



EXPLORING THE ECONOMIC BENEFITS OF STRATEGIC ROADS

Report for the Department for Transport

July 2017



CONTENTS

1	Executive summary	4
2	Introduction	14
2.1	Background and policy context	14
2.2	Objectives and scope of evidence review	14
2.3	Channels through which major road investments can deliver improved economic performance	17
2.4	Structure of the report	26
3	Evidence from literature	27
3.1	User benefits	27
3.2	Agglomeration	28
3.3	Business investment and FDI	37
3.4	Labour	43
3.5	Trade	49
3.6	Induced housing investment (or other transport-dependent investments)	53
3.7	Displacement	57
4	Case studies	61
	Introduction	61
4.1	A66 Long Newton Grade Separated Junction (GSJ), North Yorkshire	64
4.2	M6 Toll, Greater Birmingham	66
4.3	Southern Connector, Greenville SC (I-185-Toll)	70
4.4	A63 Melton Grade Separated Junction, west of Hull	74
4.5	Interstate 105, Los Angeles	78
4.6	US Route 460, Blacksburg, Virginia	82
4.7	A249 Iwade to Queensborough Improvement	86
4.8	Oresund Bridge	92
4.9	Wisconsin State Road 29	95
4.10	Dublin-Galway M4/M6 motorway	99
4.11	Summary of case studies and lessons learned	102
5	Policy implications	104
5.1	Observations from the evidence and policy implications	104
6	Gaps in the evidence for further study	107
6.1	Gaps and suggestions to address them	107
7	Annex	109
8	References	110

1 EXECUTIVE SUMMARY

Scope of this report

The Road Investment Strategy (RIS) 2015-2020 was published by the Department for Transport (DfT) in December 2014. This set out a long-term vision for England's motorways and major roads, a multi-year investment plan to improve the network and create better roads for users, and high-level objectives for the first roads period 2015 to 2020. The strategy made a commitment for £15.2 billion of investment in over 100 major schemes to enhance, renew and improve the major roads network.

Planning for the second RIS post-2020 is currently underway involving the DfT and Highways England. Strategic road investment will be expected to achieve a number of the government's objectives, key among which is a geographical rebalancing the UK economy and reducing economic growth inequalities at the national level. This is reflected in Highways England's recent Strategic Economic Growth Plan (2017).¹

In order to inform the identification of interventions that are most likely to boost economic performance and support balanced growth across the economy, the DfT and Highways England have commissioned Frontier Economics to carry out a comprehensive review of the best available published evidence to address four particular questions:

1. How can investments in major roads generate increases in economic performance?
2. How can such economic performance contribute to the development of economic agglomerations, or clusters?
3. How can economic impacts from roads investment support balanced growth across the UK?
4. How do these impacts vary depending on the type of road investments including intra- and inter-city roads, and area characteristics such as urban and rural areas, and the composition of skills and sectors within areas?

To address these questions, this report provides a critical review of:

- the theoretical literature on the channels through which major road investments can contribute to economic performance;
- the empirical research on the nature and magnitude of potential impacts; and
- ten case studies which examine the impacts of major road investments in the UK and overseas.

As the focus here is economic performance, other important effects of road investments are outside the scope of our review. In particular, the potential impacts on the environment or social outcomes, and the role of road investments

¹ Source: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/600275/m160503_the_road_to_growth_Our_strategic_economic_growth_plan.pdf

in promoting resilience of the transport system against sudden disruptions such as flooding, are not addressed here but are of course critical for policy makers to account for in decision-making.

Economic framework

We have carried out a review of theoretical literature, empirical studies and case study material to develop an understanding of the channels through which the economic outcomes arising from improvements to major roads typically manifest.

The purpose of this report is to provide policy makers with a clear understanding of the evidence relating to each of those channels; and to describe the conditions under which gains in economic performance through those channels are more likely to be observed.

It is useful to recognise that some of these gains in economic performance will be experienced as direct effects on people and firms as users of the transport network; others will be indirect non-transport-user effects. This is important in the context of considering how these effects can be observed and measured in order to inform investment decisions. Venables et al (2014) articulate three types of economic performance effects which are useful to reiterate here:

- **User benefits:** these refer to the direct effects of a road investment on road users. They include the monetised changes in ‘generalised’ cost including time or vehicle operating costs (such as fuel or vehicle maintenance) for both new users of the road and existing users. Where these cost savings accrue to business travellers and freight, this would be a direct boost to economic performance because, all else equal, output would rise (more output can be produced for a given cost because travel costs have reduced). These benefits are of particular importance to the strategic road network (SRN), which carries the majority of business and freight travel. The RIS1 economic analysis carried out by DfT identified that 56% of user benefits (£22.6bn in total) accrued directly to business and freight, therefore lowering costs and prices to consumers and increasing output. Such benefits filter into the economy through various channels, which are described in more detail in section 2.3.1.
- **Productivity effects:** changes in output per person can occur for all firms and workers in the area affected by the road investment, whether they use the road themselves or not. We refer here to productivity effects arising as a result of the increased proximity of firms and workers to each other because of the lower costs of travel. These productivity effects are indirect non-transport-user benefits. They are therefore additional to the benefits that would be measured through the assessment of direct user benefits because they are ‘externalities’, i.e. proximity of firms creates benefits to other firms that exceed their own private benefit.
- **Investment and employment effects:** in response to a road improvement, some firms may change their location and investment choices, and this in turn affects employment opportunities. The improved road could make an area more attractive to business investment. Such changes occur over time and contribute to the economic performance of

an area through the additional investment or employment itself, but also reinforce productivity effects as described above because they can increase the density of economic activity. It is however possible that investment may also flow away from a dense economic and productive area toward a less productive area, if a particular firm assesses the benefits to itself from doing so (such as lower rent or lower costs of accessing customers) exceed the cost of moving, including the potential productivity loss (relative to if it had not moved). It is important to note that from a national perspective, new investment in one area following a road improvement may simply represent displaced activity from another area in the country, and not necessarily new investment for the economy as a whole. In this case there would be no net gain – economic activity has simply shifted².

Each of the individual channels below delivers one or more of these types of impacts on economic performance. As shown in Figure 1, all of the impacts on economic performance flow from benefits to road users, whether existing or new users. Without these, the other impacts cannot be realised.³ These user benefits can have a direct impact on GDP, as in the case of freight and business travellers, or have an indirect impact on GDP through labour market effects, as in the case of the benefits arising for commuters.⁴

In terms of their scale, measures of direct user benefits⁵ are perhaps more straightforward to assess and would be expected to reflect the majority of benefits; other measurement techniques are needed for impacts that are realised through other indirect channels which are external to road users (such as the productivity benefits associated with the agglomeration channel). Some channels would include a mixture of direct and indirect effects⁶.

² The net impact depends on the extent to which economic activity has simply been displaced from one area to another, and the extent to which productivity of the two areas differs.

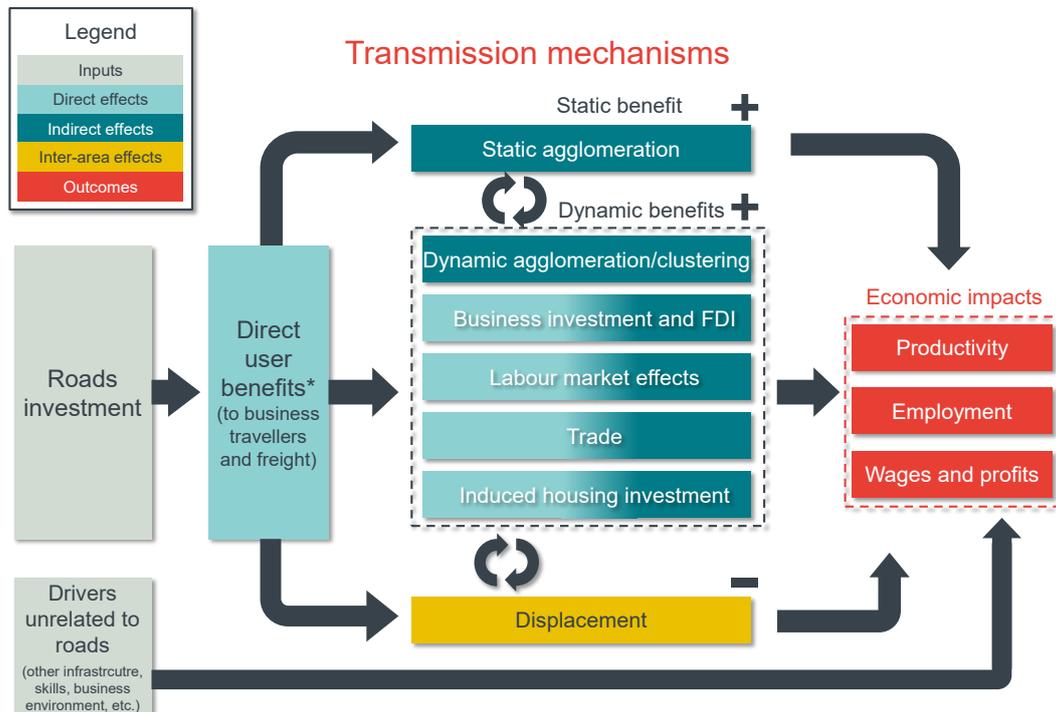
³ Some benefits may be to new users who haven't used a road before, and not to existing users – such as the increase in a road's capacity.

⁴ Faster travel times for commuters are not in themselves a GDP benefit, but they are a necessary condition for labour market effects to filter through the economy as they affect accessibility to jobs.

⁵ Direct effects are those that would mostly be captured in level 1 of the DfT 2016 wider economic impacts consultation, section A2.

⁶ As an example, consider the trade channel. When a new road is built, firms face lower costs of moving goods and services (the direct user benefit); this can lead to increased output (direct effect through the trade channel and already captured in user benefits), which in turn can lead to increased competition or specialisation in the area (indirect effect through the trade channel).

Figure 1 Channels through which investment in major roads can impact on economic performance



Source: Frontier Economics

Notes: Benefits to commuters are not a direct measure of a change in economic performance but they are a pre-condition for labour market effects.

Some of the channels assume no change in the location of firms or workers (so are 'static') and others result from changes in the location of firms and workers (so are 'dynamic').

The channels are:

- Agglomeration and clustering.** Road improvements bring people, firms and places *effectively* closer together (even if they do not in fact move), which increases the occurrence of activities and behaviours that boost productivity. Greater effective proximity enables more sharing of resources and risks, better matching between workers and firms, and more opportunities for learning.⁷ This can then lead to dynamic agglomeration or clustering over time as firms and workers move in response to changes in travel costs and the consequent productivity changes.
- Business investment and FDI.** In response to reduced transport costs, productivity benefits may incentivise firms to invest in those areas - both to take advantage of the productivity benefits themselves and through the signal that major road investments provide to investors. This inflow of capital could be both in the form of foreign direct investment (FDI) or

⁷ In this review, we define agglomeration as the 'static' agglomeration benefits that arise for any given structure of the economy (that is, they do not rely on changes to the composition or location of workers and firms), which corresponds to the definition of 'static clustering' in the DfT 2016 wider economic impacts consultation. This includes between-industry agglomeration ('urbanisation') and within-industry agglomeration ('localisation'), as well as clustering of similar functions across different industries ('functional agglomeration').

domestic businesses opening and/or expanding. Such investment may change the structure of the local economy.⁸

- **Labour market effects.** Employment opportunities may open up and workers may be attracted to an area due to shorter commuting times or the benefits of increased agglomeration and investment (for example higher wages and access to a wider variety of goods and services, if these are not outweighed by high housing costs). Individuals could also be attracted back into the labour force.
- **Trade.** Reduced travel times and increased reliability may increase trade opportunities between areas in the UK; whilst improved access to airports, ports and major transport hubs may also increase international trade. Firms may re-locate to exploit these opportunities. Higher levels of trade may lead to higher levels of specialisation,⁹ and in addition, increased competition between firms may drive efficiency, increase output and reduce prices to consumers.
- **Induced housing investment.**¹⁰ Reduced travel costs that result from a road improvement can make areas that are now more accessible more desirable in which to locate for workers and businesses. Where the land is already used for housing, this could increase house prices and encourage developers to supply more housing if planning policies permit. Or it may contribute to changes in land use, such as from brownfield sites to housing or commercial use.
- **Displacement.** For the channels above that lead to changes in the location of firms or workers, although there are likely to be *local* improvements in economic performance, there may not be an overall national improvement in economic performance if gains in one area are at the expense of others¹¹. This effect is little understood.

These channels interact and can be self-reinforcing. For example, agglomeration effects which lead to gains in productivity can attract new business investment which further reinforces agglomeration.

Importantly, the channels through which changes in economic performance may arise following a road improvement should not be considered in isolation. **The wider local economic context and policy environment are critical factors in the extent to which road improvements can deliver changes in economic performance.** The absence, or inadequacy, of complementary infrastructure or policy could hinder the economic gains that the road improvement could otherwise offer.

⁸ It is also possible that in response to a road improvement, some firms may move out of a more productive dense economic area to a less productive area if that particular firm assesses the benefits it would gain from the move (to take advantage of lower rents and lower costs of accessing customers given the road improvement) exceed the costs of moving (including the lost productivity). The net effect on local economies would depend on the composition of firms who move into, stay or leave the area.

⁹ In effect, firms in specific areas concentrate on producing goods and services in which the distribution of resources there gives them a comparative advantage relative to other areas.

¹⁰ This could also apply to other forms of investment that are dependent on road infrastructure, such as regeneration-related investments in office space or public infrastructure (schools, hospitals etc).

¹¹ This would be most likely if there are constraints on the availability of labour (such as in areas with high employment).

Observations

The available evidence base we have examined, although limited in some respects, has allowed us to identify several conditions under which changes in economic performance are more likely following investments in major roads.

It is essential to note that the potential to impact on economic performance is highly context-dependent and requires an understanding of the specific features and characteristics of the local economy where the road investment is taking place.

The available evidence suggests the following:

- **User benefits** are the immediate results of road improvements and their existence is a necessary pre-condition for the other channels to materialise. User benefits can both directly increase economic performance (as is the case with user benefits to business and freight travellers); or facilitate wider benefits to occur (as is the case with benefits to commuters acting as a pre-condition for labour market effects).
- **Agglomeration benefits:** existing evidence suggests that these benefits are likely to be highest from investments that lead to improvements to roads within cities (particularly if those cities have a high concentration of service-sector firms); and improvements to roads connecting cities that are already relatively close by. This is for two main reasons. Firstly, service-sector firms engage in more activities for which proximity and agglomeration are important drivers (such as sharing knowledge or ideas). Secondly, cities represent a larger base of economic activity so even small productivity (output per worker) improvements can have large overall effects given the total number of workers¹².
- **Business investment and FDI** is likely to occur following a road investment for firms dependent on logistics, or firms in the manufacturing sector. This is because these firms depend heavily on road travel times and reliability for the efficiency of their business. High-technology firms and firms which depend on face-to-face contact who can all exploit agglomeration economies would also be more likely to invest in response to a road improvement.
- **Labour market effects** (i.e. labour supply decisions and labour mobility) interact strongly with the other channels. For example, labour market changes can be perhaps more readily observed when business investment increases (to allow the creation of new jobs) and where appropriate housing is available (for workers).
- **Trade effects:** Increased investment on the SRN makes it possible to exchange goods and services at lower cost between areas. This allows productivity gains to be realised from specialisation in production because firms have the opportunity to trade more and concentrate on producing goods and services in which the area has a comparative advantage. These impacts are more likely to occur near local and international

¹² Evidence on the potential for improvements to long-distance connections to contribute to agglomeration effects is currently very limited.

transport hubs like ports and airports, and in areas with a high share of heavy manufacturing, due to the link between domestic and international trade, and to manufacturing firms' sensitivity to transport costs. These impacts could potentially be significant, although there is much that is still not well understood about this channel.

- **Induced housing investment** can be 'unlocked' by road improvements, by addressing bottlenecks or congestion that may otherwise constrain development. But this also requires other complementary factors to be in place, notably amenable local planning policy.
- **Displacement** is poorly understood. The potential for displacement would depend on a range of factors such as the extent of 'spare' capacity in the local economy (e.g. available workers with the required skills); or the nature of trade of businesses affected (whether they trade domestically or internationally). In general, local economic change cannot be interpreted as national economic change unless certain very specific economic conditions are observed.

Policy implications

A number of key observations can be made the evidence, as follows:

1. User benefits to business, freight or commuters are a critical pre-condition for gains in economic performance to be realised.

Road user benefits to business and freight directly translate into reduced costs and increased output and productivity. These benefits are particularly important on the SRN which carries the majority of business and freight travel. These user benefits are also a pre-condition for the realisation of benefits to the economy through other channels such as agglomeration, business investment and FDI, labour market and trade effects and induced housing investment.

User benefits for commuters are also important. Although they do not directly count towards gains in economic performance, they are a necessary pre-condition for other channels to be realised, notably labour market effects.

Unless user benefits are realised for business, freight or commuters, gains in economic performance therefore cannot follow. This suggests that policy makers should target strategic road investment where there is currently (or a high likelihood of future) high demand from those users and where there are constraints on economic activity arising from congestion or unreliability, the relief of which would benefit business, freight or commuter travellers.

2. It is critical to consider policy interdependencies to realise the full economic potential of investment in roads.

Adequate major road infrastructure is a necessary but not sufficient condition for gains in economic performance to be realised. The adequacy and extent of complementary policy and local drivers of economic performance (such as housing, skills etc) are also critical factors. This suggests that because responsibility for these policies is often split across national and local government, a co-ordinated approach to investment decisions by national and local policy makers, as well as private investors, is needed so that policy

interdependencies can be accounted for and opportunities to deliver gains in economic performance can be maximised.

The importance of policy interdependency also suggests a valuable role for local authorities to co-ordinate with Highways England in the development of local economic plans, where strategic roads may play an important role in facilitating gains in local economic performance.

3. Local economic conditions are critical to understand.

The scale of potential contribution to economic performance is highly context specific. Important factors include the composition of local businesses; the skills composition of the local labour force; local policies that could facilitate or act as a barrier to gains in economic performance being realised; travel conditions in the local urban centres; geographical location of economic activity (density); the adequacy of complementary infrastructure; etc.

This suggests that to inform investment decisions, an in-depth understanding of the local context surrounding any proposed road investment is essential.

4. Future-proofing road investments.

The contribution to economic performance of road improvements is dependent on local economic conditions, as explained above. However, because those conditions can change over time – such as if changes in technology or other factors fundamentally change the composition of economic activity away from sectors that are reliant on transport – there are risks to the ability of the road to deliver anticipated gains in economic performance.

This suggests that investment decisions should be informed by exploring:

- A number of feasible future scenarios relating to the economic composition of the relevant areas, along with the implications for potential travel demand (with a particular focus on business, freight and commuters); and
- An assessment of the risk that the anticipated gains in economic performance are exposed to changes in the economic activity of any particular sector or sectors.

5. Costs are essential to consider

Although the focus of this study has been the channels through which gains in economic performance are likely to materialise, the costs of investment are a critical element of the decision-making process about where to invest.

6. Unintended consequences, particularly displacement

Investments in major roads have the potential to boost economic performance in a number of ways. However, there is a risk of unintended consequences: namely that a boost to economic performance in one area holds back other areas in a way which would be contrary to government objectives. This suggests that policy makers need to be mindful of the potential trade-offs between achieving gains in economic performance that may be at the expense of other areas, and the potential for conflict across government objectives (notably economic efficiency and social equity).

Evidence gaps and suggested future research

Our evidence review has revealed the following gaps.

Ex post evaluation evidence

There is a shortage of robust ex post evaluation evidence of road interventions.¹³ A particular gap relates to the lack of evaluation evidence on the impacts on economic performance of long-distance intercity road investments.

