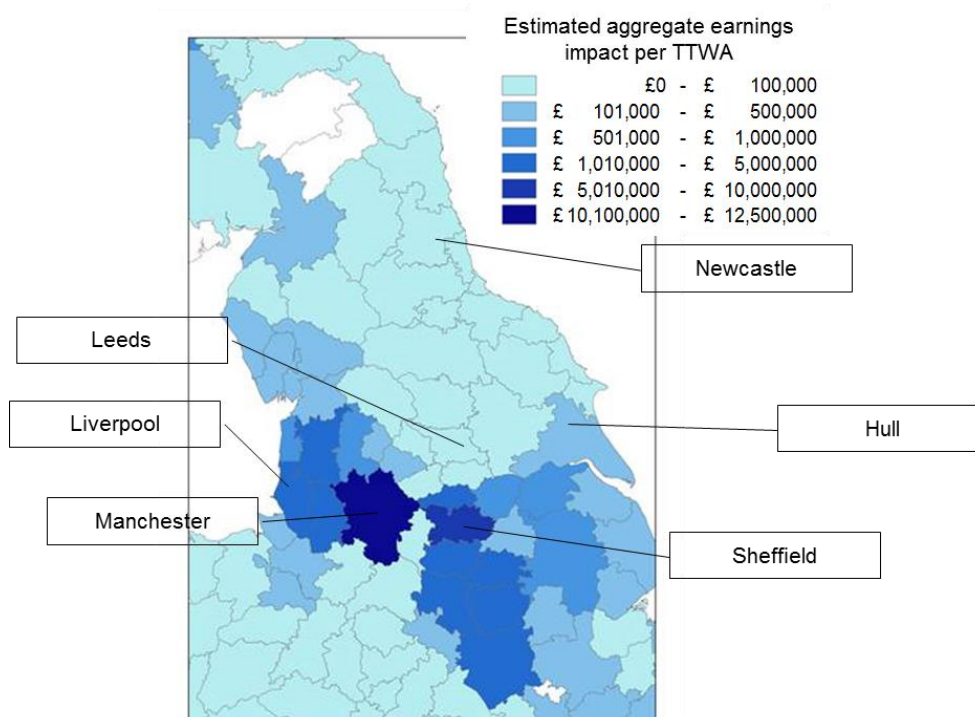
Again using an agglomeration elasticity of 0.03, this implies a potential increase in earnings of around £18 million a year within the six Northern city TIWAs or £41 million per year across Great Britain, including the wider northern area.

The smaller estimated increase in earnings relative to the Leeds–Manchester scenario reflects that Sheffield is a relatively smaller city, implying fewer connections with other cities, as well as the scenario modelling a slightly smaller reduction in travel times compared to the aspiration for the Leeds–Manchester rail link. Within the six Northern cities, potential aggregate earnings gains are material in three of the cities – compared to potential earnings gains being material in five of the six cities in the Leeds–Manchester scenario considered above. The absolute gains are largest in Manchester, at £11 million per year, compared to £5 million per year in Sheffield. This represents a greater relative change in Sheffield, given lower initial employment. As before, the potential gains per employee in annual earnings are small: at £14 per annum in Sheffield,

and £9 per annum in Manchester. This is an average figure across all employees – some individuals may gain more, and some less, for example reflecting how far individual employees are able to better match their skills to their job following the change in connectivity.

The distribution of earnings gains is shown in **Figure 29**.

Figure 29. Implied aggregate change in earnings at TTWA level: Sheffield–Manchester cities only linked



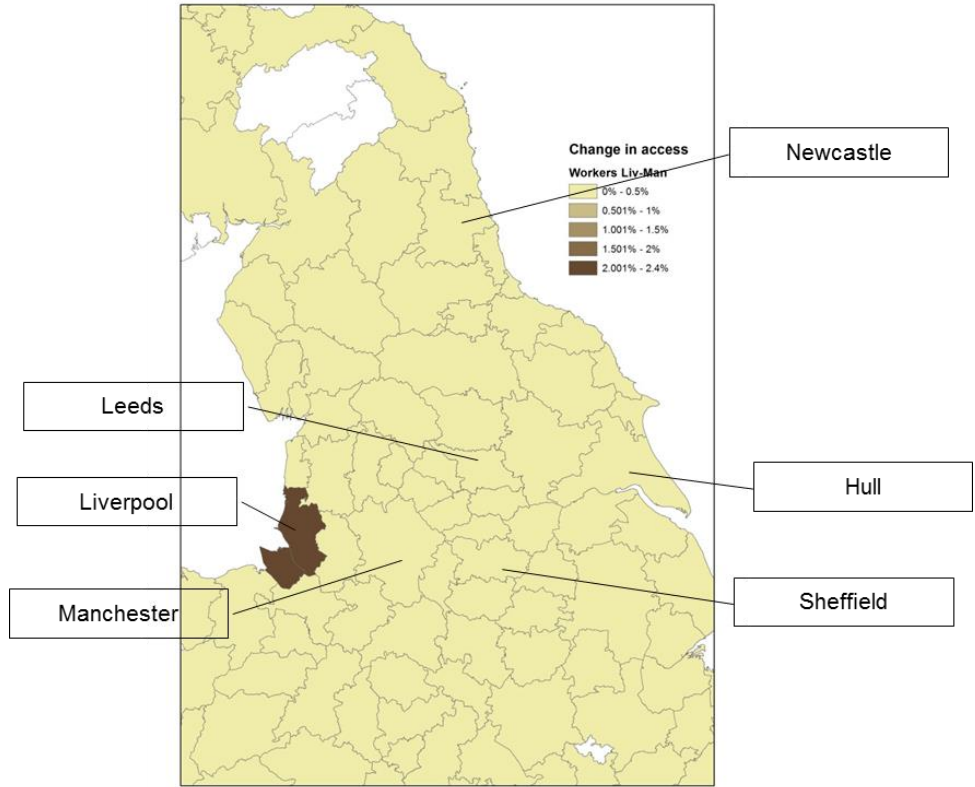
Source: Analysis for this study

Note: Estimated earnings brackets are continuous, but have been rounded in the key above.

Liverpool–Manchester scenario

An improved Liverpool–Manchester rail travel time could increase accessibility by 2.0% in Liverpool, 0.4% in Manchester, and by smaller amounts elsewhere. This is shown in **Figure 30**.

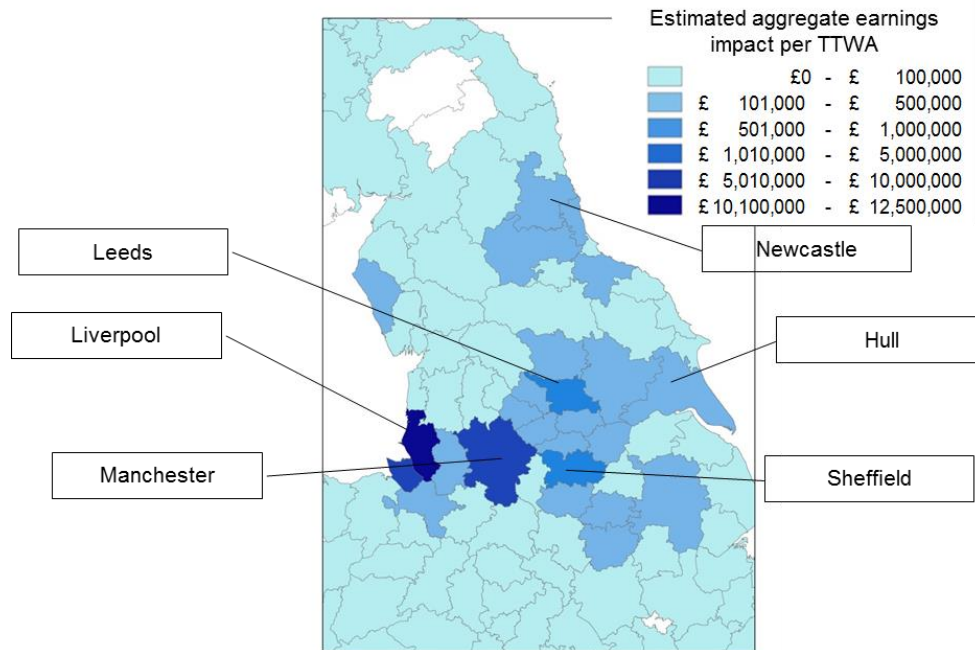
Figure 30. Percentage change in accessibility to workers: Manchester–Liverpool



Source: Analysis for this study

In total, this accessibility increase implies a potential increase in earnings of around £12 million a year within the six Northern city TTWAs or £18 million per year across Great Britain (this includes gains across Northern England). Within the six Northern cities, potential aggregate earnings gains are largest in Liverpool, at £6 million, compared to £4 million in Manchester. The relative earnings change is estimated to be larger in Liverpool because of its increased accessibility to productive workers in Manchester. As before, the potential gains per employee in annual earnings are small: highest at £15 per annum in Liverpool, and £3 per annum in Manchester. As above, these are average impacts on earnings, in practice some may gain more and some may gain less. The distribution of earnings gains is shown in **Figure 31**.

Figure 31. Implied aggregate change in earnings at TTWA level: Liverpool–Manchester cities only linked



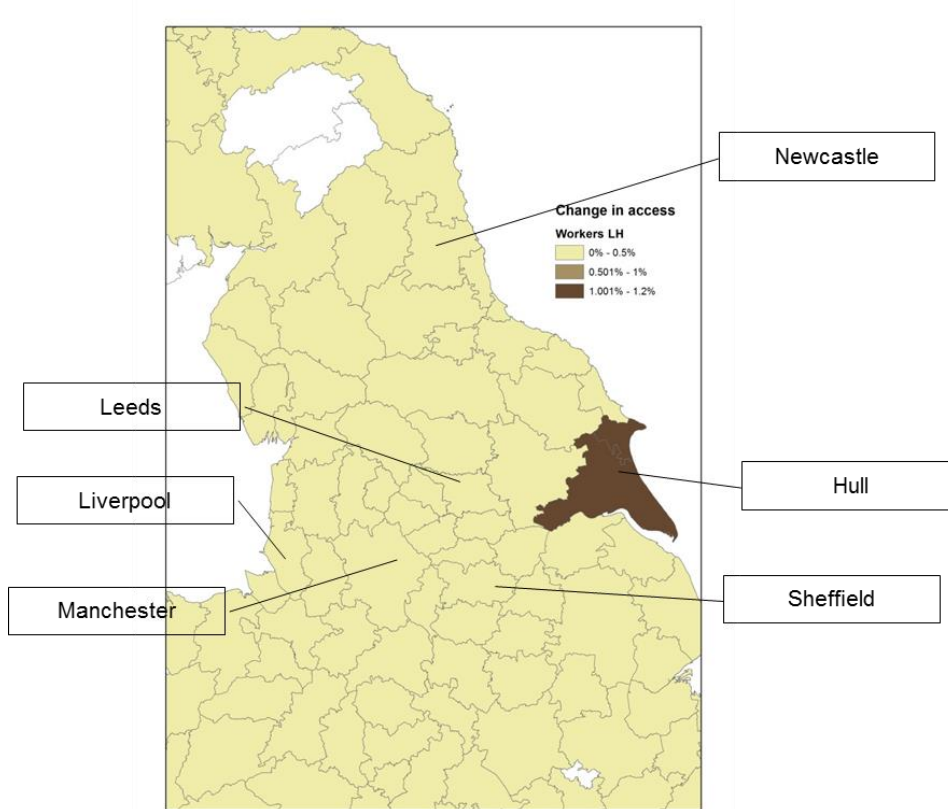
Source: Analysis for this study

Note: Estimated earnings brackets are continuous, but have been rounded in the key above.

Hull–Leeds scenario

The accessibility gains from improving Hull–Leeds rail journey times are relatively modest, in part reflecting the smaller size of these cities and the longer baseline travel time between them. The results also reflect the more limited choice of direct rail routes from Hull compared to the direct routes available travelling from larger cities such as Manchester. Hull could show accessibility gains of 1% but with minimal changes elsewhere – including a gain of only 0.1% in Leeds. This is shown in **Figure 32**.

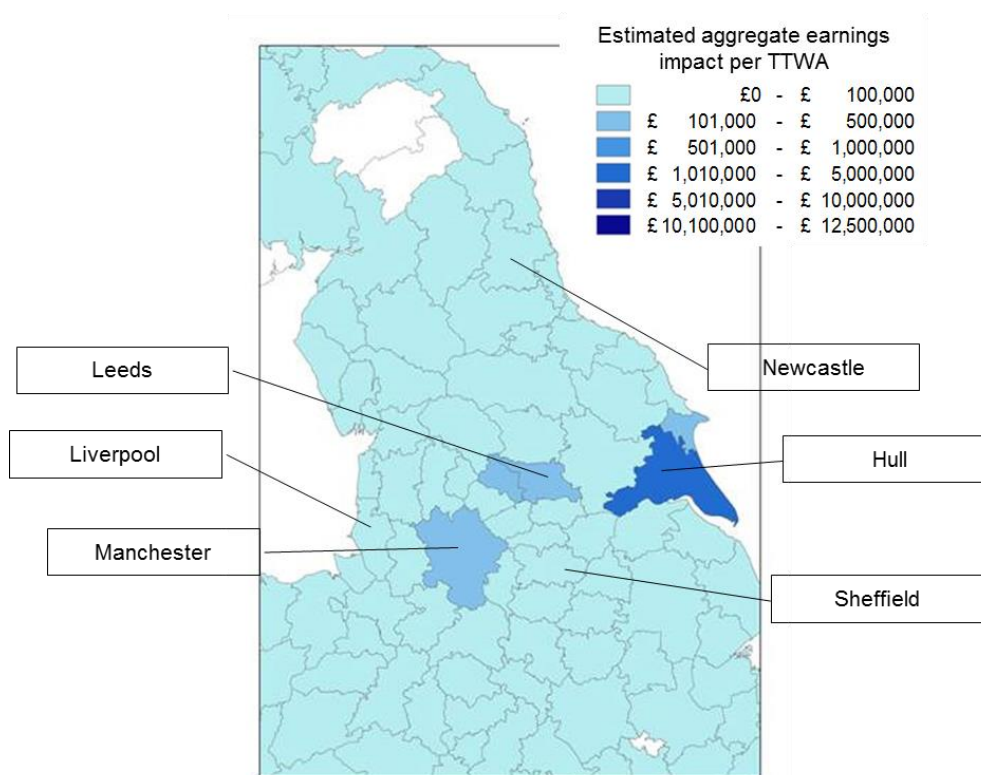
Figure 32. Percentage change in accessibility to workplace workers: Hull–Leeds scenario



Source: Analysis for this study

Reflecting the small accessibility gains as a result of improving rail connectivity, the estimated potential earnings gains as a result of the improvement is just £3 million across Great Britain, of which around £2 million per year accrues to Northern cities (almost entirely to Hull – an average gain of £7 per employee in Hull). This is shown in **Figure 33**.

Figure 33. Implied aggregate change in earnings at TTWA level: Leeds–Hull cities only linked



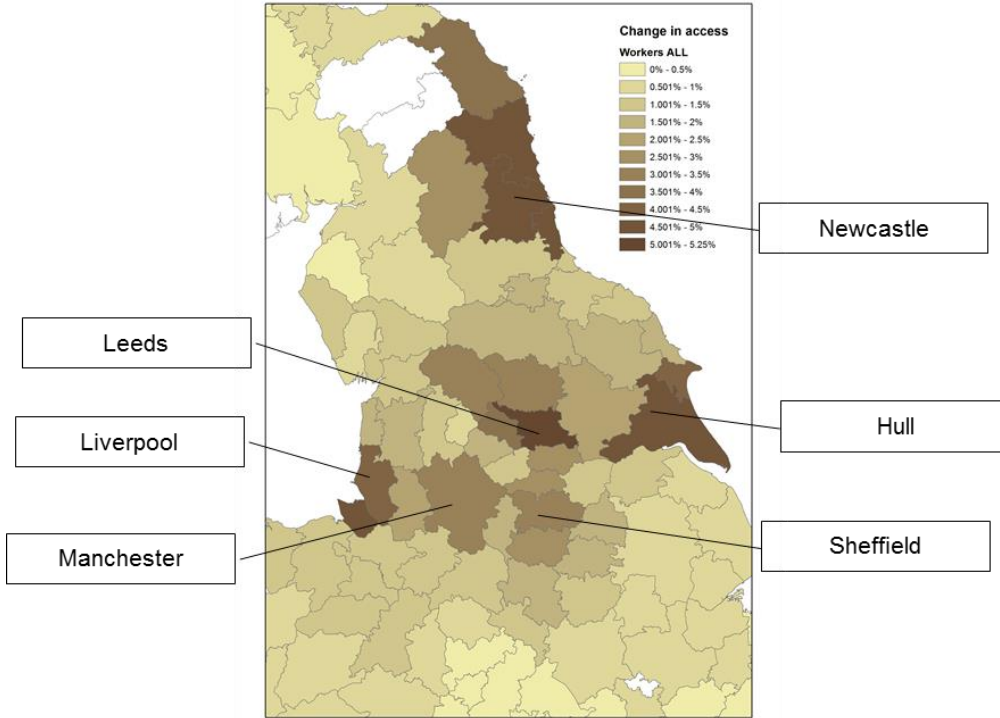
Source: Analysis for this study

Note: Estimated earnings brackets are continuous, but have been rounded in the key above.

Achieving all Northern Powerhouse rail aspirations

For comparison, we modelled a scenario in which all inter-city rail journey time reductions aspired to by TfN are achieved. The accessibility improvements associated with this scenario are shown in **Figure 34**. It shows accessibility gains averaging 4.2% for the six Northern cities, along with smaller accessibility gains across Northern England. The percentage accessibility gains are highest in Leeds and Newcastle, given that they start from a relatively lower base.

Figure 34. Percentage change in accessibility to workplace workers: all Northern Powerhouse inter-city aspirations

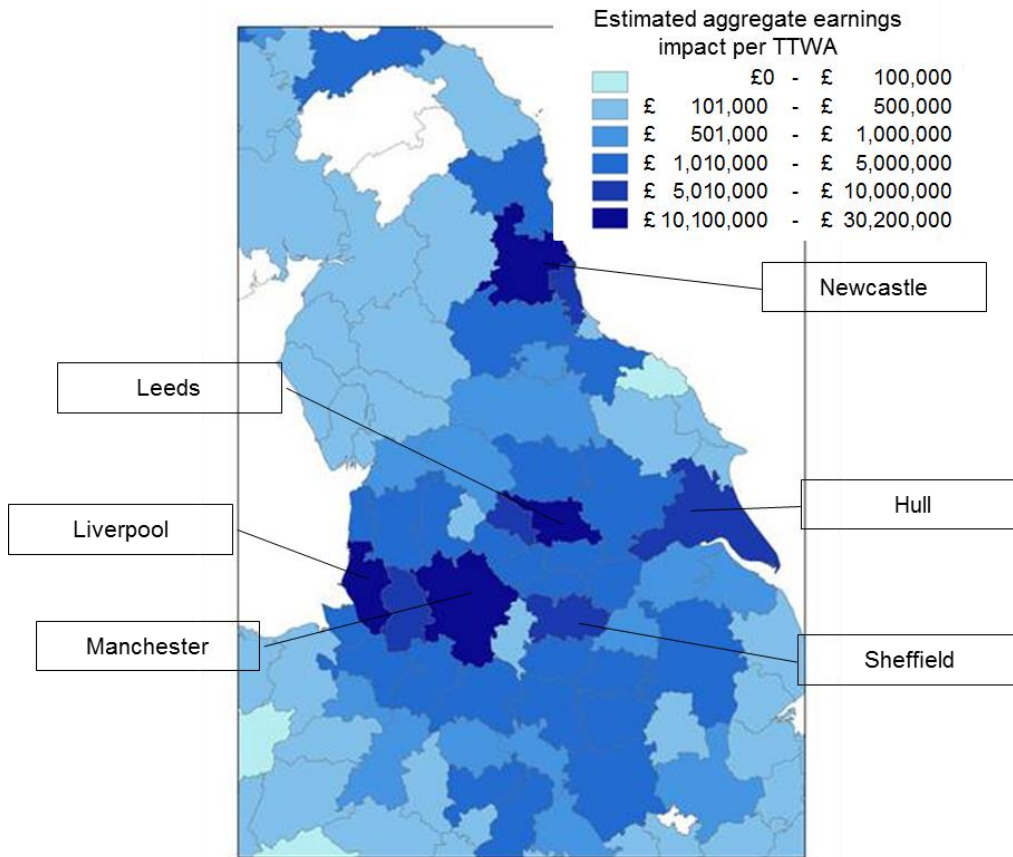


Source: Analysis for this study

The potential earnings increase estimated using the 0.03 agglomeration elasticity is around £93 million per year for the six Northern cities we focus on, and around £189 million per year across Great Britain, including the wider northern area. The largest estimated earnings gains are likely to be for Manchester at £30 million per year, as shown in Figure 35. This compares to potential earnings gains of £17 million each in Newcastle and Leeds, £13 million in Liverpool, £8 million in Sheffield and £7 million in Hull. To put this into context, the estimated aggregate gains to Northern cities represent less than one percentage point of estimated 2014 GVA in the six Northern Powerhouse city regions. Per employee potential annual earnings gains are highest in Leeds (£41) and Newcastle (£36).

Unsurprisingly, the results of this scenario show that the potential benefits are greater when a greater number of rail travel time improvements are made between cities, meaning that all Northern cities become more accessible to workers in a variety of different locations. In practice, there may be winners and losers, given that an employee accessible to a number of different city regions will not work in all of these locations.

Figure 35. Implied aggregate change in earnings at TTWA level: all Northern Powerhouse cities linked



Source: Analysis for this study

Note: Estimated earnings brackets are continuous, but have been rounded in the key above.

5.4 Implications

Comparing the scenarios, we find that improving the rail travel time between the largest, most productive, cities (Leeds and Manchester) leads to the greatest gains in accessibility (i.e. the number of workers to whom cities have access) – supporting the findings in Chapter 3. Accessibility of Leeds could increase by around 2.8%, Hull by 1.5% and Manchester by 1.3% (increase in the latter is relatively lower as it starts from a higher base of workers). The estimated increase in opportunity to boost economic performance (measured by earnings) for the six Northern city regions from this improvement could be of the order of £30 million per year. Improving other inter-city connections could also result in increased earnings, though of a lower magnitude.

More detailed analysis of the scenarios above highlights some key observations:

- Improvements in journey times, at least in the first instance, can only increase accessibility to the workers that are within reach.⁷³ The level of skills is on average lower in the Northern cities than in the Southern cities of England, so accessibility to workers increases accessibility to low-skilled workers disproportionately.
- A notable proportion of the door-to-door journey time for inter-city trips is at either end of the journey i.e. the intra-city connections. Therefore, the potential gains from even very substantial improvements in inter-city travel times could be diluted if intra-city travel times are excessive.
- Small changes in productivity can have a significant impact on the total earnings of the larger city regions, simply because of the numbers of workers in larger cities.
- The level of responsiveness of earnings to accessibility assumed here (elasticity 0.03) reflects the gains to individuals from being effectively closer to other workers due to improvements in rail travel times, holding the road network constant. It is drawn from the best available evidence. The scale of change in earnings could be higher still over time because workers could identify the opportunities for higher earnings and seek to up-skill,⁷⁴ or they could move across cities to find jobs with higher earnings.⁷⁵ Plus, more skilled workers and investment could be attracted to better connected and higher productivity areas from far away (or overseas). There is reason to be cautious in trying to estimate the potential scale of overall longer-term effects given the lack of evidence in this area, particularly in relation to where workers may move to and from. Due to the limited evidence currently available, our modelling has not estimated second-order effects, but these effects could potentially add significantly to the estimated economic benefits (subject to displacement) of improved connectivity.

⁷³ Second-order effects may include workers moving into the area accessible to the city region.

⁷⁴ However, we note that in a full cost benefit analysis the costs of acquiring these skills would need to be deducted from the predicted benefits. In addition, evidence suggests that the gains from a switch to more productive jobs are the tax gains to the Exchequer, as the benefits from the net wage gains are absorbed by the transport costs in reaching these more productive jobs (see the Webtag guidance and Laird et al (2014)).

⁷⁵ However, this implies potential losses to the places that individuals move away from.

- While we do not model road travel times, a similar approach could be used to estimate potential accessibility and productivity gains from improved road connectivity. A number of the findings above (e.g. in relation to skills or intra-city journey times) would also apply to analysis of road travel.

Chapter 6: Summary and case for change

Overview of this Chapter

This Chapter provides a summary of the key findings from our analysis and draws out the policy implications. This is intended to inform a comparative assessment of the scale of the potential productivity gains associated with enhanced inter-city connections, and the conditions under which those gains are likely to be relatively greater.

6.1 The question addressed by this study

This report for the UK's National Infrastructure Commission has been exploring the following question:

'Is there a role for improved inter-city transport connections to contribute to the economic performance of the Northern Powerhouse?'

If so:

- (iii) **what is the potential scale of impacts?**
- (iv) **what are the conditions under which these impacts are likely to be comparatively greater?'**

To address the question robustly, we have systematically drawn together the best available evidence, both theoretical and empirical. We have complemented this with new indicative analysis, though we remain honest and open about the current gaps in knowledge and where uncertainties remain.

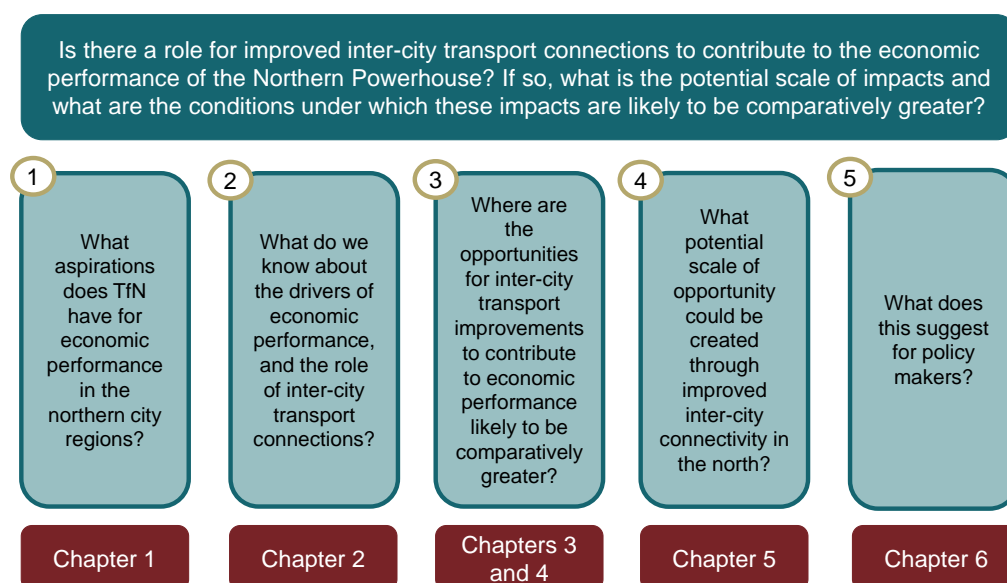
This field of research is relatively new and will continue to evolve over coming years. This report reflects the forefront of thinking on these issues and seeks to advance the current knowledge and evidence base in a clear and transparent way. We are grateful for the input and oversight of Professor Stephen Gibbons – Director of the Spatial Economics Research Centre at the London School of Economics.

This chapter brings together what we have learned, and what we conclude based on our analysis.

Overview of our approach

To address our overarching question, we have investigated a number of sub-questions, as shown in **Figure 36**.

Figure 36. Understanding the potential role of inter-city transport connections in enhancing economic performance of the Northern Powerhouse.



6.2 What aspirations does TfN have for economic performance in the Northern city regions?

Historically, there has been a productivity gap between the North and South of England – particularly when compared to productivity performance in London and the South East. GVA growth in the Northern Powerhouse region⁷⁶ has been below the UK average over the past 10 years, and its productivity (when measured in terms of GVA per worker) is 29% below productivity in London (Centre for Cities 2015).

The Northern Powerhouse policy agenda aims to address the productivity gap between the North and the South by bringing economic productivity in the North in line with the UK average (Osborne 2015). Alongside detailed plans being developed by the Northern city regions, improving transport connections is seen as one of the important components to achieving this ambition.

The analysis in this report focuses on the potential contribution of improved inter-city connections in particular. However, as we describe below,

⁷⁶ For the purposes of our analysis, we assume that the Northern Powerhouse includes the six Northern city regions of Hull, Leeds, Liverpool, Manchester, Newcastle and Sheffield. These are the city regions whose work is being taken forward by Transport for the North.

opportunities to boost economic performance can only be fully realised if other drivers of economic performance are adequate and complementary.

6.3 What do we know about the drivers of economic performance?

The evidence is clear that there are many factors that drive economic performance. Each driver is likely to be necessary, though not sufficient by itself, for realising opportunities. The drivers are the following.

- **Labour market and skills.** Cities can grow by both improving the skill base of current workers and by attracting skilled workers from elsewhere.
- **Infrastructure.** Cities rely on infrastructure of various forms, both physical and digital. The quality, capacity, reliability and efficiency of such infrastructure are important for economic performance.
- **Business environment.** All activities take place within existing policy regimes. National and local actions on tax, regulations and the stability of the policy environment are all important for economic performance as they can have an impact on workers and business investment decisions.
- **Innovation.** Cities can play a role in innovation by supporting knowledge generation and business innovation measures.
- **Quality of place.** The quality and variety of amenities available in cities affect the quality of life, and in turn influence the location decisions of workers and firms.

Transport resides in the infrastructure driver. It facilitates other activities such as providing access to work, movement of freight or visiting friends and family. In doing so, it is a means to an end rather than an end in itself. Transport interventions can therefore create opportunities to improve economic performance in two particular ways.

- **Unlocking growth.** Transport infrastructure can be enhanced so that pressures on the system (when demand exceeds capacity) which can result in congestion, overcrowding and unreliability, are minimised and do not constrain the opportunities generated by other drivers of economic performance. Such enhancements can also facilitate new journeys to take place that were not feasible or viable previously. In both cases, transport improvements can be seen to unlock the economic potential of other drivers.

- **Driving growth.** Transport can stimulate the economy; that is, it can directly drive economic performance rather than just unlocking the growth potential of other drivers. By bringing people, firms and places effectively closer together, transport improvements can generate ‘agglomeration benefits’, which directly increase productivity.

We have identified the following channels through which opportunities for agglomeration benefits could be created.