Extensive evaluation activity is already undertaken by Highways England in the form of the Post Opening Project Evaluation (POPE) of major schemes. Although this programme was neither intended nor designed to deliver in-depth evaluation of economic outcomes, this programme could be reviewed to identify where it could add additional value in terms of filling important evidence gaps. In particular through:

- **Scheme level evaluation:** the feasibility of enhancing the evaluation programme for selected schemes to include an improved assessment of the impacts on economic performance could be considered (where delivering gains in economic performance is a key objective); and
- **Programme level evaluation:** every 10-years or so, a larger-scale evaluation exercise could be carried out to assess the extent to which the investments delivered through the RIS have delivered gains in economic performance.

Given the evidence gaps, there would also be significant value in systematically carrying out more **qualitative research with businesses** to understand key factors such as:

- The drivers of their location or investment decisions;
- Their degree of responsiveness to road investments; and
- Their perceived alternative choices: if they were not located where they are now, what else would they have done.

Such evidence would be valuable to inform any interpretation of quantified evaluation evidence, but it could also helpfully inform assumptions used in land-use transport interaction (LUTI) modelling.

Land use transport interaction modelling

Transport modelling techniques and capability continue to advance at a rapid pace. In particular we note that Land Use Transport Interaction models (LUTI) have expanded in use considerably in recent years. Given the importance of such models in underpinning major investment decisions, there is value in carrying out research to:

- **Validate input assumptions:** these models aim to capture the dynamic aspects of a local economy and the interactions with transport. But there is relatively limited evidence available to inform some of the required input

¹³ This was also a key finding in “Strengthening the Links between Appraisal and Evaluation” Frontier (2016b) https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/540733/strengthening-the-links-between-appraisal-and-evaluation.pdf

assumptions, such as those relating to business location decisions. Research to increase the evidence base to inform key assumptions would therefore be valuable.

- Validate outputs: given the increasing role of such models in transport appraisal, it will be increasingly important to find ways to validate the forecasts produced by such models so that accuracy can improve over time.

Data

There are some fundamental gaps in the evidence base currently available to policy makers that, if filled, would support improved decision making with respect to road investments. For example:

- SRN usage: data on who uses the trunk road network, how and when they use it would be valuable to inform ex ante and ex post analysis; and
- Inter-regional trade: little information exists on domestic inter-regional trade but this would be valuable to inform decisions about how the trunk network could be better equipped to support this important activity.

2 INTRODUCTION

2.1 Background and policy context

The Road Investment Strategy (RIS) 2015-2020 was published by the Department for Transport (DfT) in December 2014. This set out a long-term vision for England's motorways and major roads, a multi-year investment plan to improve the network and create better roads for users, and high-level objectives for the first roads period 2015 to 2020. The strategy made a commitment for £15.2 billion of investment in over 100 major schemes to enhance, renew and improve the major roads network.

Planning for the second RIS post-2020 is currently underway involving the DfT and Highways England. Strategic road investment will be expected to achieve a number of the government's objectives, key among which is a geographical rebalancing the UK economy and reducing economic growth inequalities at the national level. This is reflected in Highways England's recent Strategic Economic Growth Plan (2017).¹⁴

In order to inform the identification of interventions that are most likely to boost economic performance and support balanced growth across the economy, the DfT and Highways England would like to ensure they have a robust evidence base to draw on. They have therefore commissioned Frontier Economics to carry out a comprehensive review of the best available published evidence to address four particular questions:

1. How can investments in major roads generate increases in economic performance?
2. How can such economic performance contribute to the development of economic agglomerations, or clusters (defined as concentrations of interconnected businesses, suppliers, and associated institutions within or across cities)?
3. How can economic impacts from roads investment support balanced growth across the UK?
4. How do these impacts vary depending on the type of road investments including intra- and inter-city roads, and area characteristics such as urban and rural areas, and the composition of skills and sectors within areas?

2.2 Objectives and scope of evidence review

The purpose of this evidence review is to provide the DfT and Highways England with a better understanding of the transmission channels through which road investments can potentially lead to improved economic performance, and the conditions under which this is more likely.

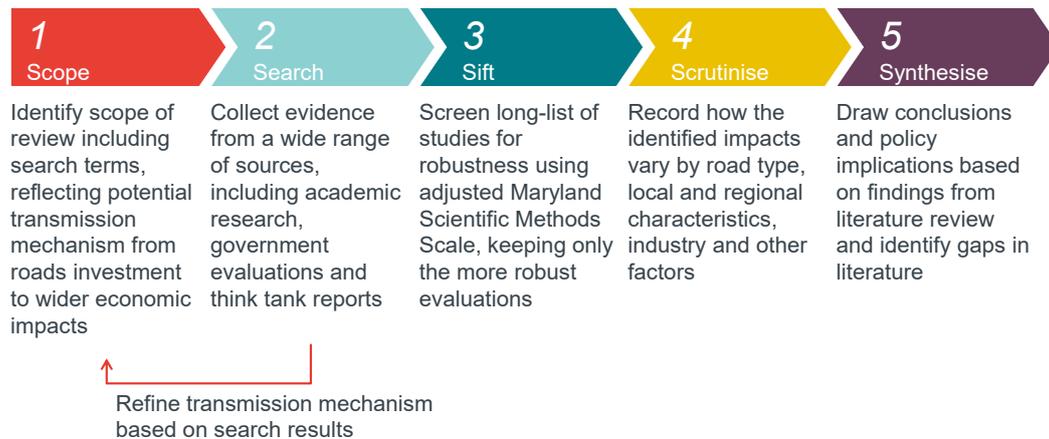
¹⁴ Source: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/600275/m160503_the_road_to_growth_Our_strategic_economic_growth_plan.pdf

The report provides a critical review of both the theoretical literature on the channels through which road investments can lead to improved economic performance and the empirical research on the nature and magnitude of impacts. To ensure our review meets a rigorous standard, we draw only on peer-reviewed theoretical papers, empirical evaluations that use robust econometric techniques to identify causal effects (as opposed to correlations) between road investments and economic performance,¹⁵ and reputable meta-analyses of empirical evaluations. We also present ten case studies from the UK and overseas to demonstrate the available evidence relating to real major road schemes. These case studies are based on independent qualitative and quantitative research reports, academic literature, US research databases and post-opening project evaluations (POPE) commissioned by Highways England.

As this report aims to review the available published literature, we have not conducted new data collection and research. The focus is on literature relating to major roads (though many of the findings are likely to be valid for considering the impacts of improving local roads); where relevant we complement our findings using evidence on other modes of transport. We have omitted 'macroeconomic' literature, for example, that which treats transport as just another form of capital investment. In addition, such macro-based analysis is not able to reflect the nuances that are important to understanding the impacts of interventions at the local level (for example, local policies or local economic characteristics). We have also focused on available ex post evidence and analysis as opposed to ex ante modelling analysis, such as studies that use computable general equilibrium models. This is because those models are complex so the underlying assumptions interactions are often opaque, so it can be challenging to understand what the key drivers of particular results are.

To conduct the literature review, we used a five-step process (Figure 2). This builds on the methodology used by the What Works Centre for Local Economic Growth (WWG) in its evidence review of transport interventions (WWG 2015), with more emphasis on how impacts vary by road type and economic geography. The proposed methodology is broadly in line with Government Social Research Service guidelines on conducting Rapid Evidence Assessments.

¹⁵ For example, research using instrumental variables, local and individual fixed effects, natural experiments and/ or evaluations using a robust counterfactual corresponding to level 3 on the Maryland Scientific Methods Scale (What Works Centre for Local Economic Growth 2015).

Figure 2 Methodology for conducting literature review

In addition, we have sought the advice and input of several leading academic experts at numerous stages throughout the drafting process. These include Professor Stephen Gibbons (Director of the Spatial Economics Research Centre at the London School of Economics), Tom Worsley CBE (visiting fellow at the Institute of Transport Studies in Leeds) and Professor Alain Bonnafous (Emeritus Professor of the University of Lyon). We are grateful to them for their valuable input. We are also grateful to Professor Peter Mackie of the Institute of Transport Studies in Leeds for his valuable peer review comments.

We are aware that any overview of empirical literature can be subject to publication bias, meaning researchers or journals may tend to publish positive results disproportionately. There is evidence that a small positive publication bias exists in the agglomeration literature (see Melo et al. 2009), and unfortunately there is no robust way to account for this. However, we aim to be pragmatic and cautious in our interpretation of the evidence.

The review covers the plausible channels through which road improvements may contribute to improved economic performance and clustering, and covers the full range of the 'wider economic impacts' as defined in the DfT 2016 wider economic impacts consultation, alongside those in the guidance on supplementary economic modelling. That is, the channels highlighted in this review capture what is assessed under levels, 1, 2 and 3 of DfT 2016 wider economic impacts consultation.

Where possible we include empirical evidence relating to each channel; however in many cases the available literature on a particular channel, and the conditions under which it is likely to be material, is limited.

The focus of this study is economic performance. The impacts of major road investments on the environment and social outcomes are of critical for decision-makers to account for, but these are outside the scope of our work so should be considered through separate analysis.

Another economic benefit of road investments not explicitly included in our framework is the potential to improve the resilience of the transport system more widely. This can be particularly important in areas which are susceptible to

sudden disruptions, for example the case of flooding, or if there are interdependencies with other infrastructure systems, the failure of which could affect the performance of the road network. In such areas, ensuring sufficient capacity on the road system and/ or increasing the availability of alternative routes can minimise the cost of delays and disruptions caused by such events, and can therefore be seen as an economic benefit. The role of the strategic roads network in promoting resilience is discussed in other reports, for example the Transport Resilience Review (DfT 2014).

2.3 Channels through which major road investments can deliver improved economic performance

This section sets out an economic framework for the channels through which road improvements may lead to enhanced economic performance; the interactions between the different channels; and the interactions with non-transport policies that are critical to recognise given their potential to enhance or inhibit gains in economic performance and the development of clusters. First however, we outline the economics behind those effects which is important when considering how they can best be measured, and if they are additional (i.e. above and beyond what would have happened anyway without the intervention).

2.3.1 The underlying economics

The role of a transport appraisal is to estimate all of the costs and benefits of the intervention, relative to the case without the intervention, such that an overall assessment of value for money can be made to inform investment decisions. Our focus here is on the impacts on economic performance of investing in strategic roads. As noted above, environmental and social impacts are of course critical for decision-makers to account for, but this particular evidence review is focusing on economic impacts only, i.e. productivity, employment and output (GDP).

In this context, changes in economic performance must be measured. To capture all of these effects, it is useful to recognise that some of these effects will be experienced as direct effects on people and firms as users of the transport network; and others will be experienced as indirect non-user effects. Venables et al (2014) articulate three types of effects which are useful to reiterate here:

- **User benefits:** these refer to the benefits to those using the road – whether existing or new users. They reflect the monetised changes in ‘generalised’ costs which include time or vehicle operating costs, fuel or vehicle maintenance. Where these benefits accrue to business travellers and freight, this would be a direct boost to economic performance because, all else equal, output would rise (the same outputs can be delivered at lower cost because travel costs have reduced). In practice, a substantial proportion of user benefits that are estimated from a major road investment are accounted for by benefits to business and freight users. This is because not only do these travellers place a higher value on their time saved than other travellers, but importantly, most business and freight journeys are made on the SRN (for example, two thirds of all freight travel

takes place on the SRN). To illustrate what this means for user benefits, the RIS1 economic analysis carried out by DfT identified that 56% of user benefits (£22.6bn in total) accrued directly to business and freight. These user benefits are therefore a core part of the benefits of road improvements as they provide a direct gain to economic performance as well as acting as a pre-condition for the other channels of economic impact. Benefits to commuters are also important because they are a necessary pre-condition for labour market effects to arise over time following a road improvement.

- **Productivity effects¹⁶**: these refer to the changes in output per person that can arise for all firms and workers in the area affected by the road investment, whether they use the road themselves or not. These effects arise as a result of the increased proximity of firms and workers to each other because of the lower costs of travel. Such increased proximity facilitates a range of effects which are described below but all stem from increased accessibility of firms and workers to markets and to each other. These proximity productivity effects are additional to the benefits that would be measured through the assessment of user benefits because they are 'externalities', i.e. proximity of firms creates benefits to other firms that exceed their own private benefit.
- **Investment and employment effects**: this refers to the change in the location and investment choices of firms and hence employment opportunities, in response to a road improvement. Such changes can occur over time and contribute to the economic performance of an area through the additional investment or employment itself, but can also reinforce productivity effects as described above. It is however possible that investment could also flow away from a dense economic and productive area toward a less productive area, if a particular firm assesses the benefits to itself from doing so (such as lower rent and the lower costs of accessing customers) exceed the cost of moving including the potential productivity loss. The overall effect on the local economy would depend on the net change in business activity and its composition after firms have responded to the road improvement. It is also important to note that from a national perspective, new investment in one area following a road improvement may simply represent displaced activity from another area in the country. In this case there would be no net gain – economic activity has simply shifted.

Unit A2.1 of DfT 2016 wider economic impacts consultation refers to the above three types of impacts on economic performance as level 1: direct user benefits with no change in firms' or workers' location decisions; level 2: productivity effects with no change in firms' or workers' location decisions; and level 3: investment and employment effects with changes in firms' or workers' location decisions.

All of these effects can be measured through their impact on local or national Gross Domestic Product (GDP). We focus on the impacts on GDP because this is what the relevant literature focuses on. We describe below some of the

¹⁶ This refers to productivity effects arising from proximity.

channels through which the impacts of a road improvement percolate to the economy.

Transmission channels

On the basis of evidence reviewed, we articulate below a framework that presents the transmission channels through which investment in strategic roads that deliver user benefits in turn deliver gains in the performance of the wider economy.

Some of the channels assume no change in the location of firms or workers (so are 'static'). Others result from changes in the location of firms and workers (so are 'dynamic'). As shown, all of them flow from changes in user benefits to business and freight (or commuters) - without these, the other impacts cannot be realised.

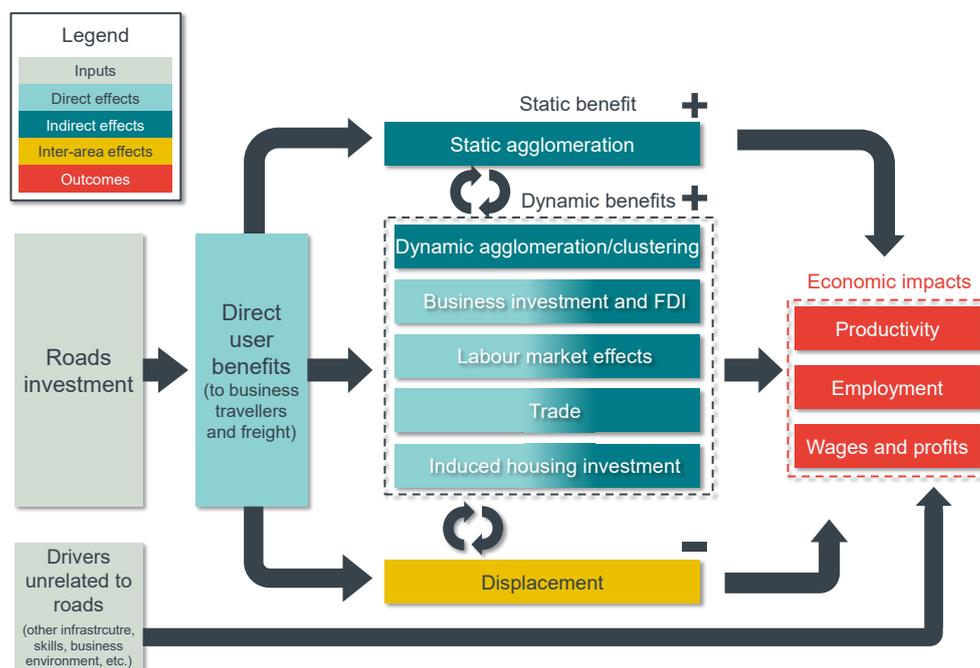
In terms of their scale, measures of direct user benefits¹⁷ are perhaps more straightforward to assess and would be expected to reflect the majority of benefits; other measurement techniques are needed for impacts that are realised through other indirect mechanisms which are external to road users (such as the productivity benefits associated with the agglomeration channel). Some channels would include a mixture of direct and indirect effects.¹⁸

The channels are summarised in Figure 3 below.

¹⁷ Direct effects are those that would mostly be captured in level 1 of the DfT 2016 wider economic impacts consultation, section A2.

¹⁸ As an example, consider the trade channel. When a new road is built, firms face lower costs of moving goods and services (the direct user benefit); this can lead to increased output (direct effect through the trade channel), which in turn can lead to increased competition in the area (indirect effect through the trade channel).

Figure 3 Channels through which investment in major roads can impact on economic performance



Notes: Benefits to commuters are also a pre-condition for other channels to be realised, notably labour market effects but are not shown in the 'direct user benefits' box as they do not directly contribute to economic performance.

The channels include:

- **Agglomeration.** Road improvements bring people, firms and places effectively closer together, which increases the occurrence of activities and behaviours that boost productivity. Greater proximity enables more sharing of resources and risks, better matching between workers and firms, and more opportunities for learning. In this review, we define agglomeration as the 'static' agglomeration benefits that arise for any given structure of the economy (that is, they do not rely on changes to the composition or location of workers and firms), which corresponds to the definition of 'static clustering' in the DfT 2016 wider economic impacts consultation. This includes between-industry agglomeration ('urbanisation') and within-industry agglomeration ('localisation'), as well as clustering of similar functions across different industries ('functional agglomeration'). We also refer to dynamic agglomeration/ clustering which results from changes in the location decisions of firms and workers.
- **Business investment and FDI.** In response to reduced transport costs, productivity benefits may incentivise firms to invest in the area of the road improvement - both to take advantage of the productivity benefits themselves and because of the signal that major road investments provide to investors. This inflow of capital could be both in the form of foreign direct

investment (FDI) or domestic businesses opening and expanding. Such investment may change the structure of the local economy.¹⁹

- **Labour market effects.** Employment opportunities may open up due to the increased accessibility of more jobs; and workers may be attracted to an area due to shorter commuting times or the benefits of increased agglomeration and investment (for example higher wages and access to a wider variety of goods and services, if these are not outweighed by high housing costs). Individuals could also be attracted back into the labour force. It is also possible that some workers would upskill.
- **Trade.** Reduced travel times and increased reliability may increase trade opportunities between areas in the UK, whilst improved access to airports, ports and major transport hubs may also increase international trade. Firms may re-locate to exploit these opportunities. Higher levels of trade may lead to higher levels of specialisation, and increased competition between firms may drive efficiency and reduce prices to consumers.
- **Induced housing investment.**²⁰ Reduced travel costs that result from a road improvement can make areas that are now more accessible more desirable to locate in for residents and businesses. Where the land is already used for housing, this can be expected to increase house prices and encourage developers to supply more housing if planning policies permit. Or it may contribute to changes in land use, such as from brownfield sites to housing or commercial use. Where bottlenecks or congestion are inhibiting development, road improvements can ‘unlock’ such investment, provided other complementary factors are also in place.
- **Displacement.** For the channels above that lead to changes in the location of firms or workers, although there are likely to be *local* improvements in economic performance, there may not be an overall national improvement in economic performance. This would be true if changes in economic performance in one area are achieved at the expense of other areas (such as if firms have simply re-located from one area to another). Displacement can therefore be seen as a negative economic impact of road improvements for the areas in which investment, labour and/ or trade is displaced.²¹

It is worth noting the terminology used in this review with respect to agglomeration. As we mention above, agglomeration benefits as defined above represent the benefits to productivity that arise without any changes to the economic structure of the local area, that is, without any changes to the composition of firms or workers in an area. This corresponds to the definition of ‘static clustering’ in the DfT 2016 wider economic impacts consultation and the

¹⁹ It is also possible that in response to a road improvement, some firms may move out of a more productive dense economic area to a less productive area if that particular firm assesses the benefits it would gain from the move (to take advantage of lower rents and lower costs of accessing customers given the road improvement) exceed the costs of moving (including the lost productivity). The net effect on local economies would depend on the composition of firms who move into, stay or leave the area.