- **First-order effects.** Agglomeration increases the productivity of the existing stock of workers and firms, by enabling scale and specialisation, better matching among workers and firms, and learning and knowledge spillovers. First-order effects increase productivity holding the composition of the economy constant (e.g. levels of employment and location of businesses). Therefore, they do not depend on other drivers of economic performance.⁷⁷
- **Second-order effects.** In response to the reduced travel times and associated rise in wages and returns to investment (the first order effects), further high-skilled workers and investment can be attracted to an area over time. This changes the economic composition of the area and adds to economic performance.

The nature and scale of second-order effects crucially depends on other drivers. For example, quality housing and amenities are needed to attract high-skilled workers to the area, and a favourable business environment is needed to increase investment. This means that it may be necessary to invest in other drivers of economic performance to fully realise the opportunities created by investments in transport.

Although first-order effects will always have a positive impact as they reflect the gains to the current stock of workers from being able to access a greater number of markets and opportunities, second-order effects involve movement of economic activity and occur over time. Therefore, there is the potential for some areas to gain (if productive workers move in) at the expense of others (if productive workers move away), yet there is little evidence to suggest the scale or direction of such changes following an improvement in an inter-city connection.

The ability of inter-city connections specifically, as opposed to improved transport connections more widely, to drive economic performance is relatively less well understood in published evidence. Our approach in this report is therefore cautious and honest about the limitations in the knowledge base, and

⁷⁷ However, to the extent that improvements in inter-city transport connectivity increase traffic flows, it may be necessary to invest in intra-city transport networks to ensure that congestion does not occur (because congestion could erode any improvement in door-to-door journey times).

we only draw conclusions that are well-founded while highlighting where further evidence is needed.

We begin by setting out our understanding of the conditions under which the economic gains associated with improvements in inter-city transport links are likely to be comparatively greater, based on the evidence. We then explore this understanding by using new analysis of the change in the number of workers that firms in a particular city have access to when inter-city transport links in the Northern Powerhouse are improved. This is then used to estimate the associated increase in productivity because firms and workers are effectively closer together. This allows us to draw conclusions about where the scale of opportunity is likely to be comparatively greater, and where further work would add value to the evidence-base.

6.4 Where are the opportunities for inter-city transport improvements to contribute to economic performance likely to be comparatively greater?

The identification of transport corridors that are able to create comparatively greater opportunities for boosting economic performance will depend on how we see the role of transport in promoting economic performance, for example, the following.

- **Unlocking growth.** The role of transport interventions in this context is to release constraints that might occur because of the demand for travel associated with other drivers of economic performance. Attention should therefore be targeted on inter-city connections that are demonstrating high levels of demand related to economic activity (commuting, business travel and freight travel) and that are showing signs that pressures – through congestion or overcrowding – are having a negative effect. In addition, attention is needed on connections between the fastest growing cities in the North, where such pressures are likely to arise in the future. Our analysis of transport performance (Chapter 4) suggests the following.
 - The links with the highest commuter demand are those between Manchester and Liverpool (road and rail), Manchester and Leeds (for rail only), and Leeds and Sheffield (road and rail). In each case, flows in the morning peak are relatively greater from the smaller to the larger city, reflecting travel to dense employment centres.
 - The greatest pressures on the strategic road network are on the M62 between Liverpool and Manchester, and also between Manchester and Leeds; on the M60 around Manchester; on the M1 near Sheffield; on

the M6 leading into Manchester; and, on the A1(M) near Newcastle. On the rail network, the greatest (morning peak) pressures are on services into Manchester and Leeds.

- Key freight routes, particularly those around ports attracting new investments, such as Liverpool and Hull, are likely to experience significant increases in traffic. The M62 is a critical freight link (freight is around 40% of traffic).
- **Driving growth.** The nature and scale of this opportunity depends on the size and economic composition of the cities that will be better connected; the distance between these cities (in terms of journey travel times); the quality of their intra-city networks; their geographic location in relation to surrounding cities; as well as the extent to which other drivers – such as skills of their labour force – are adequate and complementary.

The corridors that are identified with a potential to unlock growth may not in all cases match the corridors where transport is currently constraining economic performance. It is important to consider both perspectives.

The greatest comparative opportunity for driving economic performance through inter-city transport improvements is on connections between cities that have the following characteristics:

- **Large and fast growing cities.** The potential gain in overall earnings is likely to be greater by improving connections between large and fast-growing cities simply because of the volume of workers who would benefit from that boost in productivity. Cities with the largest numbers of jobs are Manchester, Leeds and Newcastle. These cities have also experienced more rapid growth than the other cities, with annual growth in GVA over the last decade of 1.43%, 1.49% and 1.59%, respectively.
- **High and intermediate skills.** There is considerable evidence that productivity gains associated with improved accessibility are greater for workers with high, or intermediate, skills levels. The proportion of skilled workers appears fairly similar in each of the northern city regions, both in terms of NVQ level 4+ (ranging from 27% to 32% of the working age population) and level 3+ (ranging from 49% to 53%).

Productivity levels in terms of GVA/worker do, however, vary more noticeably across the city regions. For example, Liverpool, Manchester and Leeds (which have the highest levels of productivity) have GVA/worker which is around 11–12% higher than Sheffield (which has the lowest level of productivity).

- **Relatively high shares of sectors for which face-to-face or business-to-business contacts are important.** Producer services (which include finance, insurance, real estate and consulting services)⁷⁸ and transport services are therefore most amenable to gains in accessibility and associated increases in earnings. The Manchester and Leeds city regions have higher proportions of their economies in producer services than the Northern Powerhouse average.
- **Cities already relatively closer together (in terms of travel times).** The benefits of increased accessibility decline rapidly with the travel time from the source, particularly for service sectors. We note that Liverpool–Manchester (fastest time of 32 minutes by rail) and Leeds–Sheffield (fastest time of 40 minutes by rail) are closer together than the connections between the remainder of the six city regions: for example, Manchester–Sheffield, 48 minutes; Hull–Leeds, 55 minutes; Hull–Sheffield, 86 minutes; Newcastle–Leeds, 87 minutes; and Leeds–Manchester, 49 minutes.
- **Adequate intra-city connections.** Inter-city links are only part of a journey. The overall change in accessibility depends on door-to-door journey times. If intra-city travel times are prohibitively high, reductions in inter-city travel time may do little to improve accessibility. Further work is needed to address this in the context of the interactions with improved inter-city connections.

6.5 What scale of opportunity could be created through improved inter-city connectivity in the North?

We have carried out indicative analysis of the changes in access to workers ‘accessibility’ associated with improving rail travel times between the TTWAs around major Northern cities⁷⁹. We consider improved rail times between four city pairs plus improvements on all links between the largest city regions in the North, in line with the TfN rail travel time aspirations.

This analysis is intended to be illustrative – it considers the increase in workers that cities would have access to, if present-day rail travel times were to reduce to the TfN’s aspirational travel times. These changes in ‘accessibility’ are then

⁷⁸ SIC codes 65 to 745.

⁷⁹ The equivalent analysis using road travel times was not possible in the timeframe of this study.

converted into an estimated impact on earnings by using evidence-based estimates of how, at a national average level, worker productivity (earnings per worker) changes when accessibility changes⁸⁰. It does not account for actual or forecast levels of travel demand along corridors, nor does it include any of the planned or committed transport capacity improvements, which could affect journey times.

Some important points about this analysis are:

- This indicative analysis focuses on the scale of potential gains in productivity per worker when firms and workers are effectively brought closer together (i.e. when accessibility increases because of improved journey times). ***This effect is additional as it is not captured within the standard approaches to assessing the transport user benefits of a transport intervention*** (which are largely driven by time savings, reductions in collisions or accidents or reduced overcrowding).
- ***The productivity gains estimated in this analysis would be expected to form just one part of any assessment of the benefits of a transport intervention.*** No attempt is made to assess the standard transport user benefits – these would be expected to largely derive from the role of the transport intervention in unlocking economic performance by lowering congestion or overcrowding⁸¹. In addition, improved inter-city connectivity could contribute to other wider economic impacts that are not considered here. For example, the ability of the area to attract FDI; and the gains to freight and logistics (such gains would be likely to be largely captured in standard appraisal methods).
- ***Investment decisions should be informed by an assessment of all anticipated costs and benefits of an intervention.*** An assessment of the costs and benefits is beyond the scope of this particular study but any productivity gains would need to be considered alongside other economic impacts, environmental considerations (such as emissions or landscape impacts) and social effects.

The analysis is intended to allow us to compare the relative opportunity to boost economic performance associated with improved inter-city connections between

⁸⁰ The elasticity we use is 0.03 from D'Costa et al (2009). Please see Chapter 2 for full details.

⁸¹ For example, the Eddington Transport Study (Eddington 2006) suggested that the inclusion of wider economic impacts that are missing from current appraisals would add around 0.1 to the benefit-cost ratio on average i.e. raising the average benefit-cost ratio for these interventions from around 1.7 to 1.8. This is of course an average estimate and the returns will vary significantly across interventions.

cities of different sizes and proximity, though we do not claim spurious accuracy in the estimates.

Key assumptions are:

- Journey times between rail stations are based on current actual timetable data using a national database of every rail service in Britain;
- Planned and committed enhancements to transport capacity have not been reflected in this analysis, for example, High Speed 2 or improvements in rail franchise services. These would be expected to affect travel times along the corridors investigated. If these are accounted for, the incremental accessibility gains of further improved inter-city travel times would be lower than assessed in this report.
- Estimating the effects that improved inter-city transport links might have on earnings is an emerging area of analysis. The results shown in this report should therefore be used as a guide to relative orders of magnitude, rather than taken as literal and absolute estimates. Little is known about the nature and magnitude of displacement effects. However, there is some tentative evidence that the increases in economic performance generated by transport improvements in one area may have substantial negative consequences on surrounding areas. Further analysis is needed into the potential for these effects.

The elasticities used in this report capture only the first-order effects from improved connectivity – that is, they reflect the gains to worker productivity holding the economic composition of the local economy constant. The potential benefits associated with people and businesses changing location over time, and the extent to which workers may invest in their own skills if they have better access to jobs, would be additional.

We have compared the gains in accessibility (access to resident workers) for the following scenarios. These were selected because they reflect connections between cities of different sizes, economic compositions and rail travel time proximity, as well as different levels of inter-city commuter flows. They allow a comparative analysis to be carried out:

- Leeds to Manchester;
- Manchester to Sheffield;
- Liverpool – Manchester;
- Leeds to Hull; and
- all Northern Powerhouse inter-city rail aspirations being achieved.

We find the following.

- Improving the rail travel time between the largest cities (Leeds and Manchester) from 49 minutes to 30 minutes leads to gains in accessibility (i.e. number of workers to whom cities have access) for all six of the largest city regions. Accessibility of Leeds could increase by around 2.8%, Hull by 1.5% and Manchester by 1.3% (the latter increase is relatively lower as it starts from a higher base). This translates to an estimated gain in total earnings for the six Northern city regions in the order of £30 million per year or £62 million nationally, including the wider northern area.
- Improving other city connections could also result in earnings increases, though of a lower magnitude. For example, improving the rail journey time between Manchester and Sheffield from 48 minutes to 30 minutes could offer a gain in earnings to the six northern city regions of £18 million with a national gain of £41 million, including gains to the wider northern region. Improving journey times between Liverpool and Manchester from 32 minutes to 20 minutes could offer a gain of around £12 million in earnings to the six city regions and £18 million nationally, including the wider northern regions.
- Of our scenarios modelled, improving the link between Hull and Leeds from 55 minutes to 45 minutes could offer a comparatively smaller gain in earnings. Our analysis suggests a gain in earnings of £2 million in the six northern city regions (almost all gain is in Hull) or £3 million nationally, including the wider northern area.

These findings are therefore consistent with the notion that relative gains in earnings are likely to be greater when improving connections between larger and more productive (higher skilled) cities with relatively shorter travel times between them.

6.6 What does this suggest for policy makers?

There are some emerging findings that are relevant and important for policy makers as they seek to boost the economic performance of the North.

- Improving inter-city transport connections is able to create an opportunity to boost economic performance, especially where investment is targeted on links where there is scope **both** to unlock transport constraints, and to drive enhanced economic performance (subject to other conditions being in place).

- The importance of inter-city connections to unlock the gains in economic performance that could be attained through other drivers allows us to identify those routes that are demonstrating signs of current and future congestion and overcrowding. Those heavily used by commuters, freight and business travellers would be likely to provide the highest returns.
- The importance of unlocking freight travel in the Northern cities must be noted, given the substantial planned investments in ports (such as Liverpool, Hull and Newcastle) and the importance of surface access to international airports, such as Manchester Airport, and other regional airports.
- The extent to which inter-city transport connections are able to drive economic performance will crucially depend on the following.
 - **Other drivers.** We have seen how access to skills can only increase if there are workers with those skills within reach. **Investing in skills of the labour force is critical.** Likewise, to maximise the opportunity for enhanced economic performance, other drivers (housing, amenities, etc.) must be sufficient and complementary.
 - **Intra-city connections.** Gains from inter-city connectivity can only be fully realised if the door-to-door journey is taken in to account. Therefore, within-city travel must be adequate to cope with current and new journeys that are associated with vibrant and growing economic centres.
- Policy makers may therefore wish to focus attention on inter-city connections in which the following characteristics are present.
 - **Large and fast growing cities.** The potential to deliver gains in absolute economic performance (overall earnings) is likely to be greater for large and fast growing cities.
 - **High and intermediate skills.** There is considerable evidence that gains from accessibility are greater for workers with higher, or intermediate, skills levels.
 - **Relatively high shares of sectors for which face-to-face or business-to-business contacts are important.** Producer services (which include finance, insurance, real estate and consulting services)⁸² and transport services are therefore most amenable to gains from accessibility improvements.

⁸² SIC codes 65 to 745.

- **Cities already relatively closer together (in terms of travel times).** The benefits of increased accessibility decline rapidly with travel time from source, particularly for service sectors.
- **Adequate intra-city connections.** Inter-city links are only ever going to be part of a journey. The overall change in accessibility depends on door-to-door journey times so intra-city connections must be adequate.

This report has presented the best available evidence on the channels through which improved transport connections could improve economic performance. It describes the role that inter-city connections can play in this context and the conditions under which improvements in inter-city connections are likely to deliver comparatively greater gains in earnings.

We have carried out new indicative analysis that allows us to quantify and compare the potential gains in earnings from improving connections between different Northern cities. This should help to inform policy makers about the potential gains in economic performance from improving inter-city connectivity, and to identify where this potential is likely to be comparatively greater. We would recommend that further analysis is carried out to assess the benefits of such improvements in more detail, alongside the costs associated with such improvements.

Annex: Additional material

City analysis for Chapter 3

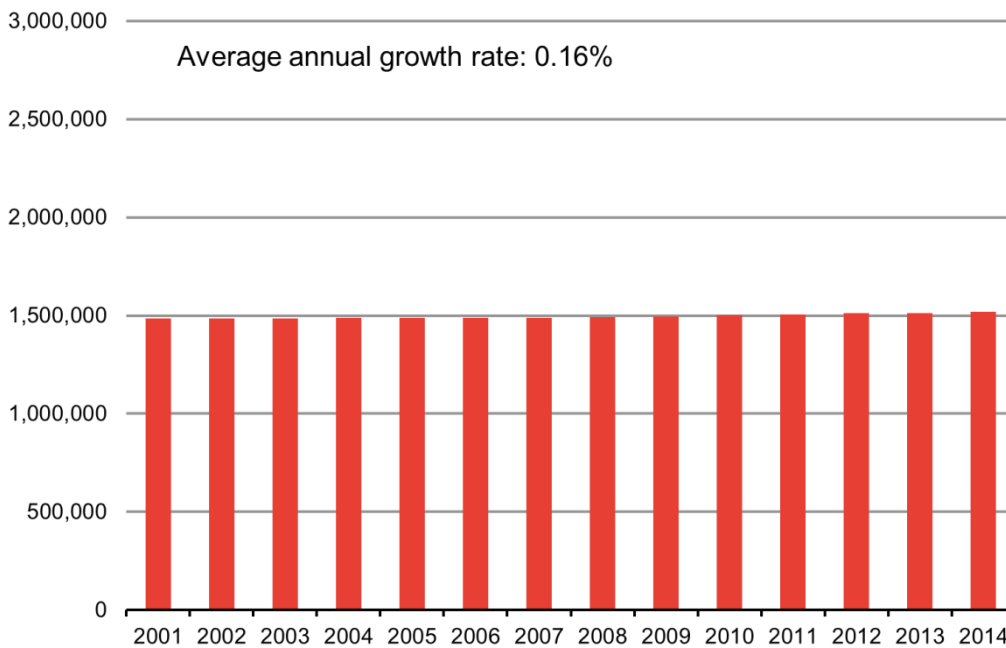
This Annex outlines the economic geography of each city region in turn.

Liverpool city region

Population

The population of the Liverpool city region is 1.5 million, 14% of the Northern Powerhouse. Population growth from 2001 to 2014 averaged 0.16% per year, with the population having been fairly constant for a number of years until a recent acceleration to 0.29% per year since 2009. This acceleration is forecast to continue, with average growth of 0.73% per year out to 2030 (United Nations 2014).

Figure 37. Liverpool city region population



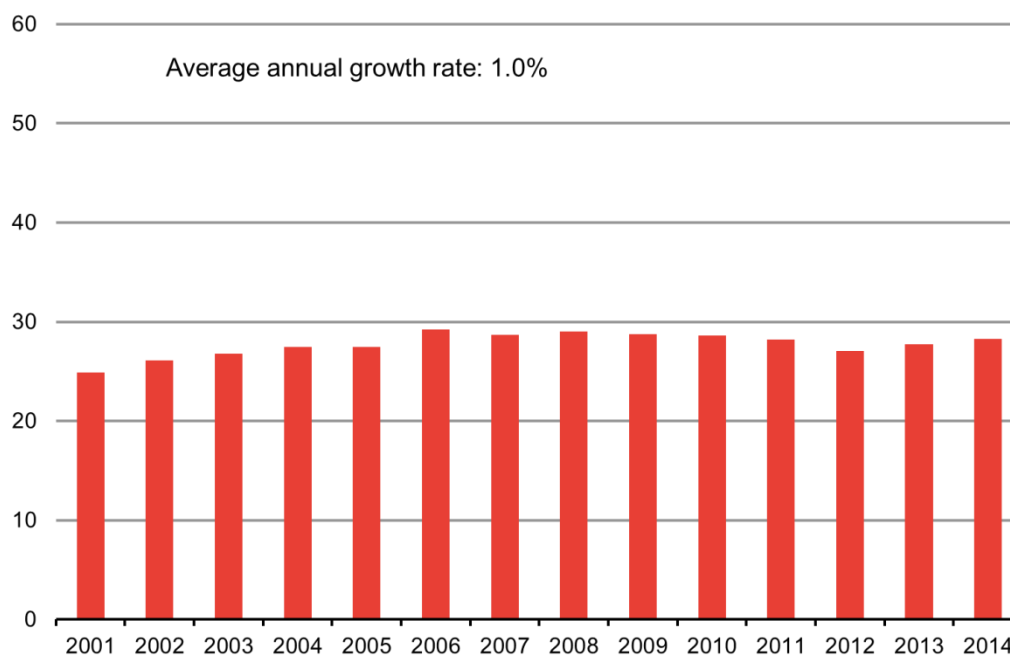
Source: ONS Population Estimates

Economy

The Liverpool city region contributes £28 billion GVA to the economy, 13% of the Northern Powerhouse total. The local economy grew at an average of 1.0% per year from 2001 to 2014.

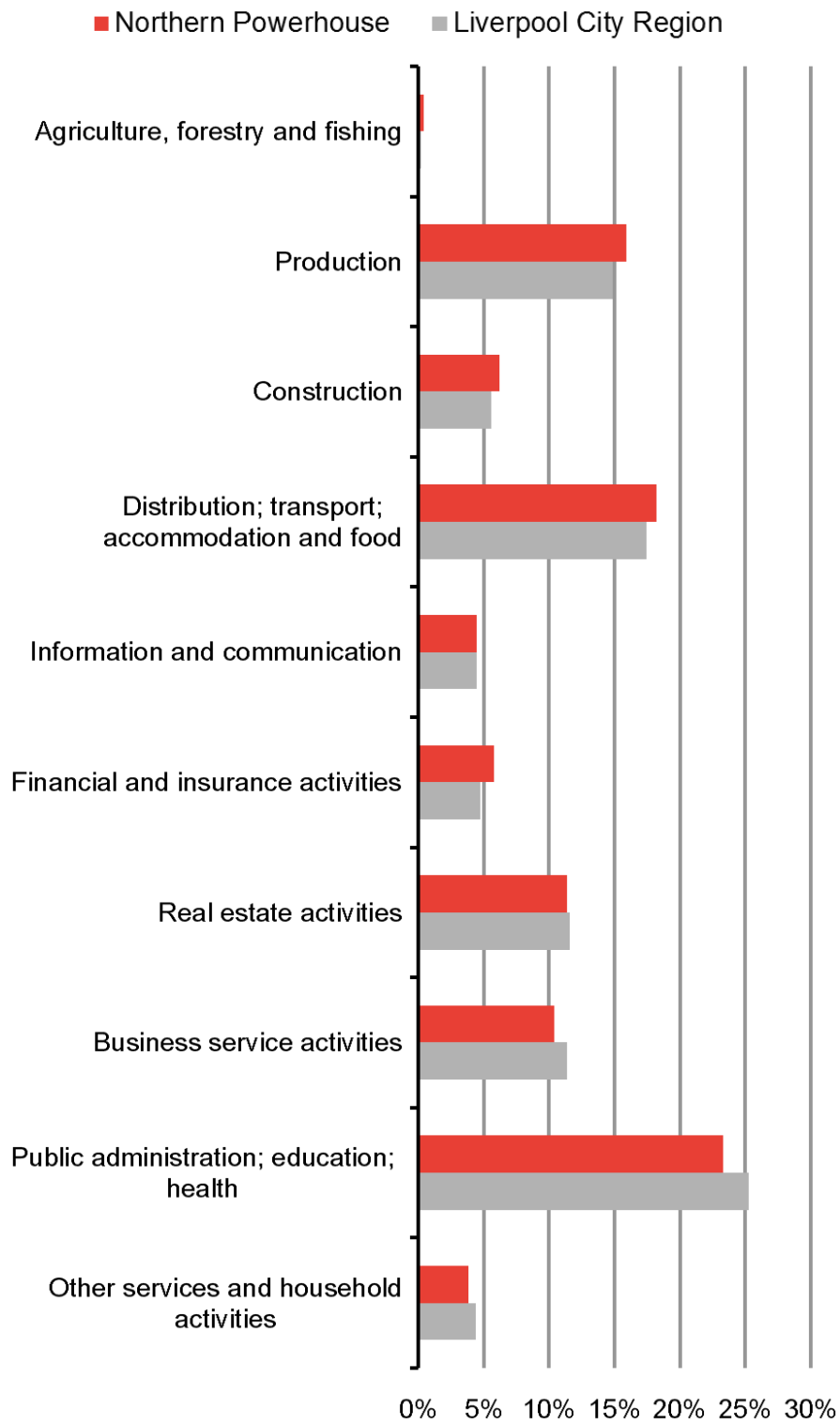
The composition of the economy is similar to the Northern Powerhouse as a whole but with a higher proportion in some service sectors, notably business service activities and the public administration, education and health sectors.

Figure 38. Liverpool city region economy – GVA £bn (2014 prices)



Source: ONS Regional Accounts

Figure 39. Proportion of GVA by industry



Source: ONS Regional Accounts (2012 data)

Productivity and skills

Productivity levels in the Liverpool city region, at £45,950 per worker, are slightly above the average for the Northern Powerhouse, but still somewhat below the national average. The 27% proportion of the population with qualifications NVQ level 4 or above is also similar to the Northern Powerhouse average, and somewhat below the national average.

Table 16. Liverpool city region productivity and qualifications

	Labour productivity (GVA/worker £s)	Qualification of NVQ4+ (% of working age population)
Liverpool city region	45,950	27%
Northern Powerhouse	44,850	29%
National average*	49,800	36%

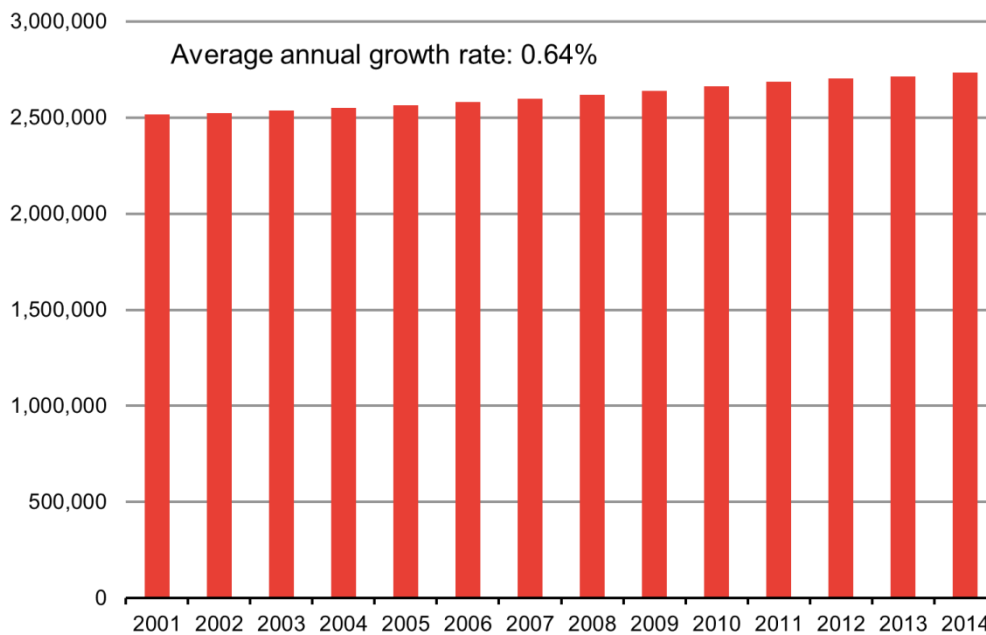
* Refers to UK for labour productivity, and to England and Wales for qualifications.

Source: for productivity, Centre for Cities (2015) and ONS Regional Accounts (2012 data); for qualifications, Office for National Statistics, Social Survey Division (2015)

Manchester city region

Population

The population of the Manchester city region is 2.7 million, which constitutes some 25% of the Northern Powerhouse, the largest of any of the city regions. Population growth from 2001 to 2014 averaged 0.64% per year. This high growth is expected to continue, with average growth of 0.77% per year forecast out to 2030 (United Nations 2014).

Figure 40. Manchester city region population

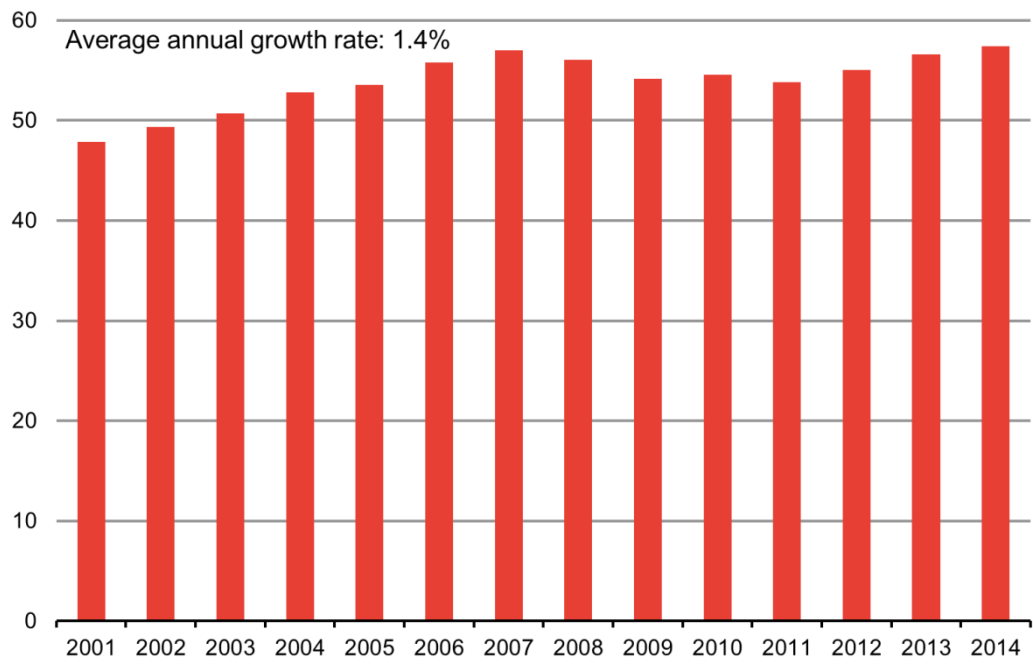
Source: ONS Population Estimates

Economy

The Manchester city region contributes £57 billion GVA to the economy, 27% of the Northern Powerhouse total. This is second only to London among proposed UK city regions (Office for National Statistics 2015b). The local economy has grown at an average of 1.4% per year from 2001 to 2014.