²⁰ This could also apply to other forms of investment that are dependent on road infrastructure, such as regeneration-related investments in office space or public infrastructure (schools, hospitals etc).

²¹ This may not necessarily mean reducing the absolute level of economic activity in the “displaced” area, but rather a relative impact, compared to a counterfactual level of economic activity.

'proximity effect' in the TIEP report (Venables et al. 2014), and has variously been called 'first-order' or 'place-based' agglomeration benefits in other papers (see for example Frontier Economics, 2016 and Overman et al. 2009). We make clear when we are referring to dynamic agglomeration or clustering, in which firms or workers change their location over time in response to a road improvement.

Some studies have identified potential benefits to the economy arising from the employment associated with the construction of transport schemes²². In keeping with Treasury guidelines, these are not considered 'additional'²³ because such employment is likely to represent displacement from another area of the economy rather than necessarily new employment.

2.3.2 Reinforcing loops and the dynamic development of clusters

The transmission mechanisms described above can interact with each other to form a positively reinforcing loop. For example, gains in economic performance generated by (static) agglomeration economies may increase wages in an area, whilst increased trade may improve the range of goods and services available and reduce prices to consumers. The promise of higher wages and consumption benefits may induce skilled workers to relocate to the area, which may in turn induce existing businesses to expand and new businesses to open (this would all be part of dynamic agglomeration). This agglomeration of firms and workers may drive further gains in economic performance, giving rise to a virtuous cycle of agglomeration, labour market changes, investment, trade and induced investment.

There are many ways in which positively reinforcing loops can arise, and the hypothetical scenario described above is only one example. The key is that when such loops arise, this can lead to the formation of a new cluster of economic activity, or in the regeneration of a 'left-behind' area. Neighbourhoods can get stuck in a low-level trap, in which individuals and firms do not find it worthwhile to invest on their own (Venables et al. 2014). By acting as a catalyst for development, road improvements have the potential to contribute to the breaking down of low-level traps in deprived regions and contribute to rebalancing the national economy.

2.3.3 Interdependencies with other drivers of economic performance

Transport is only one of many drivers of economic performance. The extent to which road improvements are able to increase economic performance is dependent on the presence and adequacy of other drivers (see Figure 4).

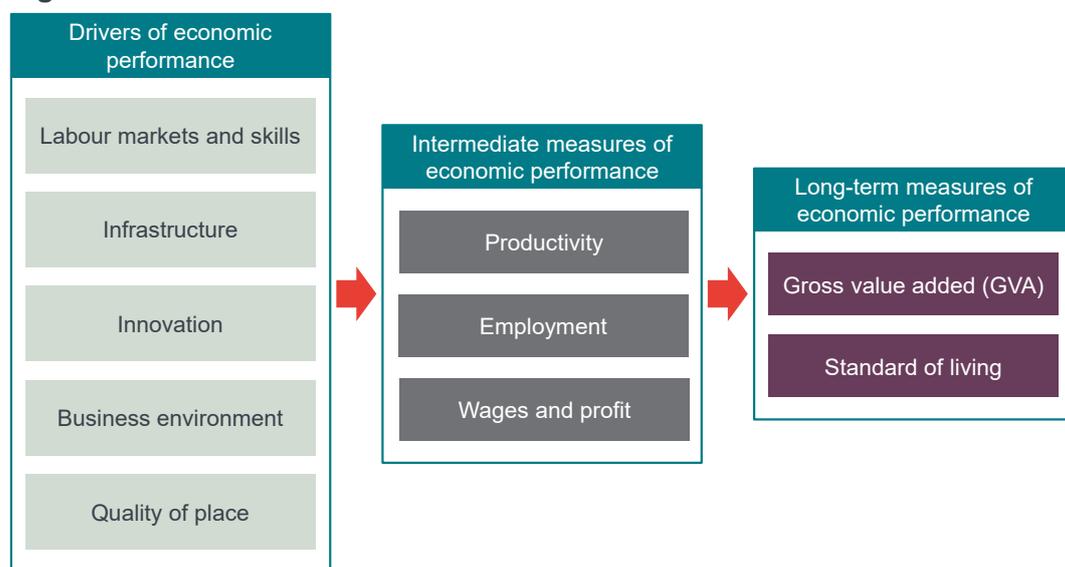
A large and growing body of evidence on urban growth identifies a number of relevant factors, including education and skills; a favourable business environment; attractive amenities and natural environment ('quality of place'); housing and other forms of infrastructure (Aghion et al. 2013, Berube et al. 2006,

²² See for instance <https://www.gov.uk/government/publications/hs2-strategic-case>

²³ In the sense that such employment would have been deployed elsewhere had it not been for the road project.

City Growth Commission 2014 and Gibbons et al. 2009). Whilst (static) agglomeration benefits can arise without any changes to the structure of the economy, other (dynamic) channels depend on individuals and firms changing their behaviour and location, which in turn are influenced by factors other than transport. For example, workers may not choose to relocate to an area with improved road links if local amenities are inadequate, or if they cannot find good schools for their children, and/ or if housing constraints mean that gains from relocation are eroded by higher housing costs. Similarly, road improvements may not induce businesses to invest in an area without a favourable business environment, for example a skilled labour force and/ or high-quality digital infrastructure.

Figure 4 Drivers of Economic Performance



Source: Frontier Economics

When supporting drivers are in place, transport interventions can have a significant economic impact, as shown by London's Jubilee Line Extension. In this case, the impact of the transport scheme on regeneration in the Docklands area was boosted by the establishment of a Development Corporation with planning powers, favourable business rates that attracted investment, as well as access to London's skilled labour pool and deregulation in the financial sector which increased the size of the sector in the UK (Eddington 2006). Conversely, a lack of non-transport drivers of growth can hinder the development of economic clusters. For example, a survey of senior executives cited in the Eddington Transport Study indicated that whilst transport infrastructure featured heavily in business location choices, the availability of qualified staff, business environment, office space and the quality of life were also considered 'absolutely essential' for a substantial proportion of respondents (Eddington 2006).

Furthermore, the impact of strategic and other major road investments will depend on the quality of intra-city connectivity. This is because many SRN journeys start and/or end in an urban area, so in these cases, the door-to-door experience depends on the quality of transport networks within those urban areas. In addition, improvements in SRN links may increase traffic volumes within cities. Unless intra-city networks are adequate, the impact of the SRN road

improvement could be dampened. This highlights the importance of appropriately representing the urban system in the transport appraisal for a robust analysis of the benefits.

Many of the channels we identify as contributing to economic performance are consistent with Highways England's "The Road to Growth: Our Strategic Economic Growth Plan (2017)."²⁴ Both the Highways England report and this study note the role of road improvements in supporting international connectivity; the interdependencies of road improvements with the housing market; and the need to consider other drivers of growth such as investing in skills to increase employment opportunities.

In our review of the existing literature, we make a note of particularly relevant interdependencies for each transmission channel when considering the conditions under which impacts are most likely. Our case studies further explore interdependencies between roads and other drivers of economic performance, and between major and intra-city roads. So, it is worth bearing in mind the existence of interdependencies throughout the report.

2.3.4 Separating level effects and growth effects

Roads investment, like any other economic stimulus, may potentially:

- have a one-off impact on the *level* of economic performance in an area ('**level effect**'); or
- cause a sustained change in the future trajectory and pace of economic growth (a '**growth effect**').

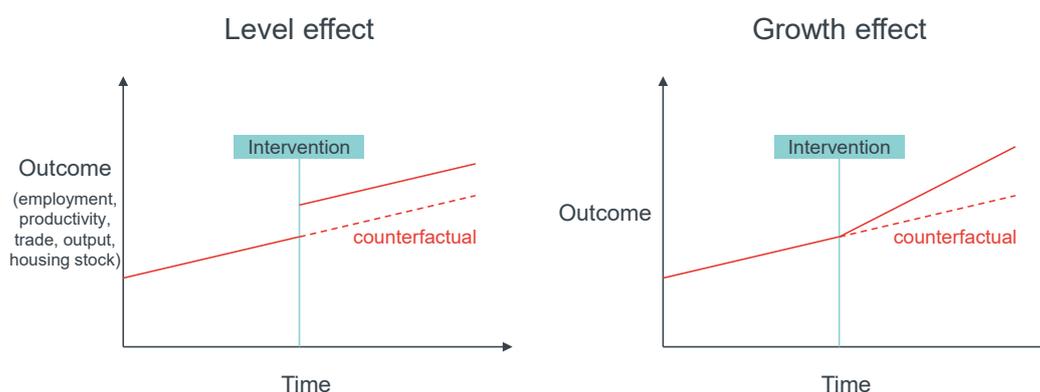
Growth effects represent a more fundamental change in the way an economy operates because it implies the rate of change in economic activity becomes ever greater over time. However, these are quite rare and theoretically only occur when there is a transformational change to the way production technology improves over time.

The effects we discuss in this report are largely 'level effects' which increase the level of the variable of interest (output per person, employment, etc), and that increase persists over time, but not necessarily its rate of growth (so for example, productivity may be 1.5% higher than it would otherwise be in each future year). See Figure 5 for a simplified graphical illustration.

When drawing policy conclusions from the literature, it is also useful to remember that the ability of a road intervention to achieve a level or a growth effect (or both) will depend on the other channels and local or national policies.

²⁴

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/600275/m160503_the_road_to_growth_Our_strategic_economic_growth_plan.pdf

Figure 5 Levels effects vs. growth effects

2.3.5 Future-proofing roads investment

The effectiveness of road investments also depends on their ability to cope with unexpected future events. These considerations are out of the scope of this report, but may affect the incentives to invest in certain strategic roads, or impact the scale of potential benefits. They fall into three main categories.

- **Resilience.** Some roads are more at risk than others to catastrophic events such as floods, other extreme weather events or other forms of major disruption. Having adequate alternative options for road users to make their journey as a result of investment in improved roads can add to the resilience of the transport system. This could be an additional benefit that would not typically be captured in standard transport appraisal methods.
- **Technological progress.** The increasing use of ‘smart’ technology in road infrastructure systems means they are becoming more interconnected and interdependent.²⁵ For example, smart motorways that use technology to actively manage the flow of traffic means that the effectiveness of those roads is not only dependent on the road itself, but also on the energy and communications systems on which the smart technology relies. This poses a risk to the efficiency of the road (and hence its potential benefits to road users) if those ‘smart’ systems fail or are not reliable.
- **Robustness.** Any roads investment must account for future scenarios of economic and demographic development, and these can have large degrees of uncertainty. For instance, when investing in roads that would be expected to offer benefits to particular industries, it is worth keeping in mind that industry mixes may change over time in unpredictable ways. A robust investment in this context is one which is expected to give rise to substantial benefits in a number of scenarios or through a number of channels, and will still be effective if the local economic composition were to change.

²⁵ See HM Treasury’s [“Valuing infrastructure spend: Supplemental guidance to the Green Book”](#)

2.4 Structure of the report

The report is structured as follows.

- **Chapter 3** sets out the evidence on each of the channels through which road improvements can generate changes in economic performance, including the theoretical principles; empirical estimates of the impact in the UK and other developed countries; and the conditions under which those effects are more likely.
- **Chapter 4** presents several case studies of major road investments in the UK and other countries, drawing on multiple sources (both qualitative and quantitative) wherever possible to explore the factors that enhance or constrain the realisation of gains in economic performance.
- **Chapter 5** draws together findings from the literature review and case studies to convey policy implications for considering investments in strategic roads.
- **Chapter 6** discusses gaps in the available evidence and recommends directions for future research.

3 EVIDENCE FROM LITERATURE

This chapter sets out the evidence on the different economic benefits or disbenefits from road investments. These include direct user benefits to business and freight travellers resulting from reduced journey times and increased reliability; and the impacts in the wider economy that flow from these direct benefits (or from the user benefits to commuters²⁶) through the channels set out in section 2.3. Each section focuses on one of the channels, and provides an overview of its theoretical basis, empirical evidence and the conditions under which each is most likely to be observed.

This chapter is structured as follows:

- Section 3.1 covers user benefits;
- Section 3.2 covers agglomeration;
- Section 3.3 covers investment;
- Section 3.4 covers labour;
- Section 3.5 covers trade;
- Section 3.6 covers induced housing investment; and
- Section 3.7 covers displacement.

After discussing the evidence for each channel, we infer from the literature several conditions under which a specific channel's effects are most likely. However, in many cases these conditions are based on deductions on our part and it is helpful to keep in mind that there is little direct evidence targeted at answering these questions.

3.1 User benefits

Major road interventions can result in benefits to business and freight travellers by reducing journey times such by easing congestion. They can also result in increased certainty about delivery times through greater reliability of the network. These reductions in journey times represent a reduction in the cost of doing business for those business and freight travellers. In most markets this would then lead to higher profits, lower prices and higher output²⁷.

Reliability also impacts on costs and profits because firms can operate more efficiently. This is because they are less likely to, for example, miss shipping deadlines, and they can manage their supply chain more effectively. These reliability benefits are on top of time savings (the evidence base for measuring reliability benefits is currently building).

The majority of business and freight travel takes place on the SRN and the benefits to these users form a core part of the overall benefits of improving

²⁶ Benefits to commuters are a precondition for benefits to arise through the labour market channel, but they are not in themselves a direct benefit to the economy.

²⁷ See the Annex for diagrams for how this cost reduction affects the price and quantity of what firms produce.

strategic roads. The RIS1 economic analysis carried out by DfT identified that 56% of user benefits (£22.6bn in total) accrued directly to business and freight.

These user benefits therefore make a direct contribution to economic performance, and are also a pre-condition for the channels described below to be realised. Benefits to commuters are also a pre-condition for some of the channels to be realised, though do not in themselves count towards measures of economic performance.

The channels through which road improvements can impact on the wider economy are described below.

3.2 Agglomeration

By bringing people, firms and places effectively closer together, road improvements have the potential to increase the occurrence of productivity enhancing behaviours and activities usually associated with city size and density. These productivity gains resulting from increased proximity are referred to as agglomeration economies. This section surveys the theoretical mechanisms through which agglomeration economies occur, the role of major road improvements in driving agglomeration, the empirical evidence on the magnitude of agglomeration economies and the way in which impacts vary according to area characteristics and the nature of road investments. As explained earlier, the focus of this chapter is mainly on ‘static’ agglomeration benefits, also termed ‘static clustering’ in the DfT 2016 wider economic impacts consultation and the ‘proximity effect’ in the TIEP report (Venables et al. 2014), which can arise without any changes to the number of individuals and firms in an area or their composition. Note that the agglomeration impact from a one-off change in economic density is usually assumed to imply a one-off, though not necessarily immediate, productivity improvement.²⁸ These ‘static’ agglomeration benefits are effects on the level of output in the economy, and do not necessarily have any implications for long run growth rates. The dynamic agglomeration or clustering effects, in which firms and workers change their location decisions, are however also discussed where we discuss clustering or localisation of firms.

3.2.1 What is agglomeration?

Agglomeration economies arise when individuals and firms benefit from physical proximity to one another. Economists have long studied the various ways in which proximity increases the productivity of individuals and firms. These can be grouped into mechanisms arising from *sharing* resources and risks, *matching* individuals and inputs to firms, and *learning* through interactions with others (Duranton and Puga, 2004).

²⁸ A productivity improvement is a boost to the level of output, given the production inputs or equivalently, a reduction in inputs and hence costs for a given level of output. Productivity improvements are usually thought of in terms of Total Factor Productivity (output from all basic inputs), labour productivity or wages, assuming workers are paid in relation to their productivity.

Sharing

Agglomeration through sharing occurs when large numbers of firms are able to draw upon a common pool of resources to produce goods and services more efficiently. One such mechanism is the sharing of indivisible facilities, which allows firms to benefit from economies of scale. Traditionally this mechanism has been used to describe the sharing of infrastructure such as water services, ports or airports. In the context of high-tech clusters, it can also be applied to sharing access to universities or commercial labs. There is research on how Silicon Valley and Boston became important centres for innovation in part because of their proximity to Stanford University and MIT (Saxenian 1994, Lee and Nicholas 2012); a similar example in the UK is the growth of high-tech clusters around Oxford and Cambridge.²⁹

A second mechanism for agglomeration economies through sharing arises from firms having access to a greater variety of intermediate inputs, which increases their productivity. Gibbons et al. (2009) give the example of PC manufacturers having access to a wider range of disk-drives, processors, memory chips and other components in large cities, which enables them to produce more and better features. Entrepreneurs in Silicon Valley may similarly benefit from a wider range of specialised services including patent attorneys, angel investors and venture capitalists (Carlino and Kerr 2015). A related mechanism is the ability of firms to specialise in larger markets, thereby benefiting from economies of scale; this is discussed in detail in the section on trade below.

In addition, firms in large markets are able to benefit from sharing risk. Firms with access to large resource pools are better able to adapt their output level to unpredictable rises and falls in demand, which increases their average productivity over time. Gerlach et al. (2009) adapt this model to innovation: in their model, R&D is seen as a process that leads to uncertainty in demand (as it may or may not be successful). The ability to share risk means that firms in clusters are more likely to invest more in research and development, which leads to higher levels of innovation in these clusters.

Matching

Agglomeration also increases productivity by increasing the number and quality of matches between firms and workers. It is easier to find jobs in larger markets, which results in smaller proportions of unemployed workers and unfilled vacancies. The quality of matches is also improved by agglomeration, due to the larger number of options available and the ability to be more selective as the opportunity cost of waiting for a prospective match declines (Berliant et al. 2006). Individuals are able to move between jobs more easily in larger markets or clusters, as evidenced by job hopping and earnings dynamics in Silicon Valley (Fallick et al. 2006) and in the software publishing industry (Freedman 2008).

Whilst mechanisms involving matching have traditionally been applied to the labour market, they can also be applied to matching inputs to firms more

²⁹ The *learning* mechanism also occurs in such cases, and there is certainly an overlap between the two. When the sharing is of an information-related resource, it can enhance the learning that is happening between firms and within firms.

generally. For example, Helsley and Strange (1991) develop a model in which immobile capital must be matched with entrepreneurs, and is allocated more efficiently in larger markets.

Learning

The final group of agglomeration mechanisms relates to the diffusion of knowledge.³⁰ The fact that face-to-face contact is conducive to learning is well recognised by firms in knowledge-intensive industries; for example, Google and Pixar have structured their offices to maximise interaction between employees (Carlino and Kerr 2015). Larger markets and clusters provide more opportunities for face-to-face interactions and random meetings, which increase productivity by enabling individuals to learn from one another. They also allow firms to learn about new or existing technologies, taking cues from the behaviour of other firms to infer the benefits of potential investments. However, whilst the benefits of agglomeration for learning are intuitive, the theoretical literature on learning mechanisms is relatively limited compared to sharing and matching mechanisms.

The benefits of proximity for learning could in some cases be permanent, so that increased agglomeration affects the rate of productivity growth over time (not just the level of productivity at the point of increased agglomeration). This could occur if knowledge and skills acquired in large markets remain with individuals and firms even as they move to less agglomerated markets, or if the rate of knowledge accumulation depends directly on proximity to other skilled workers.

Variations in the nature and scale of agglomeration economies

The precise mechanisms through which proximity drives productivity will depend on the composition of individuals and firms in the area. For instance, sectors relying on highly specialised labour may benefit more from the matching mechanism, whereas manufacturing sectors may benefit more from sharing indivisible facilities and a greater variety of intermediate inputs. The learning mechanism is likely to be particularly important for individuals and firms that gain more from knowledge, such as high-skilled workers and high-tech firms.

Agglomeration economies may arise between firms in different industries (commonly referred to as ‘urbanisation’ in the literature), or be restricted to firms within the same industry (‘localisation’). The latter provides a justification for the development of industrial clusters. The extent to which firms benefit from proximity to similar firms (as opposed to larger markets in general) depends on the way in which sharing, matching and learning mechanisms operate within and between sectors. In particular, whether they are able to benefit from sharing the same resources and labour pool, and the extent to which knowledge spillovers occur across different industries.

Each mechanism will have an impact at different spatial distances. We would expect learning through face-to-face interactions to occur within short distances, and sharing mechanisms to perhaps extend over longer distances. In

³⁰ The generation of knowledge (innovation) is sometimes also grouped under the ‘learning’ category. In this review we have grouped innovation with sharing, as it relies on sharing mechanisms (for example sharing inputs or risk, as discussed above).

one of the few empirical papers to distinguish between the three groups of agglomeration mechanisms, Rosenthal and Strange (2001) demonstrate that this is the case for US manufacturing firms: agglomeration economies through learning occur only at the zipcode (post-code) level, whereas resource and input sharing occurs at the state level. The effectiveness of efforts to increase agglomeration will therefore depend on the composition of firms and individuals, along with the spatial scale under consideration. This is explored further in section 3.2.3.

3.2.2 How can road improvements drive agglomeration?

By reducing travel times from one place to another, road improvements reduce the effective distance between places. This is termed ‘static clustering’ in the DfT 2016 wider economic impacts consultation and the ‘proximity effect’ in the TIEP report (Venables et al. 2014): it refers to the fact that given their geographical location, individuals and firms in cities with better road links will have access to more economic activity, and therefore benefit from more sharing, matching and learning activities and behaviours that drive productivity. Importantly, such benefits are ‘static’ in that they arise for any given composition of existing workers and firms in an area.

Graham (2007) finds that road congestion significantly limits such agglomeration benefits in highly urbanised areas, so addressing congestion can serve to unlock productivity gains with no changes to the spatial distribution of economic activity. For example, based on his estimates a 5% reduction in travel times across Greater London would have a similar effect on productivity as increasing the total number of jobs in Greater London by 5%.³¹

If road investments can change the behaviour of firms and individuals over time in a way that causes them to locate in a more concentrated way (for example, if improved roads into a city centre drives more investment and attracts workers into the centre), they can generate further agglomeration economies. This is related to the ‘cluster effect’ discussed in the TIEP report (Venables et al. 2014), and captures elements of ‘employment effects’ and ‘induced investment’ in the DfT 2016 wider economic impacts consultation. Increasing the concentration of workers and investment will benefit the local economy directly, and have an additional positive effect through ‘dynamic’ agglomeration economies.

Part of the driver behind these dynamic effects is lower transport costs for firms, and part could be increased productivity due to static agglomeration. In any case, these dynamic effects will be self-limiting due to the offsetting costs associated with congestion and rents, which will rise unless developers are allowed to build more and can earn a profit by doing so.³² As with static agglomeration, dynamic agglomeration effects do not necessarily therefore imply any impact on long run growth in the standard urban economic models.

The available evidence primarily relates to agglomeration resulting from relatively short distance road improvements. Improvements to long distance roads can also

³¹ Graham (2006) finds that a uniform reduction in travel times in the capital by 5% would increase productivity by 1.0%, whilst a 5% increase in employment would increase productivity by 1.3%.

³² The same process which limits the sizes of towns and cities in the absence of planning

facilitate agglomeration where they allow cities to specialise in the production of goods and services in which they have a comparative advantage. This is the subject of the trade section and is not considered here.

The empirical discussion below focuses on ‘static’ agglomeration benefits, which increase productivity with no change to the composition of the local economy. The range of ‘dynamic’ effects, which can generate further agglomeration benefits, are discussed in detail in the sections on investment, labour, trade and induced investment below. It is worth bearing in mind the potential for positively reinforcing loops between the channels, which create the potential for road improvements to act as a catalyst for regeneration and the development of new economic clusters.

There is a further potential effect that could arise: where road investments are in roads into a major urban centre or cluster, this could lead to some re-location of firms or businesses to the periphery of that cluster (for example, where rental prices may be cheaper). This could lead to dis-agglomeration in the urban centre. The extent to which this would be likely in any particular area would need to be explored empirically.

3.2.3 Empirical evidence of agglomeration economies

Empirical studies of agglomeration economies typically estimate the change in productivity arising from changes to the accessibility of an area. Accessibility can be understood as the access that individuals and firms in the area have to economic markets. It has variously been called ‘market access’, ‘market potential’ and ‘effective density’ in the literature. The accessibility of a city is often measured in terms of ‘effective density’, which refers to the sum of economic mass (typically employment) that can be accessed from that city, taking account of the cost of accessing these areas (in terms of generalised transport costs,³³ travel times or distance). It is generally assumed in the literature that the productivity gains of increased accessibility can be replicated by improvements in roads and other modes of transport, which reduce travel times and associated costs of transport, and therefore increase accessibility for any given spatial distribution of economic activity.³⁴

Average impact of increased accessibility

A recent study by Overman et al. (2009) estimates that increasing accessibility by 10% by reducing the generalised costs³⁵ of road travel, for example by reducing driving times or fuel costs, would increase local productivity by 0.7% (using average wages as a proxy for productivity). Looking at specific road links, they find that a 10% reduction in driving times *between* Manchester and Leeds city regions could increase average wages by 0.05% in Manchester and 0.06% in

³³ 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.

³⁴ For a detailed discussion of estimation methods applied to transport investments, see Frontier Economics (2016).

³⁵ Details on the way in which generalised transport costs are defined can be found in the annex to the paper (Overman et al. 2009).

Leeds. A 10% reduction in driving times *within* both city regions could increase average wages by 0.22% and 0.17% respectively. It is worth noting that in the case of inter-city improvements the individual-level effect is estimated to be larger for Leeds than for Manchester, since as a smaller city Leeds has more to gain from access to the economic mass of the larger city (however at the city-level, aggregate gains may still be higher for Manchester due to its larger population size). In contrast, in the case of intra-city improvements the effect is larger for Manchester than for Leeds given its higher density of employment.

Whilst these figures look modest, the context is that labour productivity in the North of England has remained essentially unchanged since 2000 (ONS 2015). The estimated gain from a 10% reduction in driving times between and within Manchester and Leeds could correspond to an additional £23 million and £81 million of economic activity per year respectively in the two city regions. This estimate does not include the potential impacts on surrounding areas, which would be affected by reduced travel times into and across Manchester and Leeds.³⁶

The estimate of 0.7% by Overman et al (2009) is consistent with, if slightly higher than, other recent estimates from the UK which estimate the productivity increase arising from a 10% increase in overall accessibility at 0.4-0.6% (see for example Gibbons et al. 2009, Graham and Melo 2009, Fingleton 2008 and Gibbons et al. 2012). The higher estimate by Overman et al. (2009) may be due to its focus on roads: in the same paper, Overman et al. (2009) estimate that increasing accessibility by reducing rail travel times by 10% increases productivity by only 0.3%.³⁷

In general, estimates of agglomeration economies from the UK are higher than those from other European countries³⁸. Recent studies from France, Italy, Spain and Sweden have estimated the first-order impact of accessibility improvement on wages at 0.1-0.2% (see for example Andersson et al. 2014, Puga and de la Roca 2012, Mion and Naticchioni 2009 and Combes et al 2008a and 2008b).³⁹

Variations in impact by area characteristics

The estimates above capture the average effect of increasing accessibility across a wide range of cities, sectors and individuals. The impact of any particular scheme may diverge substantially from the average. In particular, the magnitude of benefits depends on the sector and skills composition of the targeted areas and the current distance between those areas.

Meta-analysis by Melo et al. (2009) shows that on average, across a large number of countries and time periods, agglomeration economies tend to be

³⁶ For example, a reduction in Manchester-Leeds driving times would also benefit individuals travelling from Liverpool to York.

³⁷ However, this may also reflect the unit of analysis used, as their estimates for rail were based on travel times between local authorities, whilst their estimates for road were based on travel times between wards. It is unclear to what extent the estimates reflect differences between modes or the spatial unit of analysis.

³⁸ It is worth noting that elasticities are based on observed productivity and measures of effective density. The methodology used in the regressions will affect the size of the elasticity as will the existing economic geography.

³⁹ See Frontier Economics (2016) for a summary of estimated elasticities in the UK and other European countries.

stronger in service industries than in manufacturing industries. Recent studies from the UK show that producer services (such as finance, professional services and other business services) benefit up to two times more from increased accessibility than average, and two to four times more than manufacturing sectors (Gibbons et al. 2012, Gibbons et al. 2009, Graham et al. 2009b, Graham 2006). This implies that agglomeration effects of road improvements are likely to be relatively greater when they target areas with high shares of producer services.

Producer services, as well as high-tech sectors like creative/ digital/ media and ICT, further benefit from access to workers and firms within the *same* sector ('localisation') over and above accessibility in general (Gibbons et al. 2009). Innovative activity in particular tends to cluster geographically; for example, Buzard and Carlino (2013) show that R&D activity for most sectors in the US tends to be concentrated in the Northeast Corridor, the Great Lakes, California's Bay Area and Southern California. This suggests that studies on sector-level localisation may understate the true benefits of clustering, if localisation economies arise at a functional level (i.e. when firms perform similar functions to each other, even if they are in a different sector) rather than sectoral level. The overall evidence suggests that road improvements that link areas with high levels of innovation and producer services to create economic clusters is likely to have a positive impact on productivity over and above the general benefits of increased accessibility.

There is considerable European evidence that the gains from accessibility are greater for workers with higher skill levels, whilst workers in routine jobs may not benefit at all (Gould 2007, Andersson et al. 2014, Matano and Naticchioni 2012). However, Overman et al. (2009) find that the impact of increased road-based accessibility in the UK is greatest for intermediate-skilled workers, and similar for high- and low-skilled workers. 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 methods or skills classifications, or to fundamental differences in the distribution of benefits (for example due to the differences in the use of transport infrastructure among socio-economic classes).⁴⁰

Finally, the impact of accessibility depends on the distance between the areas that become better connected as result of the road improvements. Graham et al. (2009b) show that agglomeration economies decline rapidly with distance from the intervention (referred to as 'spatial decay'). Based on the standard form of agglomeration index and parameters inferred from previous work, the effect of a given reduction in travel time is directly proportional to the original length of the journey.⁴¹

The study also shows that spatial decay is substantially more rapid in service sectors than in the manufacturing sector, which is consistent with the finding that learning mechanisms operate only at short geographical distances (Rosenthal

⁴⁰ In the US, the biggest effects from interstate highways may be on areas that are already somewhat urbanised (see Rephann and Isserman 1994); this is discussed further in our case studies.

⁴¹ For instance, a 5-minute reduction from an original a travel time of 30 minutes will have double the agglomeration impact compared to a 5-minute reduction from an original travel time of 60 minutes. The authors use an economy-wide spatial decay parameter of 1.7, and estimates from this study are used in the WebTAG guidance on transport appraisals (DfT 2014).

and Strange 2001). Note that a less rapid spatial decay implies that the impact on agglomeration of a given time reduction is more evenly distributed i.e. even those relatively distant from the city centre still have some benefits.⁴² The difference between the impact of changes in time at long relative to short baseline journey times is also less marked when the spatial decay is flatter, for instance in manufacturing. All of these results suggest that road improvements are likely to be most effective in generating agglomeration economies, for a given journey time reduction, when they improve links between areas that are already relatively close together, for example by reducing commuting times into the city centre.⁴³ Conversely, improving road links between two cities that are far apart will be less likely to generate benefits from agglomeration.

Note these are all implications of specific modelling assumptions and understanding the relative benefits requires weighing the specific industry composition in an area and their potential sensitivity to accessibility improvements. Other things being equal, this evidence suggests that road improvements would offer the highest potential productivity gains when targeted at relatively short duration travel into and between major urban centres that specialise in services.

It is worth noting that the precise radius at which agglomeration effects occur and the pace at which they weaken with distance (the 'decay function') are generally empirical questions, and are subject to separate research currently being undertaken by DfT. WebTAG unit 2.1 provides one set of decay parameters for various industry groups (manufacturing, construction, consumer services and producer services), though the UK-specific work of Overman et al. (2009) suggests a slower decay than is advocated in WebTAG. There is some further UK-specific evidence of fast decay in the UK (Rice et al. 2006), with agglomeration benefits declining sharply with distance.⁴⁴ Analysis in relation to the High Speed 2 rail scheme notes that "...transport journey time changes will have the largest effect on connectivity when they occur in ranges where travellers appear to be more sensitive to changes in cost" (KPMG, 2013). This implies that a marginal change when the cost of travel is already expensive is not likely to change behaviour and connectivity as much as when the cost is a little lower and people are more sensitive to travel cost changes.

Ultimately, this question is highly context-specific and the literature appears insufficiently developed to be able to suggest a threshold above which agglomeration effects dissipate rapidly. Most evidence points to effects decaying in a continuous manner. Furthermore, the idea that improving connections between relatively distant urban areas can still have agglomeration benefits is consistent with WebTAG principles.⁴⁵

⁴² The difference between the impact of changes in time at long relative to short baseline journey times is also less marked when the spatial decay is flatter. For example, with a spatial decay of 1, the effect on agglomeration of a 30 minute reduction on 1 hour is only 1.5 times as big as the effect of a 30 minute reduction on 2 hours (2 versus 1.33).

⁴³ For example, a 10 minute reduction on a journey time of 50 minutes within a city (a 20% reduction) into the centre of a city will evidently have a bigger impact than a 10 minute reduction on a 100 minute journey between cities (a 10% reduction).

⁴⁴ This study see benefits sharply after 40 minutes and disappearing entirely after 70 minutes, but these are presentational thresholds only, and the underlying change in agglomeration benefits is a continuous one.

⁴⁵ See WebTAG unit 2.1.

3.2.4 Inferred conditions under which agglomeration effects are more likely

Taken together, the above evidence suggests that road investments are likely to be more effective in improving economic performance through agglomeration under several conditions. However, it is worth keeping in mind that these conditions point toward the most economically efficient outcomes but not necessarily the ones most desirable from a policy or equity standpoint. As an extreme example, even if road improvements bring the biggest benefits in London (albeit at a high investment cost), that does not mean investment should be avoided in other areas.

Inferred conditions under which agglomeration effects are more likely are:

- **Large and productive areas.** Because agglomeration increases productivity (output per worker) by a given percentage per worker, the aggregate gain from improved road links will depend on the size of markets affected and their initial productivity levels. In particular, large and productive areas are likely to benefit most from agglomeration in absolute terms because there are more workers who each increase their productivity. This suggests that targeting road improvements at relatively dense, productive urban centres within 'left-behind' regions is likely to be more effective for rebalancing economic performance across regions in the national economy, than targeting rural and less productive areas within those regions. In particular, investments in large cities outside London are likely to achieve higher agglomeration effects while helping to rebalance the economy.

This is partly because of the direct effect on the productivity of the urban centre, but also because the less-productive remainder of the left behind region will potentially benefit from increased access to the urban centre. In terms of inter-city roads between a smaller and larger city, individual workers in the smaller city are likely to individually gain more on average from access to the larger market than vice versa, though the aggregate effect on the city as a whole may be lower for the smaller city due to its smaller population. However, it is worth noting that in urban centres improvements to public transport and interchanges between transport modes should also be considered, both in their own right, and as a way to ensure the potential benefits from improved strategic roads are not constrained due to urban congestion.

- **Producer services and innovative sectors.** Road investments that improve links between, or within, areas that specialise in finance, professional services and business services are likely to achieve higher benefits from agglomeration. This is partly because these sectors are already more productive so percentage gains have bigger aggregate impacts. Further, firms in service and innovative sectors are usually thought to respond more to agglomeration economies, and in particular to

'localisation' benefits from better access to firms in the same sector or performing the same function ('knowledge spillovers').

- **Skilled labour force.** The international evidence suggests that high-skilled workers are more likely to benefit from agglomeration than workers in low-skilled or routine jobs. Whilst there is little evidence on skills from the UK, this is consistent with the above finding on producer services and innovative sectors.
- **Baseline travel times.** Agglomeration effects are usually assumed to operate with a constant 'elasticity' i.e. a 1% increase in agglomeration produces a fixed % increase in productivity (this ignores the decay parameter). Given the usual assumptions about the way travel times translate into agglomeration, this implies that a 1 minute reduction in average journey times of 10 minutes has the same economic impact as a 10 minute journey time reduction on average journey times of 100 minutes (other things equal). Therefore, improvements which entail a general speed improvement have the same impact regardless of the baseline travel times. However there may be cases where improvements are most effectively targeted at areas with shorter initial journey times because it is potentially easier to realise a given percentage journey time reduction when starting from a smaller base. Any assessment of where best to target improvements would, however, have to take into account the costs of delivering the anticipated journey time reductions in the different settings. These arguments rest on assumptions about the precise relationship between journey times, agglomeration and productivity which have not been robustly explored in the literature.

3.3 Business investment and FDI

Road improvements which ameliorate travel conditions and reduce the costs of doing business within an area can make that area more attractive for investment. This may take the form of new firms being set up, but could also be the expansion of existing businesses or investment in plants and operations from outside the area or country.

Business location and investment decisions are based on a number of factors. According to a comprehensive review of the relationship between firm location and transport by McQuaid (2004), surveys of businesses indicate factors include: access to and cost of key inputs (such as raw materials or intermediate goods); access to domestic and international markets; social and cultural factors; and physical and digital infrastructure (including transport).

Transportation costs make up only a very small proportion of firms' total costs on average – usually less than 5% (McQuaid 2004). As such, direct reductions in transport costs through improvements to roads would be unlikely to bring about large changes in business investment for some firms. Transport is of course much more important to some businesses, however. In this section we seek to understand how increased business investment can be driven by improvements in road infrastructure; the empirical estimates of the scale of this potential

increase; and the conditions under which road investments are more likely to lead to increased business investment.

3.3.1 How can road improvements increase investment?

Road improvements can lead to gains in economic performance of an area by attracting business investment. This could be through the direct effects of lowering the costs of doing business in the area; by providing increased access to labour markets (discussed in detail in the following section); or improved productivity through agglomeration (addressed in the preceding section). Increased business investment both contributes to economic performance itself (by increasing the level of economic output of an area – and would therefore be reflected in the measurement of user benefits) but also by reinforcing agglomeration (new/expanded firms increase the economic density of the area – and would therefore be reflected in the measurement of ‘dynamic’ productivity gains after changes in economic composition have been accounted for).

Reduced direct costs of transport

The majority of business and freight travel takes place on the SRN. Where the SRN is improved in an area, this can lower the costs of doing business in or close to that area so businesses may be more likely to expand or move in. This is particularly likely for businesses very dependent on road-related transport. For example export-focused industries for which transport costs are important could see relative cost reductions and a more reliable logistics chain as key factors in their decision making. This is why export firms will often cluster in coastal areas near ports or other areas with good access to international markets. Surveys of businesses reviewed for DfT by Lyons et al. (2009) corroborate this logic, finding that, while firms are unlikely to relocate in response to improved roads, transport provision and accessibility play a role in expansion and the creation of new businesses.

Improved access to inputs as a result of road investment can also be important for businesses. While the firm may not manage the delivery of inputs directly, improved accessibility will likely be priced in to the overall costs of production.

In the last few decades, Just-in-time (JIT) inventory services have expanded considerably, performing a very important role in a number of manufacturing industries. Their service allows manufacturers to either store inputs in a distant (and less expensive) location or to cut down on storage costs altogether by ensuring inputs arrive just before they are needed. The costs (and risks) of a JIT system would be expected to increase when road systems do not allow for reliable and accurate travel time estimates. An extensive business literature on logistics (e.g. Taniguchi et al. 1999, 2001) discusses the fact that it is the reliability of transport systems, not the travel time, which is important to these logistics firms. Sample calculations (Goodwin 2004) show that, as congestion grows (which it is forecast to do), unreliability of travel times will grow *more than proportionally*. As logistics firms respond to this reality and manufacturers respond to the associated risk, the economic costs of congestion to road freight are likely to be more than the value of increased time. The way that road

investments improve and manage reliability and resilience of the road system as a whole will therefore be pivotal to its attractiveness for logistics-dependent investment.