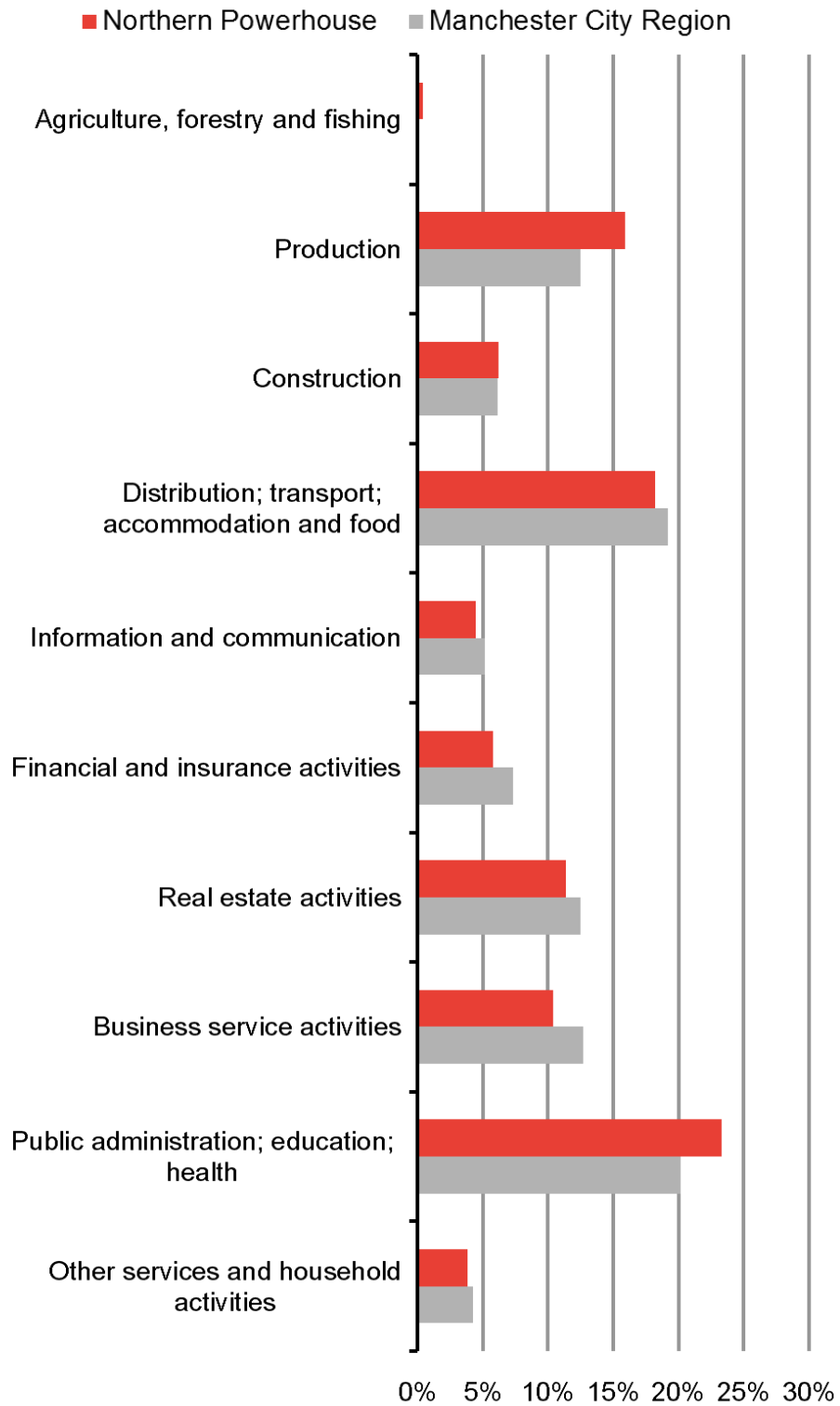
The composition of the economy is similar to the Northern Powerhouse as a whole, but with a higher proportion across almost all of the service sectors. The production sector and the public administration, education and health sectors are a smaller proportion of the Manchester city region's economy than the average in the Northern Powerhouse.

Figure 41. Manchester city region economy – GVA £bn (2014 prices)



Source: ONS Regional Accounts

Figure 42. Proportion of GVA by industry



Source: ONS Regional Accounts (2012 data)

Productivity and skills

Productivity levels in the Manchester city region of £45,550 per worker are slightly above the average for the Northern Powerhouse, but still somewhat below the national average. The 32% proportion of the population with qualifications NVQ level 4 or above follows the same pattern. This suggests slightly higher skill levels in the Manchester city region than elsewhere in the Northern Powerhouse, but the difference appears to be relatively small.

Table 17. Manchester city region productivity and qualifications

	Labour productivity (GVA/worker £s)	Qualification of NVQ4+ (% of working age population)
Manchester city region	45,550	32%
Northern Powerhouse	44,850	29%
National average*	49,800	36%

* Refers to UK for labour productivity, and to England and Wales for qualifications.

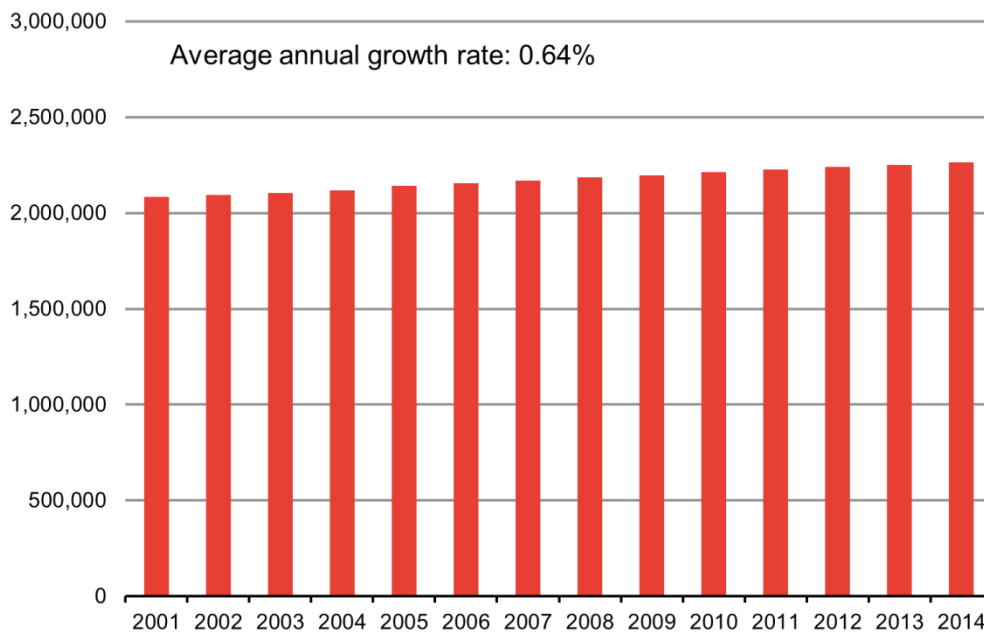
Source: for productivity, Centre for Cities (2015) and ONS Regional Accounts (2012 data); for qualifications, Office for National Statistics, Social Survey Division (2015)

Leeds city region

Population

The population of the Leeds city region is 2.3 million, which constitutes 21% of the Northern Powerhouse. The Leeds city region is the second largest in the Northern Powerhouse behind Manchester. Population growth from 2001 to 2014 averaged 0.64% per year. Population growth is forecast at around 1% per year on average out to 2030 (United Nations 2014).⁸³

⁸³ Note that the geographic region for this forecast uses UN definitions for West Yorkshire, which do not exactly match the Leeds city region.

Figure 43. Leeds city region population

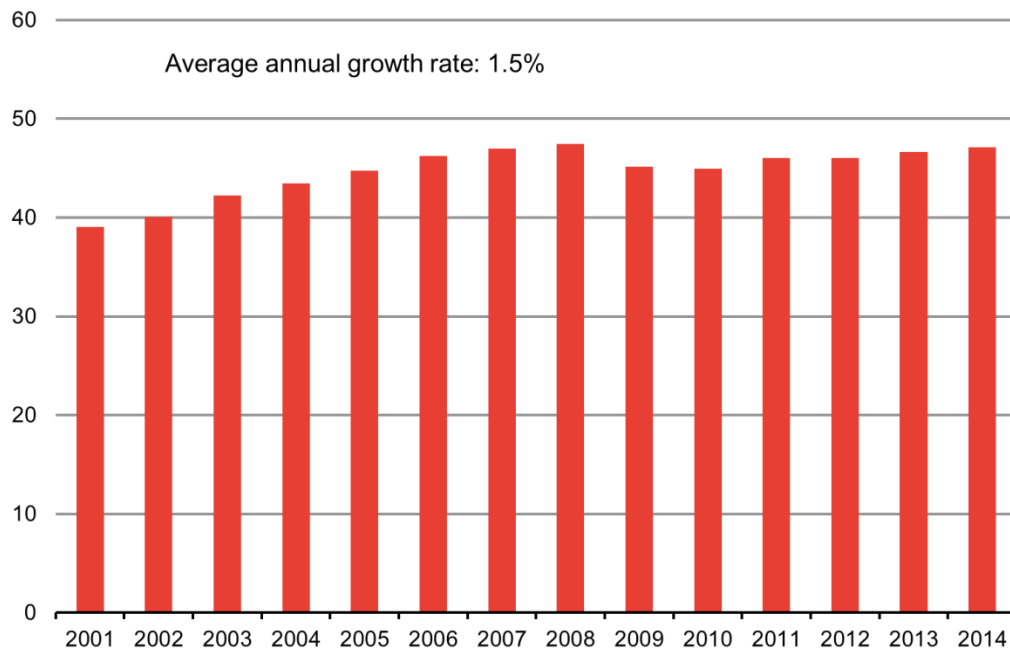
Source: ONS Population Estimates

Economy

The Leeds city region contributes £47 billion GVA to the economy, 22% of the Northern Powerhouse total. The local economy has grown at an average of 1.5% per year from 2001 to 2014.

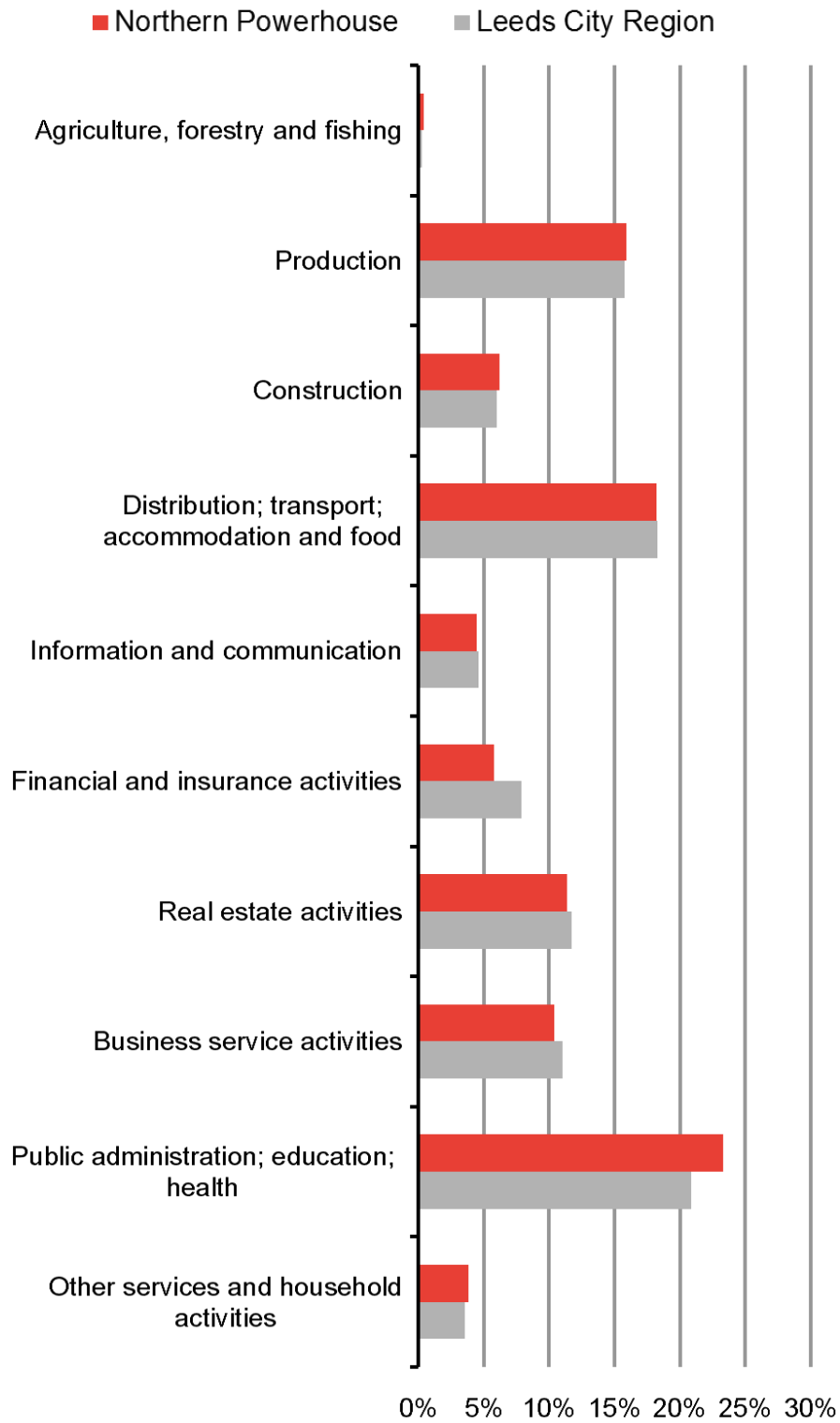
The composition of the economy is similar to the Northern Powerhouse as a whole, but with a higher proportion in financial and insurance activities and a lower proportion in the public administration, education and health sectors.

Figure 44. Leeds city region economy – GVA £bn (2014 prices)



Source: ONS Regional Accounts

Figure 45. Proportion of GVA by industry



Source: ONS Regional Accounts (2012 data)

Productivity and skills

Productivity levels in the Leeds city region are £45,650 per worker, slightly above the average for the Northern Powerhouse, but still somewhat below the national average. The 29% proportion of the population with qualifications NVQ level 4 or above is the same as the Northern Powerhouse average, and somewhat below the national average.

Table 18. Leeds city region productivity and qualifications

	Labour productivity (GVA/worker £s)	Qualification of NVQ4+ (% of working age population)
Leeds city region	45,650	29%
Northern Powerhouse	44,850	29%
National average*	49,800	36%

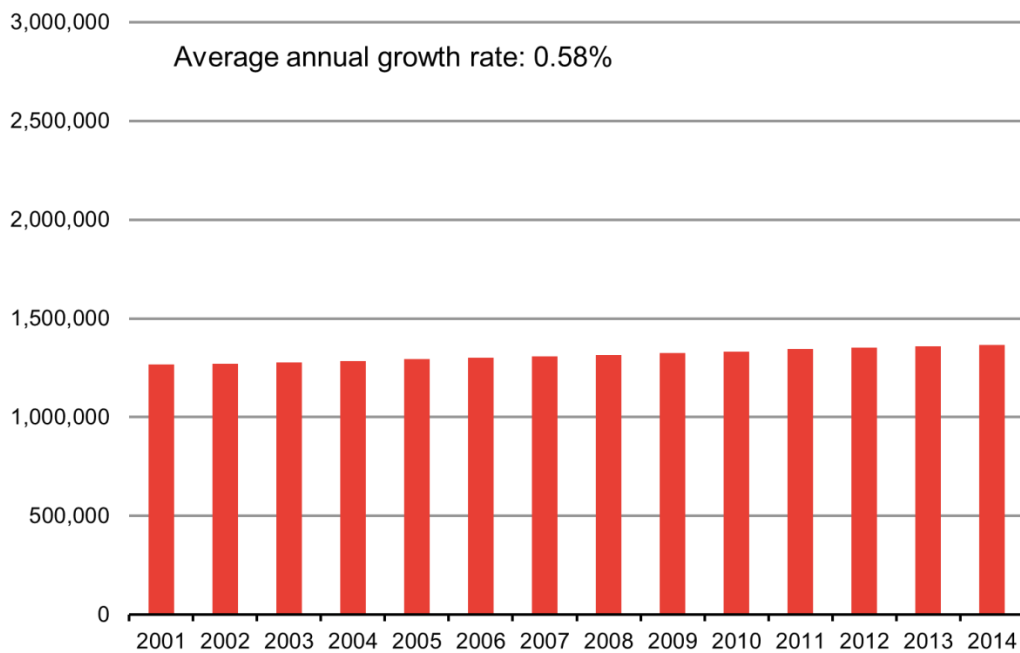
* Refers to UK for labour productivity, and to England and Wales for qualifications.

Source: for productivity, Centre for Cities (2015) and ONS Regional Accounts (2012 data); for qualifications, Office for National Statistics, Social Survey Division (2015)

Sheffield city region

Population

The population of the Sheffield city region is 1.4 million, which constitutes 13% of the Northern Powerhouse. Population growth from 2001 to 2014 averaged 0.58% per year. Population growth is forecast to increase to 0.89% per year on average out to 2030 (United Nations 2014).