As noted above, these reduced travel costs will be captured in the direct transport user benefits, and not be additional.

Increased attractiveness of areas due to other responses

In addition to the reduction in direct travel costs, firms may respond to other channels of economic growth triggered by improved road infrastructure, potentially creating a positive feedback loop.

First, businesses can be expected to be attracted to the productivity gains resulting from agglomeration economies. As such, the 'static' agglomeration benefits discussed in the previous section can lead to 'dynamic' effects if they encourage businesses to relocate to/ expand in areas with improved productivity, thereby leading to further agglomeration economies.

Second, the availability of appropriately skilled labour is a commonly cited reason behind location decisions (McQuaid 2004). To the extent that improved transport makes a location more attractive to skilled labour, firms may be more likely to follow that process with further investment. The effectiveness of transport infrastructure in attracting skilled labour is covered in more detail below.

Finally, there are high transaction costs to changing business location, which typically rise with relocation distance. This means that when firms decide on locations to expand, start or invest they are taking into account future expectations of profitability. As such, incentives to relocate or expand are not simply a sum of the mechanisms listed above, but a forward looking expectation for how transport costs, market access, agglomeration and labour will change in the future. As discussed by Venables et al. (2014) in the TIEP report, neighbourhoods can get stuck in 'low-level traps' if investment is profitable only when other firms invest, but no firm wants to be the first mover. By committing to long-term investment in a way that affects the entire local geography, investments in strategic and major roads can act as a signal to investors, raising expectations about future prospects for the area and potentially breaking such coordination failures. Where this is the case, major road improvements can act as a catalyst for improved economic performance.

Where investment is able to reinforce dynamic agglomeration effects, these benefits would be additional to transport user benefits.

3.3.2 Empirical evidence of the impact of road improvements on investment

The impact of road improvements on investment has been studied in a number of ways. First, there is a large body of literature on the role of transport in informing firm location decisions, which provides evidence of the direct impact of road improvements on firms through reducing transport costs and increasing reliability. Second, literature on the impact of agglomeration on driving investment, in particular foreign direct investment (FDI), provides evidence on the way in which

road improvements can induce investment indirectly through other channels. Finally, research on the impact of transport investments and economic activity provide an indication of the overall impact of transport on business output, though these studies do not allow us to distinguish between impacts that arise through ‘static’ agglomeration economies and impacts arising (either directly or indirectly) through investment.

The role of transport in firm location decisions

The review by McQuaid (2004) for the Department for Transport provides a thorough overview of the drivers of business location decisions and in particular the role of improved transport in the decision-making process. This study establishes that transport can affect business location through the financial cost of transporting goods; time costs; reliability of travel time; the costs of physically meeting customers and suppliers; and staff and customer travel costs. Importantly, it finds that empirical estimates of the importance of transport in location decisions are low on average, especially relative to other factors like labour quality and availability. The Lyons et al. (2009) review finds that only 1% of businesses cite transport or accessibility as the most important factor in determining location choice.

McQuaid (2004) also finds that for some sectors it is not direct transport costs to the business which primarily determine location decisions, but more prominently access to logistics companies and service-sector firms that allow for lower cost supply chains (such as Just-In-Time delivery of inputs, or distribution to consumer markets). The same “strategic networks” allow for the increased suburbanisation and ruralisation of some types of business for whom there is less need to access the large, concentrated pools of labour found in cities. There is, however, no currently available empirical research linking the availability of logistical services to investment location decisions.

A study of the establishment of new firms in Portugal (Holl 2004) found that plant birth was affected positively within 10km of new motorways for most sectors, though the effect was largest for primary industries.⁴⁶ The share of new manufacturing firms within 10km of motorways increased at a much higher rate than the share of new service sector firms, which is likely to be due to the greater reliance on transport by manufacturing firms. Gibbons et al. (2016) found that road improvements also affected the establishment of new firms in the UK; in particular, a 10% improvement in accessibility resulting from road construction led to a 3% increase in the number of businesses up to 30km from the site of improvement. Research from the Netherlands also suggests that proximity to transport infrastructure is a significant driver of firm location choice (De Bok and Sanders 2005). It is worth noting however that a study by Garcia-Mila and Montalvo (2013) found no impact of national road capacity on the total number of firms in Spain.

⁴⁶ Industries that focus on obtaining or providing raw materials, such as mining, agriculture or forestry.

Drivers of foreign direct investment (FDI)

A separate branch of evidence concerns the geographic decisions of foreign companies when choosing where to invest. This literature can help to elucidate the drivers of location decisions facing investors in general; however, it is also of direct interest as FDI is less likely to detract from other areas of the UK than forms of domestic investment, and is therefore more likely to lead to additional gains to the UK economy as a whole (see the displacement section below for a more detailed discussion). This research focuses on the impact of agglomeration on FDI, rather than specific evaluations of road improvements; as such, it is assumed that agglomeration benefits caused by roads investment will have similar effects.

Much of the literature focuses on the drivers of foreign investment across different states in the US. States compete strongly for direct investment from foreign companies. Strategies include tax breaks, subsidies, investment and direct encouragement by state governments. The result is policies supportive of business growth in a number of states in an effort to establish manufacturing bases. A study by Head et al. (1999) examines the determinants of Japanese firms investing in manufacturing across different states. They show significant effects from agglomeration over and above various pro-investment policies pursued by state governments. This indicates an important role for road improvement related agglomeration in attracting investment, both from outside and within the UK.

A study by Guimaraes et al. (2000) investigates the construction of foreign-owned factories in Portugal during the inflow of FDI that followed Portugal's accession to the European Community. The authors use information at a more detailed level than US states, using something closer to county-level information on manufacturing expansion and existing economic characteristics. They find that agglomeration economies are a decisive factor in determining the location of new factories, and that the agglomeration of industry services (tertiary sector) is more important than industry-specific agglomeration. This suggests two conclusions. First, if agglomeration is brought about by road investment, it is likely to be effective in attracting investment. Second, to the extent that road improvements support tertiary sector activity specifically, it is likely to be effective at attracting other forms of investment.

The impact of transport on business growth

Finally, a wide range of studies have attempted to explore the relationship between transport investments and economic activity. By virtue of the way they are constructed, these studies tend to bundle improved productivity (which may arise through 'static' agglomeration economies) with investment decisions. However, they provide general indications into the overall impact of transport investments on business output.

A meta-analysis of the impact of transport investment on output shows that across a large number of studies, a 10% increase in transport capital increases output by an average of 0.6% (Melo et al. 2013). Investment in roads is shown to have a larger impact than other modes of transport, with a 10% increase in roads

capital leading to a 0.9% increase in output, compared to 0.4% for rail and 0.3% for airports. The meta-analysis shows that the impact on manufacturing output is much higher than on output in service sectors, which is consistent with the evidence on firm births above. Combined with the finding that that service sectors benefit more from agglomeration, this suggests that the direct impact of transport investment (for example through direct cost reductions and reliability) is significant over and above the impact through agglomeration, especially for the manufacturing sector. This is consistent with the finding by Duranton et al. (2014) that changes in transport availability encourage firms which produce heavier output to locate around the area affected.

Finally, the meta-analysis shows that estimates tend to be larger in the long run (more than a 5-year horizon), which indicates that impacts on business output take some time to feed through (Melo et al. 2013). The 5-year cut off is a consequence of the way in which Melo et al. (2013) have grouped papers into the meta-analysis, and not a direct result of the data. However, the authors find no significant difference between output elasticities in their “short run” group (under one year) and “medium term” (1-5 years), but do find such a difference when looking at outcomes over five years later. This suggests that the largest effects of transport infrastructure may take years to materialise.

3.3.3 Inferred conditions under which investment effects are more likely

The evidence suggests that the composition of businesses in an area is likely to be important for understanding to what extent road improvements could affect investment and which firms are more likely to benefit. In particular, investments in roads are likely to be most effective at attracting investment from the following types of firms:

- **Manufacturing sector.** Firms in the manufacturing sector, in particular firms producing heavy goods, are likely to be most affected by improvements in road infrastructure. Whilst ‘static’ agglomeration economies are greater for service sectors, transport improvements have a larger effect on overall business output for firms in the manufacturing sector, likely through the impact on transport costs and reliability.
- **Firms with high storage costs and complex supply chains.** Firms which focus on assembly and are concerned about the storage of parts and inputs are a specific subset of manufacturing firms. Firms that depend on ‘Just-In-Time’ services would be expected to be particularly responsive to the prospects of reliable transport infrastructure and the potential for a well-functioning logistics sector. This is an area where expectations around future investment and support are also important: a new road is only an incentive if it indicates road investments will be made in future as demand expands.
- **Areas with a skilled and employable workforce.** A number of studies⁴⁷ address the fact that quality road infrastructure is a necessary, but not

⁴⁷ e.g. reviews for DfT by McQuaid et al. 2004 and Lyons et al. 2009

sufficient, condition for encouraging firm investment. The roads that will be most effective at attracting businesses will be those that “unlock” the economic potential of an area. These areas might include those with centres of knowledge and skill (such as universities) or those which have slack in the labour market.

- **Areas with, or near, a well-developed service sector.** In addition to transport costs and labour availability, firm location is sensitive to the availability of well-functioning tertiary industries, or service sectors.⁴⁸ These services in turn are particularly dependent on the agglomeration benefits of effective density, so could be encouraged to expand their services where there are improved roads.
- **Firms which depend on knowledge, shared inputs and skilled labour.** To the extent that the agglomeration benefits mentioned in the previous section accrue to an area of interest, firms whose output depends heavily on those benefits will be more likely to locate/expand there. This means that high-technology firms, firms which depend on face-to-face contact, and firms with more esoteric potential customers and workers will be more likely to respond to road investment which improves agglomeration.

3.4 Labour

Road improvements, particularly between and within urban areas, can give individuals access to more and better jobs. This was discussed in detail in the agglomeration section above. Over time, road improvements can also provide individuals with the opportunity to change their employment decisions, and in turn potentially change the structure of local economies. This section focuses on these additional labour effects⁴⁹, discussing the theoretical mechanisms through which they could arise as a result of road improvements and the empirical estimates of their magnitude.

3.4.1 How can road improvements change labour behaviour?

Aside from improving matching between workers and firms, road improvements can influence the labour choices of individuals over time in three particular ways: they could relocate in response to lower commuting costs; they could relocate to areas that have been made more attractive through agglomeration, increased investment and other benefits of improved connectivity; or they could invest in their skills so as to exploit the opportunity to access better jobs that are now more accessible for them. Any of these could increase labour supply in a given region or change the composition of the labour market.

⁴⁸ Broadly speaking, primary industries deal in raw materials, secondary in manufacturing and tertiary in services.

⁴⁹ A further effect not discussed here is the net social benefit from attracting workers back into the labour force – this generates a tax effect which would boost national welfare.

Reduced cost of commuting

Transport costs typically account for a substantial share of individual expenditure, both in monetary terms and in terms of time spent commuting. In the UK from 2010-2012, 14% of all household expenditure was on transport, and people on average spent nearly an hour commuting each day⁵⁰ (Redding and Turner 2014). This was the single largest household spending item in the UK after housing, though it has slowly decreased over time from about 16% in 2001 (ONS 2015). Transport costs can therefore be expected to influence individuals' choices on whether, where and how much to work.

Conceptually, individuals trade off wages achievable in different areas with the cost of commuting to those areas (see, for example, Redding and Turner 2014). For any particular wage level, road improvements that reduce travel costs to an area would be expected to make it more attractive to workers. For example, an improvement in the M62 may provide the incentive for individuals living in Rochdale to start working in Manchester, or induce individuals in other towns to move to Rochdale in order to commute to Manchester. The effect of reduced commuting costs may potentially be significant: assuming a 7-hour working day, reducing the daily commute from an hour to 30 minutes would be equivalent to a 7% increase in effective hourly wages.⁵¹ Depending on the responsiveness of labour supply to wages, this could affect not only where workers locate but also whether and how much individuals work, and in which jobs. For example, reduced costs of commuting could provide employment opportunities for the currently unemployed – this would however be subject to the nature of employment opportunities available and the skills of the unemployed.

However, incentives to relocate in response to reduced commuting costs will also depend on the local availability of housing, as any potential gains may be outweighed by rising house prices if housing supply does not respond to increased demand. House price increases can eventually make labour market effects self-limiting, if areas do become substantially more attractive.

Increased attractiveness of areas

Road improvements can also directly increase wages in the targeted area through agglomeration economies or increased investment, as discussed in the previous sections. In turn, this would be likely to attract more individuals into the area. Individuals may also choose to relocate to more accessible cities due to the non-monetary benefits they offer, for example a greater variety of goods and services. However, as above this response might be constrained by housing supply, if there is no slack in the housing market or if new houses are not built to accommodate increases in demand. Naturally, there are also costs associated with individuals' relocation. Research on migration patterns suggests that these

⁵⁰ Note that although commuting times would be expected to affect workers' decisions, changes in commuting times do not in themselves add to economic performance (whereas changes to business travel or freight costs would).

⁵¹ Assuming the value of commuting time is equal to the hourly wage rate. Of course, these are rather implausible road journey time reductions, as the mean time savings from strategic road improvements to the current network are usually in the order of a few minutes.

costs increase with distance,⁵² making transport improvements theoretically relevant for location choices.⁵³

It is worth noting the positive interaction between these channels, as the presence of more workers (in particular skilled workers) generates further agglomeration economies and makes the area more attractive for businesses to invest in.

Incentive to invest in skills

Another important mechanism through which road improvements can drive labour outcomes is by encouraging individuals to invest in their skills. Access to a larger job market increases the potential gains to education. Individuals could therefore respond to improved connectivity by investing more in their education and skills, in order to access more suitable and better-paid jobs.

In the theoretical literature, one example of this mechanism relates to ‘hold-up’ problems. In a model developed by Rotemberg and Saloner (2000), workers in smaller markets who invest in acquiring skills have weak bargaining power with respect to local employers, since they have few options to change jobs without undertaking costly relocations. This therefore reduces their incentives to invest in their skills. In this case, road improvements offering them access to a wider range of employers could mitigate the hold-up problem and encourage individuals to up-skill.

A related model by Kim (1989) posits that workers in less accessible markets would invest in general skills (applicable to a wide range of employers) rather than in specialised skills (applicable to a specific role). In this case, road improvements may encourage individuals to pursue high-productivity and highly specialised careers.

Finally, if a major road construction programme is announced, it is conceivable that there may be incentives to gain skills due to the likely demand from sectors which provide and support smart road technologies.

3.4.2 Empirical evidence

The empirical literature on the labour impacts of road investments follows two main approaches. The first is to directly evaluate the impact of roads infrastructure on population and employment, accounting for reverse causation (the possibility that population and employment patterns can trigger roads investment as well as the other way round), as well as other factors that influence both road construction and labour outcomes (see Combes and Gobillon 2015 for a detailed discussion of estimation methods). The second compares the estimated impact of road improvement-related increases in accessibility (as defined above) with and without accounting for how the characteristics of the local labour market could influence labour market outcomes (the difference in

⁵² See Beine et al. 2015 for a recent review of this literature.

⁵³ However, reductions of the magnitudes typical for road investment schemes are unlikely to be very relevant for the one-off migration decision.

estimated impacts is interpreted as the upper bound of potential labour market responses).

Direct evaluations of the impact of road improvements

The impact of road improvements on the distribution of labour appears to be context-specific and varies greatly according to area characteristics and the road investment in question. However, some general themes can be identified.

US evidence suggests that there is a relatively well-developed literature on ‘rays’ or ‘radial segments’ of interstate highway networks that lead into city centres. The evidence shows that improved road connectivity into the city can result in people moving away from the centre and into the suburbs, with each additional ‘ray’ reducing population density in the city centre by between 5% and 9% (Garcia-Lopez et al. 2012 and 2013, Baum-Snow 2012 and 2007). This is accompanied by population growth near the highway; for example, Baum-Snow (2007) find that population density decreases by 0.1% with every 10% increase in distance from the highway.

Further, Duranton and Turner (2012) show that the construction of rays leads to increased employment in the city centre: every 10% increase in the total length of interstate highways leading into a city is estimated to increase employment in that city by 1.5% over 20 years.⁵⁴ The evidence appears to be consistent with individuals moving to the suburbs as commuting costs fall. This is likely to be conducive to economic growth as it allows for greater agglomeration of employment within dense city centres.

These studies do not find a substantial impact from other types of road investment; in particular, the number of ring-roads was not found to have an effect on population density. The literature also suggests that roads have a larger impact on population distribution than rail (Redding and Turner 2014), which may reflect that most commuting trips in the areas of the study are carried out by road (National Travel Survey 2013).

The literature on rural and semi-urban areas is more ambiguous, and the direction of estimated effects appears to vary across different interventions. Funderburg et al. (2010) study the impact of road construction schemes in three counties in California. They find that new highways in Orange County’s previously exurban area significantly increased employment, adding nearly 5,000 more jobs relative to the counterfactual within a half mile of the road with positive employment effects persisting up to 2.5 miles away from the road. However, the construction of a highway bypass to a rural town in Merced County increased population but reduced employment near the area, which points to individuals taking up jobs in nearby cities that have become more accessible as result of the bypass. New highway investments near the urban centre of Santa Clara County were not found to have any effects on population or employment.

In the UK context, there is some evidence from ex-ante economic simulations (Laird and Mackie 2014) to suggest that roads can have higher employment effects in remote rural areas. However, those benefits appear to be much greater

⁵⁴ This does not mean people *move* to city centres, but that they are able to *work* more in city centres.

when those roads are mainly used for access to the remote locations themselves, rather than when the roads in question are inter-urban ones and simply pass through rural areas.

Another strand of the literature analyses the impact of an overall improvement in accessibility on employment, though not specifically relating to road improvements. The work that uses such methods generally finds small positive effects on employment, and suggests that a 10% increase in accessibility leads to an employment rise of anywhere between 0.5% (Ozbay et al. 2006, Berechman and Paaswell 2001) and 3.5% (Gibbons et al. 2012). These results are robust to various specifications and distances, but imply smaller effects than the estimates above. In addition, they do not account for potential displacement.

To our knowledge, there is no empirical research on the impact of transport on the incentive to invest in skills. The positive correlation between the accessibility of an area and its share of high-skilled workers is well-documented in the literature (see for example Overman et al. 2009); however it is not clear whether this reflects individuals' up-skilling in response to increased accessibility, skilled individuals relocating to more accessible places, or indeed some other effect as discussed below.

Finally, there is scarce evidence on the contribution that roads investment provides to specific industries. While it is a common belief that improved roads lead to increases in tourism,⁵⁵ this has been mostly analysed through composition of tourists rather than tourism-related employment effects (see Prideaux 2000). It is also unclear whether any of these potential effects result in additional tourism rather than displaced tourism from other areas. The local construction industry is also commonly thought of as one that benefits from roads investment, but as discussed above, this impact is not likely to be additional, nor unique to roads.

Comparing estimates with and without changes in labour market characteristics

A separate strand of the research aims to identify labour impacts by comparing the estimated impact of improved accessibility (as defined in the agglomeration section above) on productivity, with and without accounting for labour market characteristics (see for example Overman et al. 2009). The estimates presented in the section above on agglomeration generated simply by individuals and businesses being effectively closer together without any changes to the structure of the labour market. In contrast, the estimated relationship between accessibility and productivity *without* holding labour market characteristics constant can be interpreted as the total effect of improved accessibility, including any changes in the skills composition of areas that arise from increased connectivity i.e. after the dynamic effects have taken place over time. In this case, the difference between these estimates can be interpreted as the impact of improved accessibility on the distribution of workers across areas and/ or on the incentives for workers to invest in their skills.