Figure 46. Sheffield city region population

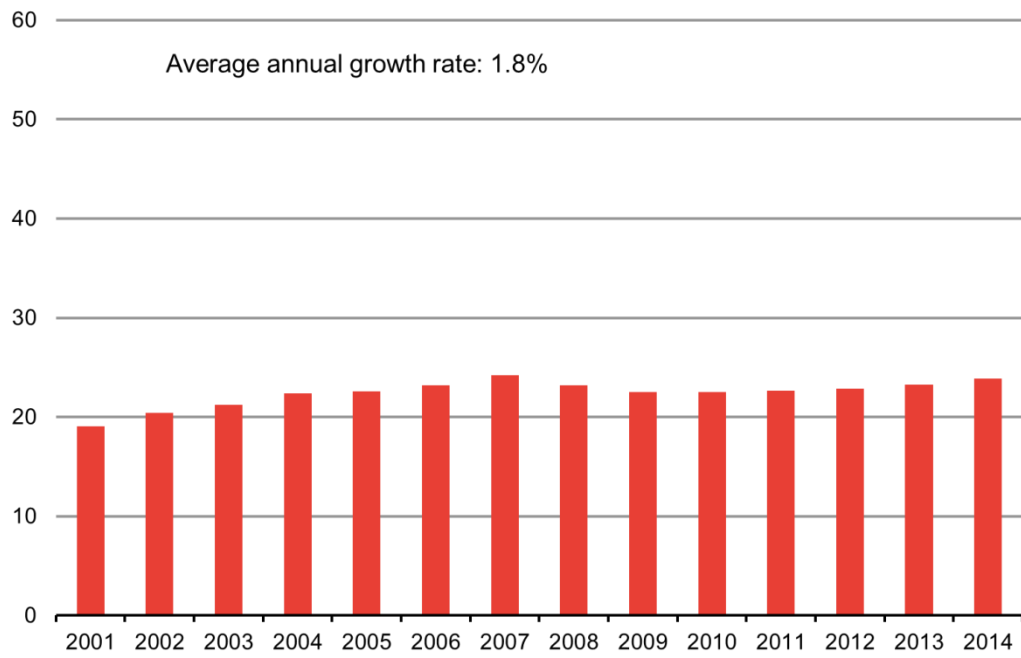
Source: ONS Population Estimates

Economy

The Sheffield city region contributes £24 billion GVA to the economy, 11% of the Northern Powerhouse total. The local economy has shown the fastest growth of all of the Northern Powerhouse cities, averaging 1.8% per year from 2001 to 2014.

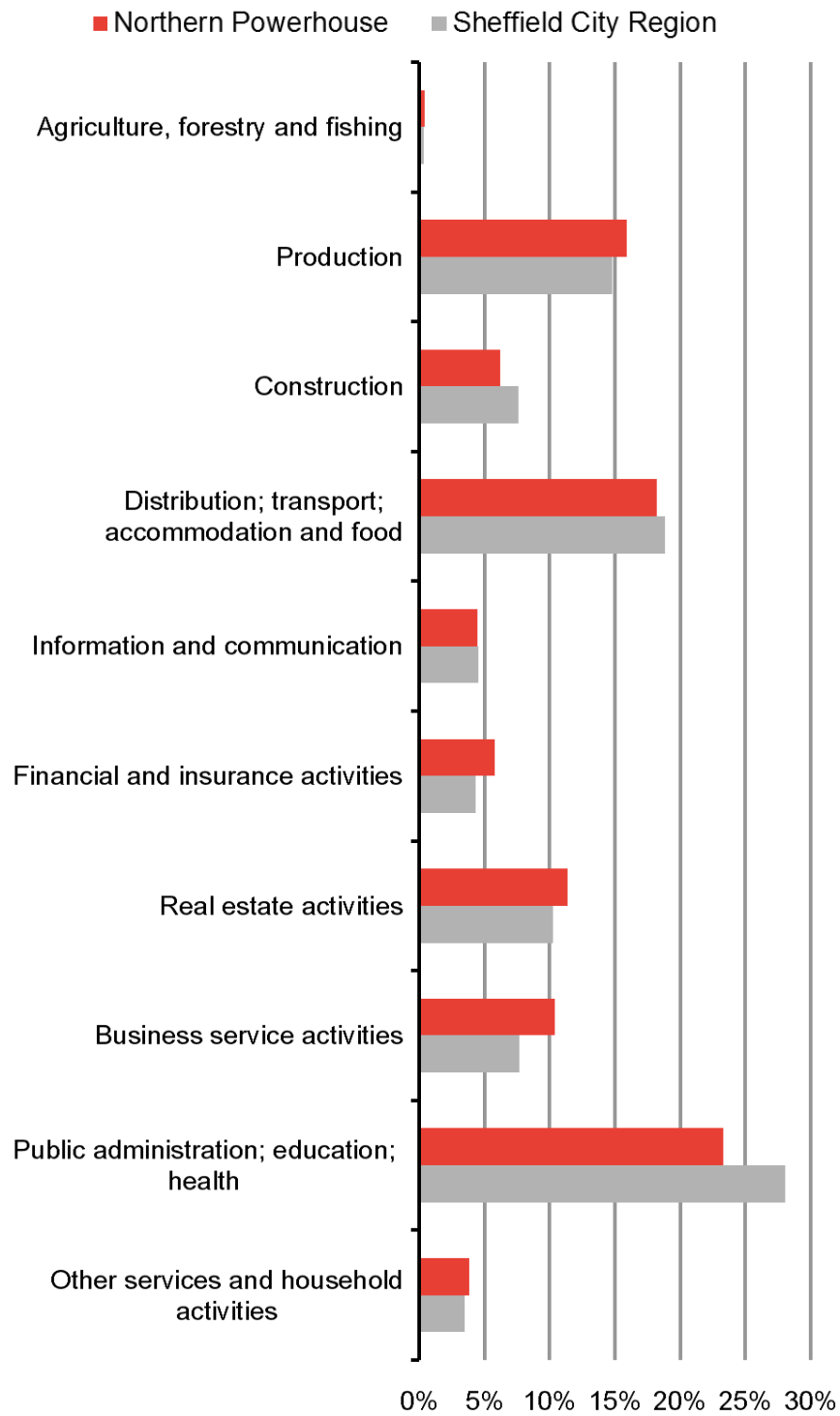
The composition of the economy is broadly similar to the Northern Powerhouse as a whole, but with some differences in the shares of specific services sectors. A significantly higher proportion of GVA is in the public administration, education and health sectors. Meanwhile, the proportion is smaller than average for financial and insurance activities, real estate activities and business service activities.

Figure 47. Sheffield city region economy – GVA £bn (2014 prices)



Source: ONS Regional Accounts

Figure 48. Proportion of GVA by industry



Source: ONS Regional Accounts (2012 data)

Productivity and skills

Productivity levels in the Sheffield city region are £41,200 per worker, which is below the average for the Northern Powerhouse and the national average. The proportion of the population with qualifications NVQ level 4 or above follows a similar pattern, showing 28% of the population with these qualifications in the Sheffield city region.

Table 19. Sheffield city region productivity and qualifications

	Labour productivity (GVA/worker £s)	Qualification of NVQ4+ (% of working age population)
Sheffield city region	41,200	28%
Northern Powerhouse	44,850	29%
National average*	49,800	36%

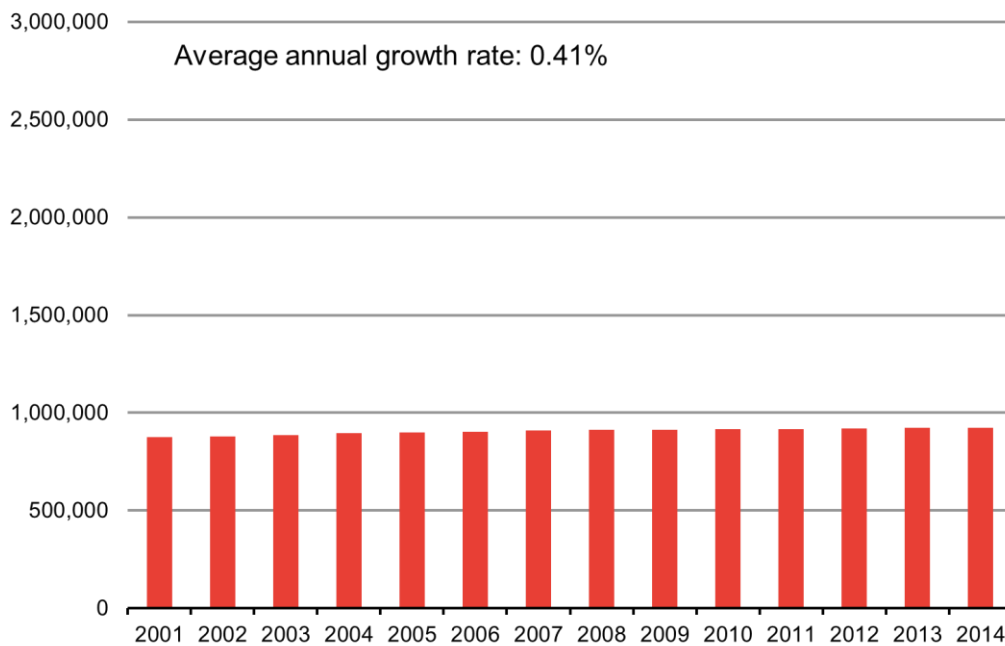
* Refers to UK for labour productivity, and to England and Wales for qualifications.

Source: for productivity, Centre for Cities (2015) and ONS Regional Accounts (2012 data); for qualifications, Office for National Statistics, Social Survey Division (2015)

Hull city region

Population

The population of the Hull city region is 0.9 million, constituting 9% of the Northern Powerhouse, the smallest of the city regions. Population growth from 2001 to 2014 averaged 0.41% per year. Population growth is forecast to increase to 0.92% per year on average out to 2030 (United Nations 2014).

Figure 49. Hull city region population

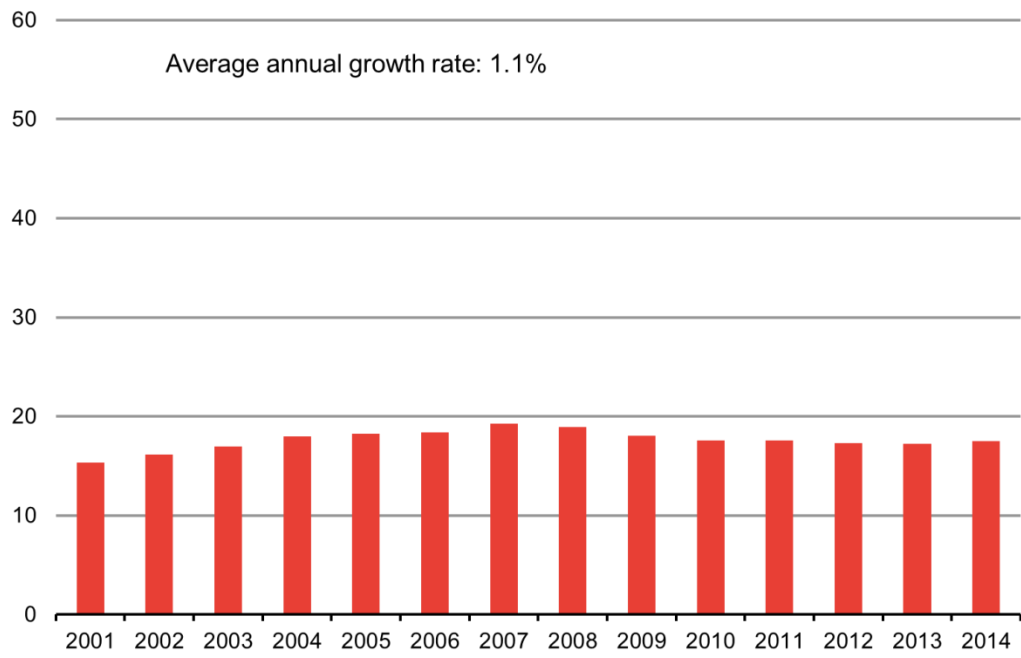
Source: ONS Population Estimates

Economy

The Hull city region contributes £17 billion GVA to the economy, 8% of the Northern Powerhouse total. The local economy grew at an average of 1.1% per year from 2001 to 2014.

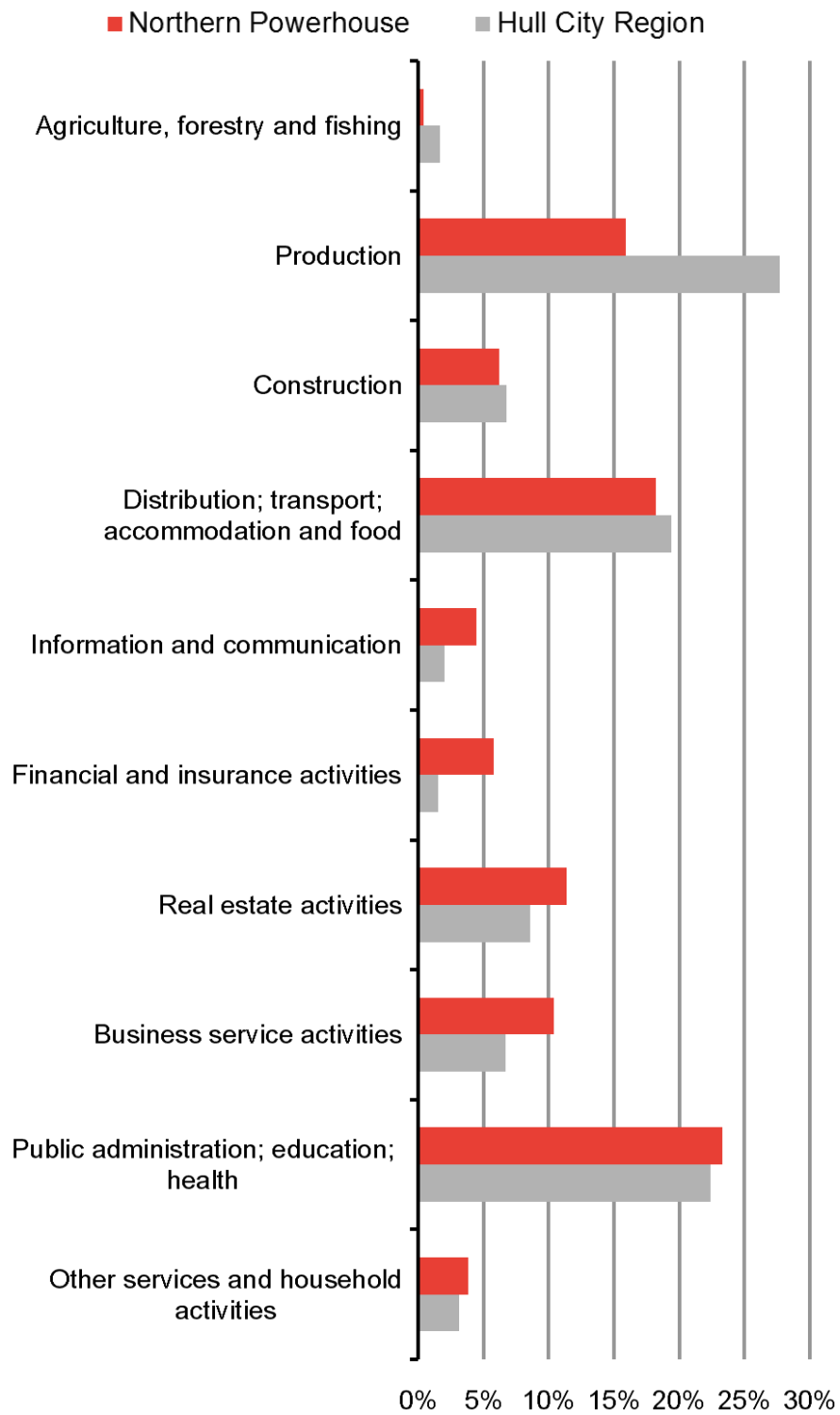
The composition of the economy shows a significantly higher proportion of GVA in the production sector, which includes manufacturing, compared with the Northern Powerhouse average. The production sector constitutes some 28% of the Hull city region economy. The relative importance of production is mirrored by a lower share of the economy in almost all of the service sectors compared with the average.

Figure 50. Hull city region economy – GVA £bn (2014 prices)



Source: ONS Regional Accounts

Figure 51. Proportion of GVA by industry



Source: ONS Regional Accounts (2012 data)

Productivity and skills

Productivity levels in the Hull city region are £45,300 per worker. This is slightly above the average for the Northern Powerhouse, but still somewhat below the national average. The proportion of the population with qualifications NVQ level 4 or above is 27%, which is below the Northern Powerhouse and national averages.

Table 20. Hull city region productivity and qualifications

	Labour productivity (GVA/worker £s)	Qualification of NVQ4+ (% of working age population)
Hull city region	45,300	27%
Northern Powerhouse	44,850	29%
National average*	49,800	36%

* Refers to UK for labour productivity, and to England and Wales for qualifications.

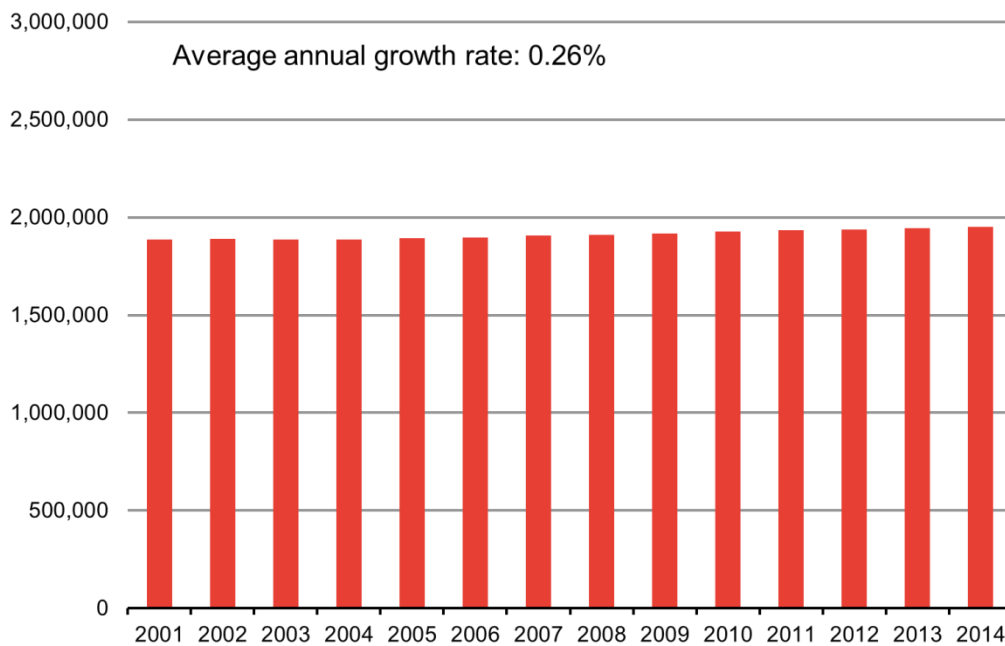
Source: for productivity, Centre for Cities (2015) and ONS Regional Accounts (2012 data); for qualifications, Office for National Statistics, Social Survey Division (2015)

Newcastle city region

Population

The population of the Newcastle city region is just below 2.0 million, which constitutes 18% of the Northern Powerhouse. Population growth from 2001 to 2014 averaged 0.26% per year, which is relatively low compared with most of the other city regions discussed above. However, population growth is forecast to increase to 0.80% per year on average out to 2030, which is more in line with the Northern Powerhouse average (United Nations 2014).⁸⁴

⁸⁴ Note that the geographic region for this forecast uses Newcastle and Sunderland, which does not exactly match the Newcastle city region.

Figure 52. Newcastle city region population

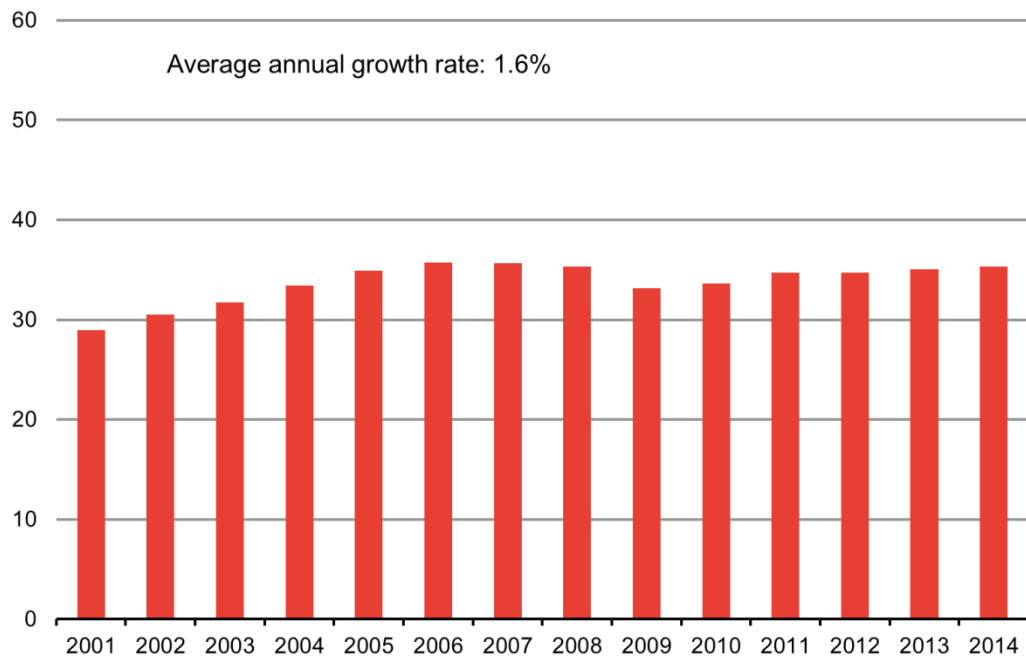
Source: ONS Population Estimates

Economy

The Newcastle city region contributes £35 billion GVA to the economy, 17% of the Northern Powerhouse total. The local economy grew at an average of 1.6% per year from 2001 to 2014.

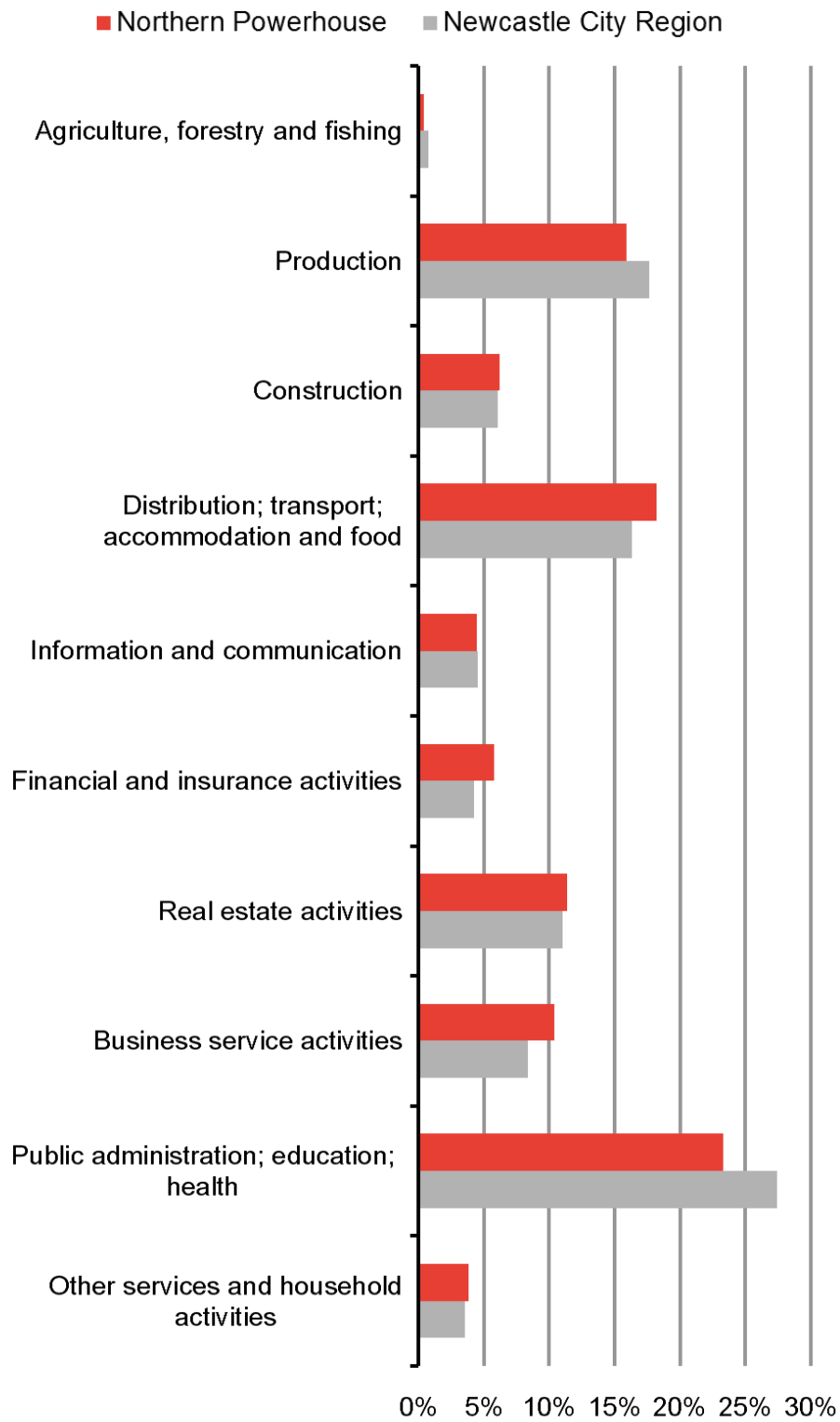
The composition of the economy is broadly similar to the Northern Powerhouse as a whole. The production sector and the public administration, education and health sectors take a higher proportion of GVA than average. Most other service sectors have a share of the economy slightly below the average.

Figure 53. Newcastle city region economy – GVA £bn (2014 prices)



Source: ONS Regional Accounts

Figure 54. Proportion of GVA by industry



Source: ONS Regional Accounts (2012 data)

Productivity and skills

Productivity levels in the Newcastle city region are £44,150 per worker, close to the average for the Northern Powerhouse and somewhat below the national average. The 29% proportion of the population with qualifications NVQ level 4 or above follows the same pattern.

Table 21. Newcastle city region productivity and qualifications

	Labour productivity (GVA/worker £s)	Qualification of NVQ4+ (% of working age population)
Newcastle city region	44,150	29%
Northern Powerhouse	44,850	29%
National average*	49,800	36%

* Refers to UK for labour productivity, and to England and Wales for qualifications.

Source: for productivity, Centre for Cities (2015) and ONS Regional Accounts (2012 data); for qualifications, Office for National Statistics, Social Survey Division (2015)

Gravity modelling assumptions in Chapter 4

The 3 gravity model specifications are as follows:

Model 1: Controls for origin and destination wages and employment and distance (does not control for unobserved characteristics)

Model 2: Controls for wages and employment, distance and unobserved characteristics separately by origin and destination (partly controls for unobserved characteristics)

Model 3: Controls for distance and unobserved origin and destination characteristics (fully controls for unobserved characteristics)

Details of the methodology can be found in D'Costa et al. 2009. The only difference is that our modelling includes distance in logs rather than levels, to capture any non-linear effects of distance on commuter flows.

Table 22. Gravity of inter-city LA-LA commuting flows

Explanatory variable	Model 1	Model 2	Model 3
Destination characteristics			
Log employment	0.945***	-0.694***	-
Log wage	1.149***	13.84***	-
Log distance	-1.900***	-1.863***	-2.480***
R-squared	0.73	0.696	0.827
Origin characteristics			
Log employment	0.761***	1.217***	-
Log wage	-1.255***	-4.206	-
Log distance	-1.900***	-2.142***	-2.480***
R-squared	0.73	0.573	0.827

Source: Modelling based on Census 2011, ASHE, NSPD data

Table 23. Predicted versus actual commuting flows (second stage)

Corridor	Model 1	Model 2	Model 3
Hull-Leeds	0.705***	0.316***	0.362***
Hull-Liverpool	-0.138	0.0884	0.126
Hull-Manchester	-0.590***	-0.552***	-0.247***
Hull-Newcastle	-0.136	-0.0677	-0.416***
Hull-Sheffield	0.942***	0.971***	0.718***
Leeds-Liverpool	-0.299***	-0.817***	-0.346***
Leeds-Manchester	0.0886*	0.0633	-0.0780**
Leeds-Newcastle	0.399***	-0.156***	0.00481
Leeds-Sheffield	0.885***	1.024***	0.344***
Liverpool-Manchester	0.268***	0.732***	0.365***
Liverpool-Newcastle	-0.161**	0.0338	-0.0830
Liverpool-Sheffield	-0.716***	-0.942***	-0.452***
Manchester-Newcastle	-0.0848	-0.0438	0.105**
Manchester-Sheffield	-0.580***	-0.558***	-0.383***
Newcastle-Sheffield	0.377***	0.330***	0.289***

Source: Modelling based on Census 2011, ASHE, NSPD data

Technical Annex: Northern Powerhouse inter-city rail connectivity methodology

This technical Annex provides further detail on the assumptions and methodology used to derive the results set out in Chapter 5.

Measuring access to economic mass and its changes

For the purposes of this study, economic mass accessible by rail from an origin TTWA i is defined by a standard form of effective density/accessibility index:

$$(1) A_i = \sum_j \frac{E_j}{time_{ij}^\alpha}$$

Where E_j is a variable capturing economic activity at destination TTWA j , and $time_{ij}$ is the minimum travel time by rail between TTWA i and TTWA j . These accessibility indices are calculated for each TTWA from measures of economic activity derived from the 2011 Great Britain census at TTWA level and from rail travel time data (RUDD as explained below). The TTWA-to-TTWA journey times are then adjusted to match aspirations for reductions in journey times between Liverpool-Manchester, Manchester-Leeds, Manchester-Sheffield, Sheffield-Leeds, Leeds-Hull and Leeds-Newcastle as set out in TfN (2015) and the accessibility indices re-calculated.

The parameter α is a time decay parameter which sets the rate at which the weights applied to destination TTWA $_j$ employment decline with travel time between TTWA $_i$ and TTWA $_j$. For the present analysis, this parameter is set to 1, in line with the value used most commonly in the literature, and in (D'Costa et al 2009) which provides the estimates of the elasticity of productivity (wages) with respect to accessibility (see Chapter 2.3).