⁵⁵ This is discussed further in our case studies.

There is reason to be cautious about this approach, not least because it is not possible to identify whether improved accessibility leads to changes in labour market composition, or the other way round. For example, transport schemes may be targeted at areas with highly productive labour forces, in which case a positive relationship between accessibility and productivity could reflect the impact of labour market composition on investments to improve accessibility rather than the other way round. Alternatively, governments may deliberately target transport investments at areas with low productivity and skills in an attempt to regenerate the areas, which could lead us to observe a negative relationship between improved accessibility and productivity. The findings of Overman et al. (2009) suggest that the latter may indeed hold for road investments.

Nonetheless, a comparison of the 'static' agglomeration effect with the overall relationship (including dynamic effects) gives us an indication of a possible upper bound on labour market effects. As discussed in the section above, studies in the UK generally estimate the static agglomeration effect of a 10% increase in accessibility leading to a gain in productivity at 0.4-0.7%. In comparison, UK studies of the total relationship between improved accessibility and productivity (after dynamic changes in labour market composition) generally estimate the effect at 1.6 – 2.4% (see Frontier Economics, 2016, for a summary of the literature). This suggests that a 10% increase in accessibility could potentially increase productivity by 0.9-2.0% through changes to the composition of the labour market, in particular by attracting skilled workers to better connected areas.

3.4.3 Inferred conditions under which labour effects are likely to be observed

The empirical evidence suggests that the impact of road improvements on the composition of the labour market is likely to depend on a number of factors, including:

- **Housing supply.** Incentives to relocate due to lower commuting costs, higher wages and/ or a greater variety of goods and services may be constrained by higher housing costs in areas benefiting from road improvements (and this in turn could change the composition of local workers), if the supply of housing does not adjust to accommodate increased demand. This means that supportive housing policy is essential to realising the full potential impact of road improvements on the labour market. When investing in roads in locations where housing is a constraint, further housing policy steps could therefore potentially unlock the full potential of the investment.
- **Interactions with other channels.** There is a strong interaction between the different channels, and labour effects will be more pronounced in areas where other mechanisms operate more effectively. For instance, individuals are more likely to move to an area if there are higher wages brought about by (static) agglomeration effects or increased investment, and/ or a greater variety of goods and services brought about by increased trade. Particularly, this is more likely to occur in urban areas, in areas with a high share of

manufacturing industries, or in areas near international or regional transport hubs.

- **Local availability of skilled labour.** The ability of a region to attract skilled labour depends on the availability of such labour in reasonably nearby areas. For example, there is evidence that regeneration of the Docklands following the Jubilee Line Extension was boosted by the abundance of skilled labour in London (Eddington 2006). The specific nature of those skills may vary depending on the specific locations.
- **Type of road investment.** The impact of a particular road investment scheme will depend heavily on the setting and context of the improvement. The evidence suggests that major roads leading into city centres are likely to allow people to move to the suburbs, though work in the city centre, and therefore unlock greater agglomeration in city centres. However, improving road links between rural and urban areas may shift economic activity away from the rural area rather than rebalancing the regional economy; this ‘two-way roads problem’ is explored further in the section on displacement below.

3.5 Trade

Facilitating trade is a key role of the SRN. In 2016, there were 9.8 billion vehicle miles driven by HGVs on the SRN (11% of all motor vehicle SRN traffic); and 13.6 billion vehicle miles driven by vans (15% of all SRN motor vehicle traffic). Overall, 68% of all HGV miles driven on England’s roads were on the SRN in 2016, and 33% of all van miles.

Improved road connections are therefore likely to not only improve economic outcomes through agglomeration, but also reduce barriers to trade with the economies of other regions and countries. Investments in roads can (to the extent that they reduce congestion) affect trade by lowering the costs and improving the reliability of transporting goods and services. This in turn may increase the volume of traded goods and services (the benefit of which would be reflected in measures of user benefits) and also increase productivity by facilitating learning between trading partners, encouraging specialisation and increasing competition to overcome problems with imperfect markets, with consequent benefits to consumers.

3.5.1 How can road improvements affect trade outcomes?

Increased volumes of inter-regional trade

While there are no formal barriers to trade of physical goods within the UK, transport costs can act as a barrier on trading activity. The costs of transport for low-value goods moving by road can be as high as 20% of their value for the average distance travelled (Glaeser and Kohlhase 2004). These costs are particularly relevant in the context of considering the gains from road improvements, as over 90% of freight is transported by road (Eurostat 2012). Reductions in these costs would therefore be expected to facilitate domestic trade; and improving access to transport hubs, ports and airports could improve

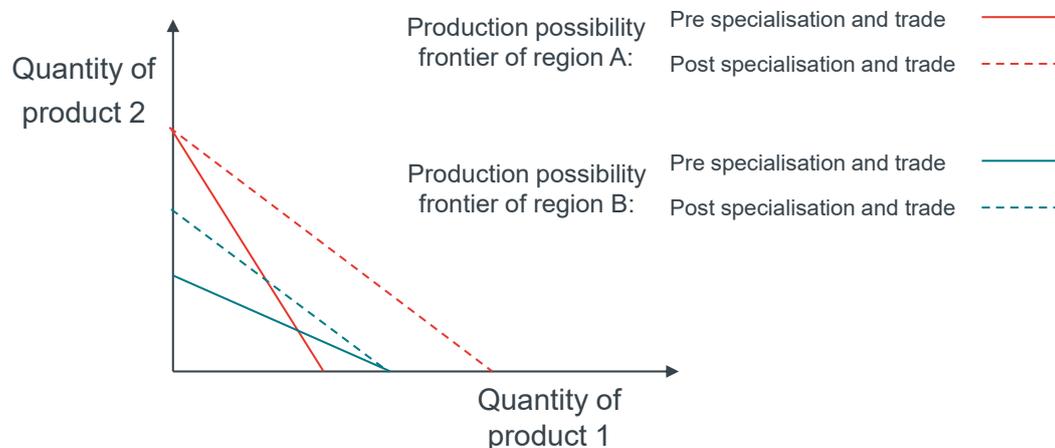
prospects for import and export activity from even further afield. A reduction in trading costs would be expected to increase the overall volume of traded goods and services.

The direct cost of transporting goods in the developed world has declined steadily since 1900, particularly relative to the costs of transporting people (Glaeser and Kohlhase 2004). However, evidence suggests that distance, and therefore transport, continue to be important limiting factors for all firms. DfT statistics suggest that the average length of haul for GB-registered HGVs in 2015 was 92 kilometres, similar to that in 2014 (91 kilometres).⁵⁶

Greater scope for specialisation

The theory of comparative advantage, dating back to Ricardo in 1817, states that allowing different regions to specialise improves the efficiency of the whole economy. Given that different areas have different strengths and characteristics with unique benefits, all areas can be made better off if they are able to produce in ways which allow them to focus on the activities in which they are more productive. A stylised example is presented in Figure 6. Here, a change in the costs of travel for product 1 (the red line) allows more of product 1 to be produced for a given cost i.e. the red line swivels out to the red dotted line; likewise if the cost of transporting product 2 declines, more can be produced for a given cost (as shown by the green line swivelling up to the green dotted line).

Figure 6 Stylised basic example of comparative advantage and trade



Source: *Frontier Economics*

This specialisation can occur through:

- Specialisation within areas by sector (sometimes called ‘sectoral specialisation’ or ‘sectoral agglomeration’); or
- Specialisation within areas by function: clustering of similar functions of different firms at the same place (‘functional specialisation/agglomeration’).

⁵⁶ The average length of haul for articulated HGVs (possessing a joint or a trailer) was 124 kilometres in 2015 which was longer than that of rigid HGVs (49 kilometres).

These specialisation advantages extend beyond consideration of factors like natural resources (with which some areas are naturally endowed) to encompassing aspects such as the economies of scale and scope that result from business decisions. Redding (2012) finds that reductions in the transport-related barriers to trade are often accompanied by substantial changes in organisation of economic activity. The extent to which opportunities arising from lower transport costs can be realised are obviously dependent on, for example, the mobility of factors of production involved and the leadership and preparedness of organisations who can exploit those opportunities.

Specialisation also occurs within firms, with management and production units increasingly located on separate sites. Duranton and Puga (2005) find that this even extends to particular areas as some cities seek to specialise in particular activities as well as particular sectors. Improving road links between urban centres and hinterlands makes the separation of factories and headquarters more attractive to firms and hence they can adopt different organisational forms that are more efficient overall as this facilitates learning and higher productivity.

Increased competition across markets

Improved road links can make it easier for firms in each better connected area to access customers in other areas (see Melitz 2003 for an in-depth theoretical discussion). The effect of this is to expand the size of the market in which those firms compete, forcing businesses to take into account the offerings of rivals further afield. Firms would, in this case, face pressure to lower prices, improve quality or become more efficient to retain profitability and market share. For example, reductions in the costs of transport have allowed for the proliferation of national courier package delivery firms alongside traditional monopolistic postal services and local couriers (Glaeser and Ponzetto 2007).

The positive effects of competition could be two-fold: higher productivity from efficiency gains; and increased choice and lower prices for consumers. However, the negative consequence of such gains to the national economy is that firms in areas exposed to increased competition may suffer if they are not able or willing to make efficiency improvements or move into other activities. If firms in less productive regions are unable to compete, this could further exacerbate differences in economic performance between regions in the UK.

3.5.2 Empirical evidence

The literature on trade effects is limited when compared to other transmission channels. Most of the focus of trade economics has traditionally been on international trade, which forms a substantial part of the global economy and is easier to measure than domestic trade. The existing empirical evidence on the impact of road improvements on trade volumes and specialisation is explored below. Note however that there is little empirical evidence on the impact of domestic roads on competition.⁵⁷

⁵⁷ Inaccessibility of some remote areas may lead to decreased competition and higher prices (see Laird and Mackie 2014), but that does not necessarily mean roads improvement will reduce these effects.

Overall trade volumes

At the international level, there is strong evidence that low transport costs and improved infrastructure are associated with high trade between countries (see Limao and Venables 2001, Clark et al. 2004 and Behar and Venables 2011). It is often unclear whether improved transport leads to higher international trade levels, or the reverse. This is even less clear in relation to domestic trade.

The US is one place where there is extensive inter-city trade data available, and some researchers have made use of that information to assess the impact of transport infrastructure on domestic trade patterns.⁵⁸ While this empirical question suffers from some of the same difficulties described above (namely, non-random allocation of road improvements to cities), Duranton et al. (2014) were able to overcome this problem in their analysis. They find that highway distances, both between cities and within cities, have substantial impacts on the volume of trade, proxied by the weight and value of trade:

- Reducing the effective distance *between* cities by 10% through highway construction leads to a 16-19% increase in the weight of trade between those cities and a 12-14% increase in the value of trade;
- Increasing the total length of highways *within* a city's metropolitan area (thereby increasing its effective density) by 10% increases the weight of exports from the city by 5%, but does not necessarily affect the value of exports.⁵⁹ Such an improvement also leads to a 2-4% increase in both the weight and value of trade within the city.

With regards to differences between roads and other modes of transport, Duranton et al. (2014) find that road trade is more sensitive to distance than rail trade, at least in the US. They also consider road transport to be a reasonable substitute for rail freight as well as waterways and air travel in some cases.

Within-sector specialisation effects

The results of the research presented above (Duranton et al. 2014) also suggest that road investment does not necessarily change the amount of economic activity within a city as much as its composition. The evidence of a larger impact of road improvements on the weight of trade, compared to the value of trade, supports the hypothesis that cities that are better connected by roads (internally and externally) tend to specialise in heavy industries and in the export of heavy goods. This is true even when comparing US cities with a similar share of workers employed in manufacturing, implying that at least some of the effect of roads is to change the within-industry composition of the city, by way of shifting some economic activity from manufacture of light goods to manufacture of heavy goods.

Research by Michaels (2008) supports this finding. In a study of employment and trade in various urban and rural counties, some sectors were found to respond

⁵⁸ Another strong piece of evidence is work by Donaldson (2010), finding an increase in regional trade from infrastructure investment. But that research is in the context of railroads in colonial India, rather than roads in a developed economy.

⁵⁹ The implications of this on specialisation are discussed below.

quite strongly to the building of new highways, with incomes in trucking, warehousing and retail sales higher by 7-10% in rural counties crossed by a highway relative to other rural counties. This is likely to have been driven not by employment shifts between manufacturing and non-manufacturing industries, but again by within-industry reallocation.

3.5.3 Inferred conditions under which trade effects are likely to be observed

Although the evidence on the trade impacts of road improvements is not as well-developed as the evidence on other transmission mechanisms, we can infer the following on the conditions under which impacts are more likely:

- **International or central transport hubs.** Improvements in road links to areas with ports, airports and/ or major transport hubs⁶⁰ are likely to have a notable effect on trade, as they facilitate an expansion of international as well as domestic trade and therefore allow firms to take advantage of trade opportunities.
- **Heavy manufacturing.** Road improvements targeting areas with a high share of tradable goods, in particular heavy manufacturing, are more likely to impact economic performance through trade. Similarly, firms that export heavy goods are most likely to benefit from road improvements.

3.6 Induced housing investment (or other transport-dependent investments)

Reduced travel costs that result from a road improvement can make areas near the road more desirable to locate in for residents and businesses. Where the land is already used for housing, this can be expected to increase house prices. Or it may provide the incentive for increased development. Where bottlenecks or congestion are inhibiting development, road improvements can ‘unlock’ the land for development, provided other complementary factors are also in place. This is referred to as induced, or dependent, investment. We focus in this section on the use of land for housing, as changes in business investments are discussed in section 3.3.

3.6.1 What do we define as the house price and housing impacts arising from road improvements?

Improving roads can potentially lead to changes in house prices and induced housing development.

As outlined in Venables et al (2014), it is important to note that house price impacts are included within measures of user benefits under certain well-defined conditions. For example, suppose a tenant gains user benefits through reduced transport costs from living near an improved road. The tenant could be charged higher rent by their landlord, which the tenant would be willing to pay up to the

⁶⁰ This is similar to Highway England’s definition of ‘key hubs’.

amount of the transport cost reduction. Therefore counting increased rental or house price impacts on top of user benefits would be double counting. We discuss in the next section the circumstances under which these assumptions do not necessarily hold, and so house price impacts could be, at least in part, additional.

Incentives for housing development (or other transport-dependent investments) could also be affected by road investment. This occurs where bottlenecks or congestion mean that a 'reasonable level of service' would not be provided for road users if a development took place without first implementing road improvements.⁶¹ Through relieving bottlenecks, road improvements can help to 'unlock' an area for development, contributing to induced housing investment. However, it is important to note that investments are also reliant on other conditions being in place, such as sufficient underlying demand for housing and provision of other types of supporting infrastructure.

3.6.2 How can road improvements affect house prices and housing (or other transport-dependent) development?

For the most part, where road improvements lead to increases in house prices or investment, these would be captured in measures of user benefits. However, such effects can be additional to transport user benefits under two types of circumstances:⁶²

- where there are significant feedback effects from housing development on road user benefits; and
- where the rest of the economy does not operate perfectly efficiently, as a result of distortions or market failures.

Feedback effects

Changes in housing development from road improvements can contribute to feedback effects that alter the user benefits from the road improvements. For example, increased housing development that generates more demand for road use can potentially contribute to increased congestion, which may reduce the extent of journey time benefits achieved. In such cases, such feedback effects would need to be picked up in the transport modelling to measure user benefits appropriately.

Distortions and market failures

DfT 2016 wider economic impacts consultation⁶³ sets out four types of distortions or market failures which could mean housing development effects (or changes in house prices) are not fully reflected in user benefit estimates:

⁶¹ See Department for Transport (2015), 'TAG UNIT A2.3: Transport Appraisal in the Context of Dependent Development'

⁶² See: Department for Transport (2016), 'TAG UNIT A2.2: Appraisal of Induced Investment Impacts' and Department for Transport (2015), 'TAG UNIT A2.3: Transport Appraisal in the Context of Dependent Development'

⁶³ Department for Transport (2016), 'TAG UNIT A2.2: Appraisal of Induced Investment Impacts'

- **Imperfect competition:** supply of land for housing development could be low if land is held by a small number of individuals who may have incentives to restrict supply in order to raise land values, or if the land is protected by the planning system (such as greenbelt land, see 'land rationing' below).
- **Co-ordination failure:** there may be an inefficiently low level of housing investment due to a failure of investors to coordinate where benefits are widely dispersed across several parties.
- **Land rationing:** planning restrictions may limit the release of land for new developments below optimal levels.
- **Clustering effects:** as outlined in section 3.1, there may be productivity benefits from clustering and agglomeration of people and activity. There could be underinvestment in housing if these benefits are not taken into account.

3.6.3 Empirical evidence

A recent study by the What Works Centre for Local Growth (2015)⁶⁴ undertakes a systematic review of impact focussed policy evaluations of transport investments. Four evaluation studies are identified that provide empirical evidence of the impact of road improvements on house prices. All of the studies find price increases from road improvements, at least within certain distances from the road. The extent to which these price impacts are additional to transport user benefits is not clear. As noted above, under well-defined circumstances, it would be assumed that all of the impacts are captured within transport user benefits. There is also some evidence of induced housing investment creating feedback effects from road improvements. These issues are discussed further in turn below.

House prices

Vadali (2008) assesses toll road impacts in major metropolitan areas in Dallas County, Texas. House price effects are found to vary with the distance from the road. Houses within 0.2 miles of the road experience a negative price effect of around 10%, whereas there are price increases of 13% for those 0.25-1 mile away, and 19% for 1-2 miles away. The negative effect very close to the road is likely to reflect local disamenity impacts offsetting reductions in transport costs.

Chernobai et al (2011) analyse highway improvement impacts in Los Angeles. House price increases are found to occur in all treatment areas. Areas a moderate distance from roads experience the highest increases, with those 0.4 miles from the highway increasing by \$22,000 to \$33,000. Houses either very close or further away experience smaller, but still positive, price effects. Price increases were found to occur in anticipation of the road improvements studied only to some extent. No price effects are found in the 2 years prior to construction, but start to take effect once construction has commenced. This suggests house markets do not operate perfectly in anticipation of road

⁶⁴ What works centre for local growth (2015), 'Evidence review 7: transport'

improvements. House price impacts are greatest once the road is complete, and then tail off in subsequent years after the road is opened.

Boarnet and Chalermpong (2001) examine house price and urban development impacts from toll roads constructions in Orange County, California. The authors find evidence of an ‘accessibility premium’ for properties close to new roads. Home buyers are found to be willing to pay for increased accessibility, and this is reflected in house prices and development patterns.

Márk (2013) assesses property price effects from new highway sections on the M6 in Hungary. Selling prices of properties are compared for properties within 10 kilometres of the highway, to those that are further away but for which the M6 is still their closest highway route. Selling prices are found to be 11-15% higher for those within 10 kilometres following the road construction. Repeating the analysis only for areas with smaller populations (below 30,000) roughly doubles the estimated price effects.

Housing (or other transport-dependent) development and feedback effects

Housing development may be dependent on road improvements. For example, in an area that is already congested, planning policy may restrict development to avoid increasing traffic flows. Road improvements that alleviate congestion concerns can therefore help ‘unlock’ land for development. The DfT 2016 wider economic impacts consultation outlines that induced investment impacts are context specific.⁶⁵ Realising development potential may also be reliant on other conditions or policies, such as investment in skills, or other types of infrastructure such as utilities, schools and health services.

Changes in housing development can contribute to feedback effects, potentially increasing traffic flows. For example, Boarnet and Chalermpong (2001) assess development patterns in their analysis of the Orange County road improvements outlined above. The study finds evidence of induced travel effects in this case, with changing development patterns following road improvements contributing to increased road use.