Accessibility indices A_{i0} and A_{i1} are calculated for the baseline period (assumed to be present day travel times) and for the post-policy period with inter-TTWA travel times adjusted according to some or all of these Northern Powerhouse aspirations (depending on the scenario being analysed). The difference between the natural log of these indices then gives the approximate proportionate changes in accessibility:

$$\Delta \ln A_i = \ln \sum_j \frac{E_j}{time_{ij1}} - \ln \sum_j \frac{E_j}{time_{ij0}}$$

Note the employment values in the numerators of these indices are held constant at 2011 values (derived from the 2011 census).

Estimates of the response of wages to changes in this accessibility

The accessibility changes are translated into a change in worker productivity by multiplying them by a parameter taken from published literature. This

agglomeration elasticity parameter has been estimated in many studies in various contexts as detailed in Chapter 2.

In the empirical literature, these parameters are derived from regression analyses, of a generic form

$$\ln y_k = \beta_0 + \beta_1 \ln A_k + x_k' \beta_2 + u_k$$

Where y is some measure of productivity (e.g. value-added, wages), A is an index of economic mass, city size, density, accessibility or market potential and x is a set of control variables (worker, firm or city characteristics depending on the units of analysis). This regression may be estimated on city or other area-level data, data on workers or data on firms. Estimates of parameter β_1 provide estimates of the percentage response of productivity to a 1% increase in accessibility (holding other factors in x constant).

Given an estimate of β_1 based on an accessibility index as defined above and an estimate of $\Delta \ln A_i$ based on a predicted change in accessibility arising from some transport policy change, an implied percentage change in productivity or wages can be imputed for a given location from:

$$\Delta \ln y_i = \hat{\beta}_1 \Delta \ln A_i$$

An estimate of $\beta_1 = 0.03$ is taken from (D'Costa et al 2009), because that study provides an estimate of the effects rail-specific accessibility changes on wages using micro data on British workers. It also uses an accessibility index of the same form as (1), and is the most directly relevant study. Having an estimate of the impact on earnings means that the accessibility changes can be translated into potential earnings increases in each TTWA and in Britain as a whole.

Estimates of the aggregate impact on earnings in each TTWA and in the country overall are calculated from TTWA mean wages and TTWA worker numbers. Mean wages (gross annual earnings, all workers) are taken from Annual Survey of Hours and Earnings data which is available at Parliamentary Constituency (PC) level (2010 PC definitions, wages averaged over 2010-2015) from www.nomisweb.co.uk. Given that PCs overlap TTWA boundaries and vice versa, PCs are matched to TTWAs using an area-based weighting procedure (PC workers and aggregated earnings are assigned to TTWAs according to the land area of intersection between PCs and TTWAs).

Since β_1 gives the percentage change in mean earnings from a 1% change in accessibility, estimates of aggregate changes in total earnings in a TTWA are given by:

$$\Delta y_i = \hat{\beta}_1 \Delta \ln A_i \times workers_i \times meanearnings_i$$

Measuring minimum TTWA-to-TTWA journey times by rail

This section outlines the approach to estimation of the inter-travel-to-work-area (TTWA) travel time matrix between every origin and destination TTWA. This is required for computation of the accessibility index in equation (1). Two datasets were used namely: 1) the Rail-Usage-Driver-Dataset (RUDD) supplied with permission by DfT; and 2) a RUDD station to TTWA lookup dataset.

The RUDD data contains station-to-station journey times and is derived from timetable information. It represents around 80% of journeys in Britain. These data have been processed using a network analysis journey-time weighted shortest path algorithm to derive the minimum journey times from any given origin station s to every other destination station j in the RUDD set of stations. The journey time between each station is calculated from the difference of the arrival time at its destination station and the departure time at its origin station.

The second step is to collapse (average) every RUDD origin and destination station pair according to its corresponding TTWA using the lookup table from the dataset. There are often multiple stations in any given TTWA and hence multiple station-station journey times corresponding to any potential TTWA-to-TTWA journey. For example, suppose there is one station, station 1, in TTWA 1 and two stations, stations 4 and 5, in TTWA 2. This gives two station-station link times between TTWA 1 and TTWA 2: $stime_{14}$ $stime_{15}$.

From the origin-destination matrix of station-station minimum journey times, unique origin-TTWA-to-destination-TTWA journey times are estimated by averaging the minimum station-station journey times. The averaging is done according to which TTWAs contain the origin and destination stations. A simple average of the station-station journey times would be misleading since it would give insufficient weight to services that were more frequent and heavily used. For instance, suppose in the above example, $stime_{14}$ was 30 minutes and stations 1 and 4 have 6 trains per hour whereas $stime_{15}$ was 1 hour and station 5 only has 1 train per hour. A simple mean would give an average journey time between TTWA 1 and TTWA 2 of 45 minutes, which would be an overestimate since most journeys would presumably be via station 1 and 4. Ideally, to construct the actual average journey times would require passenger volumes, but these data were unavailable in the time available for this study. Instead, the station service frequencies (f_s) are used to construct appropriate weights, with the weight on a station-station link given by the product of the total service frequencies at the origin and destination stations. In the above example, the weight on link 1-4 would be $6 \times 6 = 36$, whereas the weight on link 1-5 would be $6 \times 1 = 6$. These weights are used to calculate a service frequency weighted average travel time between TTWAs. In the above example, the weighted average minimum rail journey time in minutes between TTWA 1 and 2 becomes

$$time_{12} = \frac{f_1 \cdot f_4}{f_1 \cdot f_4 + f_1 \cdot f_5} stime_{14} + \frac{f_1 \cdot f_5}{f_1 \cdot f_4 + f_1 \cdot f_5} stime_{15} = \frac{36}{36+6} 30 + \frac{6}{36+6} 60 = 34.3$$

Note, in a few cases, a TTWA contains no station in the RUDD data so is missing from the analysis (it is infeasible to compute a travel time change when there is no station present). These are shown on the maps in the report as uncoloured TTWAs. These are remote, rural and unpopulated TTWAs so will not affect the analysis substantively.

To construct aspirational TTWA-TTWA journey times, the aspirational central-city-to-central-city journey times are applied to the links between the main stations in the corresponding Northern Powerhouse TTWAs (Manchester, Liverpool, Leeds, Sheffield, Hull, Newcastle) as described in the next section. The entire station-station origin destination minimum travel time matrix is then recomputed to allow for the fact that these new links may reduce the travel times between stations throughout the network where the overall journey relies on the newly improved link. The revised TTWA-TTWA travel times are then recomputed using the frequency weighted averaging procedure described above.

Intra-TTWA travel times

The RUDD data is unsuitable for generating intra-TTWA travel times because it does not provide full coverage of all stations within cities. The modelling also should allow for the fact that many intra-TTWA journeys required to reach a station from home or the workplace would be done by road rather than rail. A full analysis would require information on intra-TTWA rail and road journey times which is beyond the scope of the present study. Instead to approximate intra-TTWA travel times an analytical approach is used. This involves: 1) calculating the average distance from a random point within a circle of the same land area as the TTWA to its centre; 2) assuming a fixed intra TTWA travel speed (set at 40km per hour, the mean vehicle speed on journeys in Britain) and; allowing for transfer/waiting times (10 minutes). The formula for inter-TTWA travel time in minutes is:

$$time_{ii} = wait + 60/speed + 2/3 \times \sqrt{area/\pi}$$

Where speed is in km/h and area is in km².

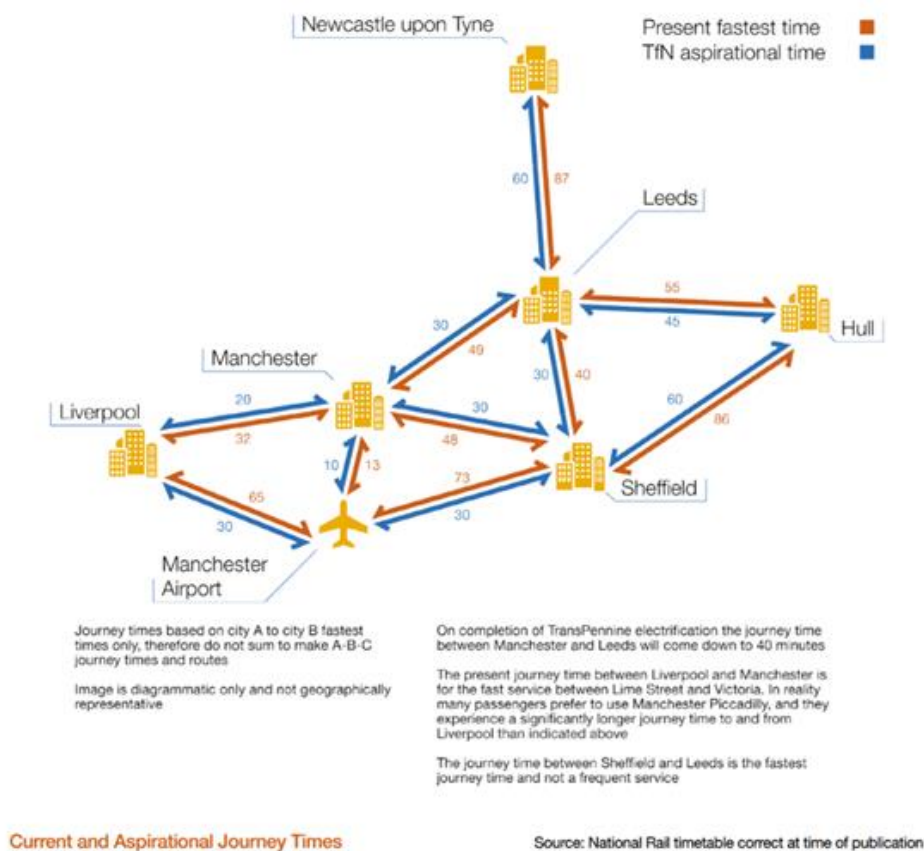
Note that inter-TTWA travel can in reality also be undertaken by road (or air). The analysis provided here does not take into account other modes of travel between TTWAs when calculating the accessibility indices. This means that the changes in accessibility calculated from changes in rail travel times in the Northern Powerhouse aspirations refer to changes in rail accessibility only. These may overstate the true percentage change in accessibility by all modes, given that a substantial part of the existing accessibility from a TTWA will be by other modes. When the changes in accessibility are used to infer potential changes in wages (productivity), elasticities are used which have been estimated conditional

on rail accessibility (D’Costa et al 2009) i.e. holding road accessibility constant. Therefore, the predictions can be interpreted as the impact of changes in rail accessibility, while the road infrastructure and road travel times, and intra-TTW travel times, are kept at their initial levels.

Scenario assumptions

A total of five inter-city rail scenarios were estimated. The scenarios use the travel time improvements highlighted in TfN (2015). The Figure below illustrates the travel time improvements for the seven key stations.

Figure 55. TfN Aspirational rail journey times between Northern cities



Source: Reproduced from Transport for the North, 2015, The Northern Powerhouse: One Agenda, One Economy, One North, A report on the Northern Transport Strategy.

Each aspiration improvement takes the report’s improvement ratio (TfN aspirational journey time/ current journey time reported by TfN) from TfN (2015)⁸⁵ and multiplies it with the current model journey time from the Rail-

⁸⁵ Transport for the North, 2015, The Northern Powerhouse: One Agenda, One Economy, One North, A report on the Northern Transport Strategy.

Usage-Driver-Dataset (RUDD) supplied with permission by DfT to calculate an aspirational model journey time. This is illustrated in the table below.

Table 24. Aspirational station-station journey times (all in minutes)

Origin	Destination	Model current	Model aspiration	Current time reported by TfN	TfN report aspiration
Hull	Leeds	57.79	47.28	55	45
Hull	Sheffield	88.28	61.59	86	60
Leeds	Manchester Br	55.93	34.24	49	30
Leeds	Newcastle	90.20	62.21	87	60
Leeds	Sheffield	46.23	34.68	40	30
Liverpool Br	Manchester Airport	71.21	32.87	65	30
Liverpool Br	Manchester Br	47.52	29.70	32	20
Manchester Airport	Manchester Br	18.91	14.54	13	10
Manchester Airport	Sheffield	77.25	31.75	73	30
Manchester Br	Sheffield	52.64	32.90	48	30

Source: Analysis for this study

The table below highlights all the current journey times between stations in grey and all the improvements highlighted for each scenarios in yellow. The existing run uses the current model journey time from the Rail-Usage-Driver-Dataset (RUDD). The proposal run 1 is the full aspiration scenario that takes the base scenario with improvements between all the pairs as listed in Table 1. The proposal run 2 takes the base scenario with improvement between Manchester and Leeds. The proposal run 3 takes the base scenario with improvement between Manchester and Sheffield. The proposal run 4 takes the base scenario with improvement between Hull and Leeds.

Table 25. Station-station travel times under various scenarios (all in minutes)

Origin	Destination	Existing Run	Proposal Run 1	Proposal Run 2	Proposal Run 3	Proposal Run 4
--------	-------------	--------------	----------------	----------------	----------------	----------------

Hull	Leeds	57.79	47.28	57.79	57.79	47.28
Hull	Sheffield	88.28	61.59	88.28	88.28	88.28
Leeds	Manchester Br	55.93	34.24	34.24	55.93	55.93
Leeds	Newcastle	90.20	62.21	90.20	90.20	90.20
Leeds	Sheffield	46.23	34.68	46.23	46.23	46.23
Liverpool Br	Manchester Airport	71.21	32.87	71.21	71.21	71.21
Liverpool Br	Manchester Br	47.52	29.70	47.52	47.52	47.52
Manchester Airport	Manchester Br	18.91	14.54	18.91	18.91	18.91
Manchester Airport	Sheffield	77.25	31.75	77.25	77.25	77.25
Manchester Br	Sheffield	52.64	32.90	52.64	32.90	52.64

Source: Analysis for this study

Final inter and intra TTWA travel times

Table 3 below shows an example of the inter and intra TTWA travel times between the key 6 Northern Powerhouse cities for the 'All aspirations' scenario, which is the end product of the steps described in sections 4 and 5. Note the full TTWA_i to TTWA_j travel time time_{ij} is derived by adding the internal TTW travel time to each end of the journey. Note the full analysis includes the baseline and post-policy inter TTWA travel times between all TTWAs with RUDD stations in Britain. This table is an extract.

Table 26. TTWA travel time matrix for 6 key Northern Powerhouse cities, under baseline and 'All aspirations' scenarios (All times in minutes)

Origin	Destination	Pre improvement	Post improvement
Hull	Hull	32.7	32.7
Hull	Leeds	62.9	55.2
Hull	Liverpool	168.4	124.7
Hull	Manchester	121.4	93.0

Hull	Newcastle	124.8	112.9
Hull	Sheffield	80.8	67.8
Leeds	Leeds	24.3	24.3
Leeds	Liverpool	114.7	78.5
Leeds	Manchester	68.0	47.0
Leeds	Newcastle	92.4	67.5
Leeds	Sheffield	52.0	42.5
Liverpool	Liverpool	23.9	23.9
Liverpool	Manchester	62.5	47.4
Liverpool	Newcastle	196.6	137.5
Liverpool	Sheffield	111.3	76.8
Manchester	Manchester	34.2	34.2
Manchester	Newcastle	152.6	106.1
Manchester	Sheffield	61.5	44.2
Newcastle	Newcastle	30.0	30.0
Newcastle	Sheffield	113.8	100.9
Sheffield	Sheffield	25.5	25.5

Source: Analysis for this study

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Frontier Economics Ltd 71 High Holborn London WC1V 6DA

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