3.6.4 Conditions under which impacts on housing (or other transport-dependent) development and house prices are more likely

The potential impacts of road improvements for house prices and housing development can vary depending on the local context. The conditions under which these impacts are more likely to contribute to economic performance are discussed below.

- **Local attributes.** The impacts of induced housing development are context specific depending on the local attributes. Induced housing development is likely to have greatest impact when local attributes are

⁶⁵ See: Department for Transport (2016), ‘TAG UNIT A2.2: Appraisal of Induced Investment Impacts’ and Department for Transport (2015), ‘TAG UNIT A2.3: Transport Appraisal in the Context of Dependent Development’

conducive to the investment, such as availability of suitable workforce skills and developable plots for housing.

- **Complementary interventions.** Interventions that enhance local attributes, such as investment in skills or zoning of land use, can help to increase the likelihood of road investment facilitating housing development. In some cases, housing developments may be dependent on other interventions as well as road improvements, such as the provision of utilities infrastructure, schools and health services.
- **Distance from the road.** The greatest house price increases are generally for houses close, but not adjacent to improved roads. This is likely to reflect a trade-off with dis-amenity effects, such as noise and pollution, for houses very close to the road.
- **Timing.** House price impacts can occur in anticipation of a road improvement to some extent. There is evidence⁶⁶ that price impacts start during road construction, are greatest once the road is complete, and then tail off in subsequent years.
- **Feedback effects and market imperfections.** House price impacts will be fully reflected in user benefit estimates where markets operate efficiently. However, house price effects could be at least partially additional if this assumption does not hold, for example because of planning policy restricting land supply.

3.7 Displacement

The sections above discuss the channels through which roads improvements can improve economic outcomes in an area. However, it is important for policy makers to be aware that whilst 'static' agglomeration economies arise for any given composition of firms and workers in an area, some of the dynamic gains associated with new business investment, changes in labour behaviour, trade-related efficiencies and induced housing investment in the area targeted by road improvements may be drawn away from other areas in the UK. For example, if a business relocates to an area as a result of road improvements, then the area it is leaving will have lost investment. Similarly, a worker who relocates is taking his/her labour away from some other area. These effects are known as 'displacement'.

A full economic understanding of the impacts of road investment on economic performance therefore requires a framework for describing how economic activity could be displaced. This is for the following reasons:

1. Calculating the benefits of a road project could be over-estimated if we only take into account the economic changes to the area served by the new or improved road; and
2. The way in which the economic geography of the UK is changed by infrastructure investments may be of strategic and policy interest in respect of particular policy objectives. For example, a project which displaces economic

⁶⁶ See Chernobai et al (2011)

activity *towards* deprived areas may be considered preferable to one which diverts economic activity *away from* deprived areas.

3.7.1 How can road improvements result in displacement?

Displacement refers to the potential for road investments in one area to draw economic activity away from other areas. For example, investments in road infrastructure in one city may cause firms and workers in nearby cities to relocate, thereby creating negative economic impacts on those other cities. Similarly, improving inter-city road links may enable firms previously operating in both cities to locate solely in the more dense and productive city and serve all their customers from there; firms in the other city may also struggle to survive when faced with such increased competition. The spatial distribution of the impacts of road improvements, and the extent to which road improvements can help rebalance the UK economy, will therefore depend on the magnitude and nature of displacement.

The theoretical literature on the likely direction and magnitude of displacement is extremely limited. However, based on the theoretical channels discussed in previous chapters, we can infer that the extent of displacement will depend on the local and national context. For example, Venables et al (2014) note the following:

- Where a business produces output that is not internationally tradable then it is likely that when it relocates to an area following a transport investment it is likely to reflect displacement;
- Where a business produces output that is internationally tradable then location in an area is less likely to reflect displacement, since the choice for that firm is likely to be whether to locate in the UK or other countries; and
- If the economy is in full-employment (i.e. any gains in employment are not as a result of lowering unemployment or attracting workers back into the labour force) then employment gains in one area are likely to reflect displacement from another.

In general, it is the trade-off between gains in productivity as a result of any firm re-location and the costs of that re-location that will determine whether a firm moves or not. This is not straightforward to predict and hence understanding the local and national context is critical.

3.7.2 Empirical evidence

Quantitatively estimating the scale and nature of displacement is extremely difficult, since it requires understanding how much of the increased economic activity in one area in response to transport investment comes directly from other areas. In the context of road investments, this requires estimating two aspects: how much economic activity has increased in the area of the road investment; and how much economic activity has decreased in the 'untreated' (other) area. This is made more complicated by the fact that movement of people or firms in response to a road investment may not necessarily be all one way –

opportunities can be created in either area so movement could be in either direction, and indeed across multiple areas.

Although some limited evidence exists on the potential scale of displacement, very little (if any) is available in relation to road investments specifically. Indeed, the challenges are acknowledged in several recent publications.⁶⁷

Some studies have sought to estimate the different effects of transport accessibility on those areas which are directly served by a new project and those that are adjacent to it. Chandra and Thompson (2000) provide evidence that, while highways in the US raised economic activity in the counties they passed through, they drew activity away from adjacent counties. They did not find statistically significant gains at the aggregate level, which suggests that displacement occurred on an almost a one-to-one basis.

Research on enterprise zones, though not directly related to transport, can be indicative of the importance of displacement for place-based policies (targeting particular areas). A study by Mayer et al. (2012) on the impact of French enterprise zones on location decisions found that the sizable positive impact on the areas invested in came mostly at the expense of other areas via displacement. A more general review of the effect of “Place-Based Policies” by Neumark and Simpson (2014) similarly found that, while strategies to encourage investment were often effective in a given area, global outcomes were mixed.

A review of computable general equilibrium (CGE) models by Partridge and Rickman (2007) shows that the effects of transport improvements between cities will depend on the mobility and value of the factors located in each city, but the exact processes are complex and poorly understood. There is no academic consensus on exactly where activity might improve if transport between major cities were improved.

3.7.3 Inferred conditions under which displacement effects are more likely

The evidence on the nature of displacement and the types of areas that are likely to experience displacement is extremely limited. However, based on the literature we can infer the following hypotheses on the conditions under which displacement is more likely following a road improvement:

- **Factors of production are mobile.** Given the costs associated with re-locating, individuals or firms that are most likely to be displaced will be those for whom it is most feasible to move factors of production to a new location (or obtain them in the new location). This suggests industries with workers willing to move or commute, materials that are easily transportable and economic activity that does not rely heavily on fixed geographical characteristics. In contrast, firms relying heavily on climate and place-dependent natural resources (such as offshore wind or grazing land) would be less likely to relocate even with significant transport improvements. The further implication of this is that returns on *immobile* factors, such as rural

⁶⁷ See for example the What Works Centre’s evidence review on Transport, Overman 2015, and the TIEP report, Laird et al. 2014

workers and agricultural land, will fall as economic activity moves away (Fajgelbaum and Cosar 2013).

- **Local and intra-regional.** Most of the empirical evidence showing the existence of displacement, both from the perspective of firm location and economic outcomes, shows that it mainly shifts economic activity short distances. The geographic scale of competition is normally between adjacent towns or counties (Chandra and Thompson 2000), while the inter-regional and inter-urban effects tend to be smaller (or at least less empirically visible).
- **Labour market slack.** While empirical evidence on the consequences of transport-related displacement is thin, there is considerable research on the effects of business incentive policies in local areas. Criscuolo et al (2012) find that regional industrial policies increase the number of manufacturing jobs mainly by reducing unemployment, not through inward migration. This suggests economic activity is less likely to be displaced from elsewhere when there is slack in the labour market, that is, when firms can find appropriately skilled residents who are not currently employed.
- **Rural-urban divides.** There is some evidence that improving road links between cities and rural areas has led to asymmetries in growth (see for example Funderberg et al. 2010 and Glaeser and Kohlhase 2004), benefiting urban areas at the expense of rural areas. This implies that this type of road improvement may not be effective at rebalancing the UK economy.
- **International v. regional mobility.** Investments in areas which compete for business internationally are likely have higher net benefits, since they are less likely to be displacing activity from other areas in the UK.

Given the limitations of the available evidence and the importance of displacement to the spatial distribution of impacts across the UK, more consideration is needed to fully understand whether this is an issue that could be resolved by more research, or whether it is simply unknowable.

4 CASE STUDIES

Introduction

This chapter presents lessons learned from ten case studies of road investments in the UK and overseas. For each case study, we:

- present the overview and rationale for the investment;
- address the quality of evidence available;
- discuss the different transmission channels which could be relevant;
- summarise the evidence for any causal economic impacts; and
- draw potential lessons learned, or observations.

The studies cover a variety of settings, rationales and project types. An overview of their various attributes is presented in Figure 7 and their locations are in Figure 8. They have been chosen in consultation with the Department for Transport. The selection of case studies was based on a number of criteria:

- project type (bypass/road widening/new road etc.);
- geographical and economic context;
- source of evidence and type of study conducted;
- scale of economic impact; and
- transmission channel(s) which may be relevant to each project.

One methodological point to note is that when ‘displacement’ is discussed below, it relates to displacement of economic activity between different areas within the country, rather than between countries. As shown in Figure 7, although all case studies selected have assessed the impacts on the economy to some extent, given that was one of the objectives of each case study intervention, few studies offer a robust quantitative analysis of such effects, with some relying instead on qualitative assessments.

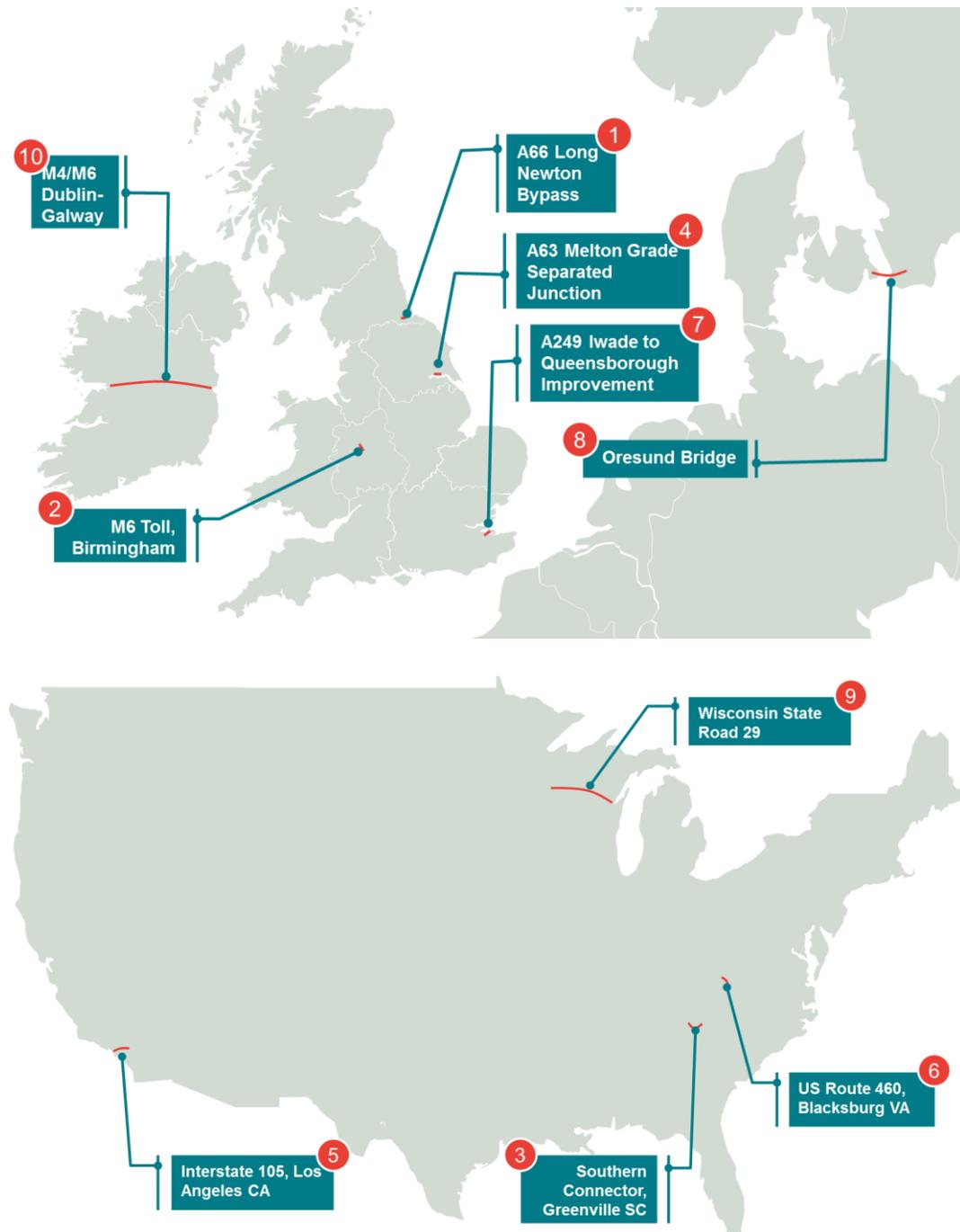
Figure 7 Overview of case studies

Section	Name	Country	Type of project	Quality of quantitative evidence ⁶⁸	Relevant transmission mechanisms
4.1	A66 Long Newton GSJ	UK	Junction	Low	Trade
4.2	M6 Toll	UK	Motorway Construction	Medium	Agglomeration, Investment, Labour, Trade, Housing
4.3	Southern Connector	US	Motorway construction	Low	Agglomeration, Investment, Labour, Trade, Housing
4.4	A63 Melton GSJ	UK	Junction	Medium	Investment, Trade
4.5	I-105	US	Motorway Construction	Medium	Agglomeration, Investment, Trade
4.6	US-460	US	Bypass/ Junction	Low	Agglomeration, Investment, Labour, Trade
4.7	A249	UK	Dualling/ Bridge	Low	Investment, Trade
4.8	Oresund Bridge	Denmark/ Sweden	Motorway construction/ Bridge	High	Agglomeration, Investment, Labour, Trade, Housing
4.9	SR-29	US	Motorway construction	Medium	Investment, Trade
4.10	M4/M6	Ireland	Motorway Construction	Low	Investment, Trade

Note: The “Quality of economic evidence” column relates strictly to our assessment of the economic evidence and the degree to which a robust evaluation has been performed, with a substantial quantitative base. It does not refer to the quality of the traffic, safety, and other transport impacts, which we are not well-placed to comment on.

⁶⁸ This relates to our assessment of the strictly economic evidence, and the degree to which a robust evaluation has been performed, with a substantial quantitative base.

Figure 8 Geographic spread of case studies



4.1 A66 Long Newton Grade Separated Junction (GSJ), North Yorkshire

4.1.1 Overview and rationale

The A66 is a strategic route in North Yorkshire, linking Middlesbrough and Stockton-on-Tees to the A1 and the rest of the national motorways network. The Long Newton grade separation project involved replacing the previous flat intersection connecting the village of Long Newton to the A66 with a grade-separated one, thereby setting the local road apart from the regional network (see Figure 9).

This was a relatively small project, at a total cost of £9-10m,⁶⁹ with work being completed in the summer of 2008. The rationale for it was threefold.

- **Safety:** The new Long Newton GSJ was expected to be much safer than the existing arrangement, as vividly illustrated by the fact that the nearby section of the A66 was known to locals as “the death mile”.
- **Airport access:** The improvement was expected to re-route traffic to the nearby Durham Tees Valley International Airport, reducing traffic volume through Long Newton while removing barriers to the airport’s projected growth.
- **Public transport access:** The project set out to increase provision of public transport to Long Newton and the neighbouring village of Elton.

Wider economic benefits were not explicitly considered as part of the project’s objectives, and were therefore not measured in the ex-post evaluation.

Figure 9 Long Newton Junction before and after the intervention



Source: POPE, Highways Agency

4.1.2 Quality of evidence available

The only available evidence on the impact of this work is the One Year After and Five Year After POPE reports. The quantitative focus is on the benefits in travel times and safety, and any evidence on other benefits is qualitative in nature.

⁶⁹ Depending on the cost measure; in 2002 prices.

4.1.3 Transmission channels for contributing to economic performance

Examining the Long Newton GSJ through the framework of the channels of impact makes it clear that some impacts are more likely than others in this type of project.

- **Agglomeration.** While the improvement theoretically reduces the effective distance between villages in the area, none of these areas is particularly large in terms of economic activity.⁷⁰ The area is also not undergoing any particular degree of urbanisation, and given the time savings from the project are relatively small (1 minute per journey), agglomeration effects are unlikely to be significant.
- **Investment.** As the project focuses on improving a junction in a specific location, it does not materially improve an existing link between economic areas and does not create a new link, so the scope for attracting investment is expected to be minimal.
- **Labour.** While the project could have potentially made some commuting journeys slightly easier and safer, the scale of the improvement is small in this case, as mentioned above, so it is not likely to affect labour market decisions.
- **Trade:** This channel could potentially be relevant due to the proximity of the project to an airport. Indeed, removing a constraint on the airport's growth was one of the stated objectives of the improvement.
- **Induced housing investment.** The GSJ does not materially change the geography of the area, nor link regions to each other in a way that would be expected to impact house prices or land use, with the possible exception of slightly reduced noise and congestion related to airport traffic.
- **Displacement.** To the extent that any economic activity could have been displaced, the extent of this risk is unclear.

4.1.4 Evidence of impacts

There is no direct qualitative or quantitative evidence for any of the above impacts taking place, and the POPE report largely focusses on the substantial and very important improvement in safety, alongside some local travel-time savings.

The most relevant evidence related to economic effects is the discussion of the traffic to and from the airport, which increased in the year following the project's completion, but then subsequently decreased when the airport saw a decline in passenger numbers.

Evidence suggests a lack of land use changes in the area, in direct contrast to a similar project along the A63, which we discuss in section 4.4. Unlike Long Newton, the A63 Melton GSJ had a particular area nearby marked for industrial

⁷⁰ Darlington has ~110k residents, Middlesborough ~140k and Stockton-on-Tees ~190k.

development. The conversion of that area was dependent on infrastructure improvements.

4.1.5 Observations

While not rich in economic data or robust evidence of economic effects, our overview of the A66 Long Newton Grade Separated Junction still provides several valuable lessons, reinforcing and illustrating the messages arising from the literature. These include:

1. **The size and nature of direct benefits to road users matter for the potential to lead to economic effects.** While this project delivered substantial safety benefits, its immediate impact in terms of reliability, resilience and time savings was very limited, with journeys becoming only one minute faster. As discussed above, the economic impacts flow from user benefits, and if these are limited, then the additional benefits are also likely to be minimal.
2. **The ability to facilitate unlocking growth at the regional airport from a junction improvement alone was minimal.** Safety improvements were the main concern of this project, and not economic impacts. But given unlocking growth by improving access to the airport was part of the rationale for the investment, the project appears to have made only a minimal impact in this regard. This provides a tangible example of a wider point addressed in the literature review: the nature of business investment and economic growth can be uncertain. Road improvements whose primary value relies on the growth of economic activity in specific locations or industries bear the risk of that growth simply not materialising, for any number of reasons.

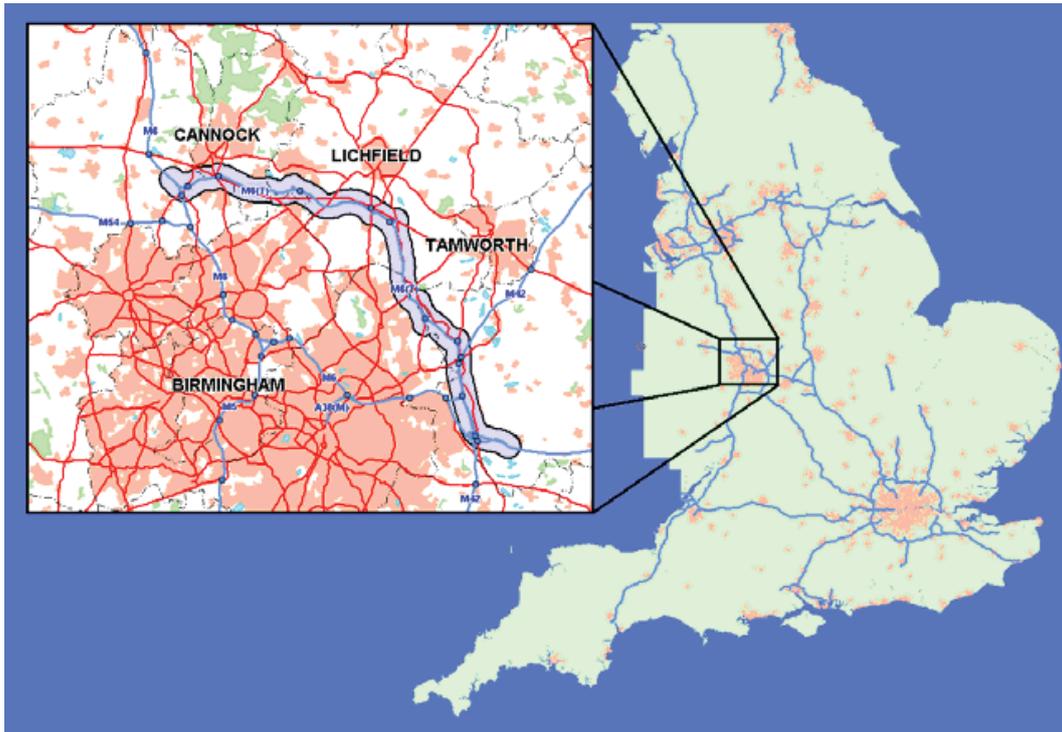
4.2 M6 Toll, Greater Birmingham

4.2.1 Overview and rationale

The M6 Toll (originally called “the Birmingham Northern Relief Road”) is a private tolled motorway (the first in the UK) which was intended to provide an alternative route through the north-east of the Birmingham metropolitan area.⁷¹ It is a three-lane motorway, 27 miles in length, and it opened in December 2003. The specific objectives of its construction were:

- **Congestion relief.** The scheme was expected to provide an alternative route to the most heavily-congested stretch of the M6 motorway as it passes through the outskirts of Birmingham, and to reduce congestion on the existing route and on other local roads nearby.
- **Reliability.** Beyond just reducing travel time, the M6 toll road was built in order to also make the journey time more reliable and predictable.
- **Connectivity.** The road was expected to improve transport links to the towns north and east of its location, and to enhance the wider motorway corridor crossing the middle of England.

⁷¹ Also known as the West Midlands conurbation or the West Midlands metropolitan area.

Figure 10 Location of the M6 Toll Motorway

Source: *M6 Toll Five Years After Study*

4.2.2 Quality of evidence available

The economic evidence for the M6 Toll benefits largely derives from a paper by Pugh and Fairburn (2008) which provides a quantitative analysis of the project's economic impacts.

The Highways Agency's (now Highways England) Five Years After POPE report also provides additional context and qualitative evidence, as well as detailed impacts of the project's traffic and safety outcomes. The road's utilisation, traffic and revenue model has been explored in depth in other work by the Department for Transport,⁷² but this has not been a point of focus for our analysis.

4.2.3 Transmission channels for contributing to economic performance

Examining the M6 Toll through the economic framework makes it clear that several of the channels discussed above are likely to materialise.

- **Agglomeration.** Due to the improved connection to a major conurbation, it could potentially deliver savings in travel times to the city and increase the urban area's effective economic size. This would suggest agglomeration benefits are likely to occur.

⁷² <https://www.gov.uk/government/collections/birmingham-m6-toll-road-study>

- **Investment.** The Birmingham conurbation is already a major agglomeration, with access to service-oriented services, manufacturing sector firms and skilled workers. These conditions increase the likelihood of investment, whether through the growth of existing firms or the attraction or birth of firms.
- **Labour.** The M6 Toll road could have significant labour market effects through two potential channels: improving commuting into Birmingham, thus driving suburbanisation and increased city-centre productivity; and improving the connectivity of nearby towns.
- **Trade.** The West Midlands is home to abundant manufacturing and logistics activity, making an investment in roads there potentially beneficial from a trade perspective. Birmingham is also home to an international airport, although it is not located directly in the area served by the M6 Toll road.
- **Induced housing or commercial investment.** Much of the land surrounding the M6 Toll, especially to the north and east, is undeveloped or rural. A better connection to the conurbation of Birmingham could provide a higher incentive for commercial or residential development. This is further helped by the fact that despite being a through road, the M6 Toll has a relatively high number (eight) of junctions with local roads, substantially improving the accessibility of the areas it passes through in southern Staffordshire.
- **Displacement.** This effect could arise but is highly uncertain. The two nearest major cities are more than a three hour drive away. There is a hypothesis in Pugh and Fairburn (2008) that displacement should be lower for toll roads than non-tolled roads due to a toll's regulation of traffic, but this is unproven.

4.2.4 Evidence of impacts

Direct benefits of traffic and safety improvements

The POPE study of the M6 Toll identified a large degree of rerouting of traffic from the M6 and other strategic roads across the West Midlands in the year immediately following the road's opening (2004). This traffic increased further during the course of 2005 and 2006, and later returned to below 2004 levels.⁷³ DfT's evidence suggests that one of the reasons for this reduction is that the recession made drivers more sensitive to paying the toll and pushed them to seek out other routes.⁷⁴

Overall, even after this reduction in traffic, the M6 Toll is suggested to have served its purpose in reducing congestion on the M6 and improving journey reliability, especially in peak rush hour. Safety has been another achievement of

⁷³ The POPE report offers a few hypotheses as to what else drives these traffic numbers, including road works on alternative routes.

⁷⁴ As of January 2009, the toll was £4.70 for cars and £9.40 for large vehicles such as lorries or buses.

the road, with accident rates on the M6 Toll being less than half of those on the M6, adjusted for traffic volumes.⁷⁵

Economic impacts through land use change

The main outcome that Pugh and Fairburn (2008) estimate is a change in industrial land development.⁷⁶ They find that:

- locations within a 5-minute drive of an M6 Toll junction are associated with just over three hectares of increased industrial land development (22% of available land);
- locations within a 10-minute drive of an M6 Toll junction are associated with about 1.25 hectares of increased industrial land development (33% of available land); and
- locations within a 15-minute drive of an M6 Toll junction are not affected.

In addition, Pugh and Fairburn (2008) estimate an indirect effect on land near the original M6 motorway, which could be driven by the reduced congestion on the M6 Toll road. Proximity to the M6 after the M6 Toll's construction is associated with an indirect effect of an additional 1.44 hectares of industrial land development, or about 12% of available land. Importantly, this effect is weaker than the direct effect of the M6 Toll and is only apparent in some specifications of the authors' model.

Economic impacts through labour market changes

To estimate a proxy for the toll road's employment effect, the above land use impacts can be multiplied by the regional average employment density to obtain an estimated figure for new jobs created (or displaced into the area) by the M6 Toll's proximity. This estimate translates to 265 additional jobs⁷⁷ at the end of Q1 2004, or just under 0.1% of regional employment. This corresponds to around £5m in annual earnings, or £100m in net present value (NPV) terms.

Displacement

While there is no direct evidence of the extent of displacement, the authors have conducted interviews in the area to get a sense for the perception of displacement among local business owners. Their evidence points to most of the development⁷⁸ being driven by investment from outside the region. This suggests that the £100m NPV figure is at best an upper bound for the total employment effect, as a large share of these jobs could have been displaced from elsewhere in the UK.

⁷⁵ Overall savings from the M6 Toll in the wider M6 corridor have been estimated at 136 casualties avoided per year.

⁷⁶ They address the difficulty of establishing a plausible counterfactual to the M6 Toll by adopting a "differences-in-differences" approach. This method compares the difference in some economic variable in a treatment group before and after an intervention to the difference between the same variable for a control group, thus estimating the causal effect of the intervention. By grouping together clusters of undeveloped land within 5 minutes of an M6 Toll junction, within 10 minutes of one and within 15 minutes of one, they construct a reasonable set of control and treatment groups.

⁷⁷ Excluding those created by the construction itself, which are assumed not to be additional to a given project.

⁷⁸ "Most" in terms of floor space.

4.2.5 Observations

Several lessons can be drawn from this case study.

1. **Land use effects can be material, but diminish quickly with distance.** While the M6 Toll did seem to aid in the development of nearby areas, this effect was relatively strong only within a five-minute radius and diminished quickly so as to be insignificant 15 minutes from a junction.
2. **Direct user benefits account for the largest share of all benefits.** The quantification of the employment benefits demonstrates that when set alongside the user benefits, they are relatively small.
3. **Quantitative evaluation is difficult, but achievable.** The Pugh and Fairburn paper highlights the challenges associated with quantification of some forms of economic impacts, however it does demonstrate that it is possible to tackle questions of causality and additionality with modern economic and statistical tools.

4.3 Southern Connector, Greenville SC (I-185-Toll)

4.3.1 Overview and rationale

The Southern Connector (I-185)⁷⁹ is a toll road in South Carolina, in the Southern United States, built between 1998 and 2001. It was established as a public-private partnership at a cost of \$231m USD in order to provide an alternative (tolled) route around the town of Greenville and for commuting into its downtown area. It is a four-lane highway 16 miles in length surrounding the southern part of Greenville and has four interchanges to local “feeder roads” leading to agricultural land.

The project had several stated purposes.

- **Addressing congestion.** The project was expected to provide an alternative route around Greenville, South Carolina, in addition to the congested I-85 between the major cities of Charlotte and Atlanta.⁸⁰
- **Commuting benefits.** The road was intended to provide another route for commuters into downtown Greenville, in addition to the congested US-276 and US-25.
- **Land development.** Part of the rationale for the I-185 toll road was to improve access to nearby rural farmland in the hope of converting it for industrial or commercial development.

At the time, the land development objective fit into the long-term economic history of the Greenville area. The region was a major textile centre in the first half of the 20th century, becoming the most populous county in the state of South Carolina, and over time it transformed into a hub for corporate headquarters, manufacturing and warehousing. The nearby South Carolina Technology and Aviation Centre (SCTAC) is home to dozens of tech and industry companies

⁷⁹ The “I” is the US designation of a major interstate road.

⁸⁰ Charlotte, North Carolina and Atlanta, Georgia - 245 miles apart.

such as Michelin, Lockheed Martin and 3M, and the area was seen as attractive for further development.⁸¹

Figure 11 Path and images of the Southern Connector



Source: Metro Jacksonville

4.3.2 Quality of evidence available

The main source of information on the impact of the Southern Connector is the EconWorks case study on the project, commissioned by the Greenville County Government and conducted by Wilbur Smith Associates.⁸² It provides a limited quantitative assessment, comparing various economic outcomes before and after the road's construction, but is mostly qualitative in nature.⁸³

An additional study focusing on toll rates analyses traffic impacts and toll revenue in some detail, but only provides a general, before/after discussion as far as economic issues are concerned.⁸⁴

4.3.3 Transmission channels for contributing to economic performance

Several of the economic channels are likely to be relevant to this case study.

- Agglomeration.** The main travel time reduction as a result of the project is in traveling around Greenville rather than within it, treating the Southern Connector like a ring-road. While Greenville itself is a rather small town of 58,000 people (56,000 in 2000), the surrounding conurbation is much larger, with nearly 480,000 people living in Greenville County (380,000 in

⁸¹ The neighbouring county of Spartanburg is also home to BMW's main US manufacturing plant.

⁸² EconWorks is a database of transport case studies managed by the American Association of State Highway and Transportation Officials (AASHTO).

⁸³ https://planningtools.transportation.org/290/view-case-study.html?case_id=50

⁸⁴ See <http://www.southernconnector.com/pdfs/Southern%20Connector%20Rate%20Study%202011-20-15.pdf>

2000). Increasing the effective economic reach of such a region should have some agglomeration benefits.

- **Investment.** This channel could potentially be relevant, as the new road was expected to improve access to an existing cluster of capital-intensive businesses. If the SCTAC were to continue its growth, the road could be expected to support new firms entering the region, the expansion of existing firms, or both.
- **Labour.** The I-185-Toll could offer labour market benefits by improving commuter access to Greenville from more distant regions and thus driving suburbanisation. However, this channel may be limited given the relatively small size of the Greenville city centre itself.
- **Trade.** This channel could be important for the Southern Connector, due to the region's focus on heavy manufacturing, as well as its relative proximity to an international airport (~14 miles from the city centre) and to a major port in the city of Charleston (~200 Miles away).
- **Induced housing investment.** The Southern Connector improved links to nearby rural areas, and the transformation of these into industrial or commercial developments was one of the stated goals of the project. Such land use changes are especially likely to occur if new business investment flows into the region.
- **Displacement.** The potential for displacement is unclear.

4.3.4 Evidence of impacts

Traffic impact and timing

The traffic impact of the project was to save between 10 and 15 minutes of travel time along the original route of the US-276 and I-85, from south-east of Greenville to south-west of the city. However, the actual traffic volumes on the road were much lower than expected, with the low end of the range at 75% of the forecast and the high end at below 50% of the forecast. This is partially due to the larger flows of traffic using the north-south axis to get into Greenville, rather than making an east to west journey.

The Southern Connector opened to traffic in 2001, just as the dotcom bubble burst. The expected tech boom in upstate South Carolina did not materialise and traffic on the road was much lower than expected, to the degree that toll revenue was insufficient to pay off the partnership's original debt and it filed for bankruptcy in 2010.⁸⁵

Before-after comparison of economic indicators

As part of the EconWorks review, some figures were published comparing economic activity in the region pre- and post-project. While the population in Greenville County still grew at 15.3% in three years compared to pre-construction levels, jobs only grew at 12.5%, representing a nearly 2 percentage-point lower

⁸⁵ Its debt was later restructured in 2012

rate of growth in employment.⁸⁶ The drop in income per capita was much more dramatic, with a decrease of 15.8% over the same period.

These changes are largely attributable to the burst of the dot-com bubble at the time. While no attempt has been made to construct a suitable counterfactual in order to assess what would have happened in the region absent the new road, this would be a very difficult exercise. The magnitude of the overall economic changes in the region at the time was very high, and would make it difficult to untangle any effects of the road.

Specific barriers to land use changes

There has not been significant development of new land near the I-185 in the years after the toll road opened, despite it being one of the objectives. As of 2013 there is only one nearby rural region which has seen a very small number of new homes. The economic downturn of 2001 was mostly blamed for this (and later, the financial crisis), although as mentioned above, it is difficult to assess what would have happened in their absence. A few large corporations (such as Phillip Morris and a subsidiary of Toyota) have been reported to have expressed interest in expanding into the region, but no relocations came to fruition.

The evidence points at several additional barriers to the development of agricultural land in the vicinity of the Southern Connector:

- **Other infrastructure deficiencies.** The rural land near Exit 7, where the I-185-Toll connects to the US-25 has some development potential, and the new road decreases its effective distance from downtown Greenville substantially. However, water and sewer facilities in this area have limited capacity, and this has been quoted as limiting further development.
- **Inter-modal coordination.** There is an additional area of potentially attractive land near Exit 10, where the Southern Connector meets US-20. However, the local road in the area runs parallel to a rail line, and crossing rights have not been obtained from its owners, making development less feasible.
- **Other roads.** Finally, there is some land west of Greenville which connects to the I-185-Toll at Exit 12 alongside the local road designated SC-153. There has been some pressure to widen that road from two to three lanes, but it is unclear whether this has been a major issue holding back the area's development thus far.

4.3.5 Observations

The Southern Connector was a large, expensive project which has not been shown to deliver its intended economic benefits in its specific setting. Several lessons can be inferred from this.

1. **Direct user benefits are a critical part of the overall economic benefits, especially for toll roads.** The traffic forecasts did not materialise, so any

⁸⁶ The number of jobs within the Greenville city limits fell by 11.2%. There is not sufficient city-level data reported on the other indicators.

theoretical wider economic benefits would not be likely to have had the chance to feed through. However, in the case of a toll road this has the added impact of causing financial challenges for the partnership, with potential negative knock-on effects.

2. **Targeting a specific current industrial cluster without considering potential future changes in economic composition can be risky.** Despite the past investment from aerospace and other heavy industries, this did not continue after the road investment. This highlights the difficulty of forecasting the development of specific sectors, and suggests that road investments can be more robust from a policy standpoint if their rationale did not rely on one specific industry to be successful.
3. **Land use change depends on many different drivers.** While transport to the rural areas south of Greenville has been demonstrably improved by the construction of the Southern Connector, other barriers have stayed in place, namely railroad coordination and water and sewage capacity. This is a tangible illustration of the interactions between drivers of economic growth, and of the need to coordinate road investments with other policy tools.

4.4 A63 Melton Grade Separated Junction, west of Hull

4.4.1 Overview and rationale

The A63 Melton improvement involved the grade separation of three junctions West of Hull to improve safety, reliability and congestion. The junctions are along a key route connecting Hull (and its port) to Leeds, Sheffield and the national motorway system. The scheme had three main objectives:

- Remove junction delays;
- Eliminate accidents caused by conflicting movements at three at-grade junctions; and
- Facilitate new development and regeneration of land around Melton, south of the A63 corridor⁸⁷.

The scheme opened in October 2006, although construction and traffic management continued until April 2007. The land development south of the A63 has been through two business parks: Melton West and Melton Park.

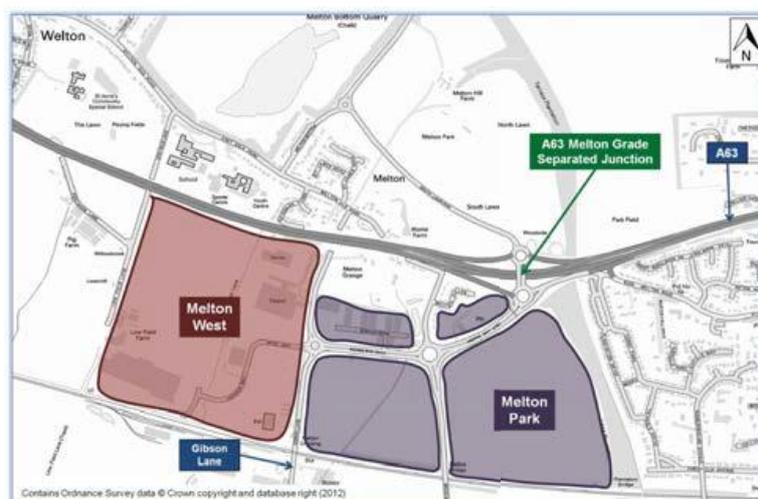
Other policies have subsequently been implemented around the area and wider region. This includes port investments in the Humber region and local growth policies through the Humber Local Enterprise Partnership⁸⁸.

The scheme is shown in Figure 12.

⁸⁷ Highways Agency (2012), 'Post Opening Project Evaluation: A63 Melton Grade Separated Junction Five Years After Study'

⁸⁸ Humber Local Enterprise Partnership, 'Humber Enterprise Zone: the UK's Energy Estuary'

Figure 12 Melton GSJ, location of Melton Park and Melton West development sites



Source: A63 Melton Grade Separated Junction Five Years After POPE study

4.4.2 Quality of evidence available

There are three main evidence sources that we have identified to assess the impact of the road investment which are described in turn below.

- **POPE Five Years After Study:**⁸⁹ provides the most detailed evaluation of the road investment to date and was published in 2012. The study's primary focus is on the extent to which envisaged costs and benefits were achieved, particularly in terms of monetised time saving benefits. The impact of the road investment on developing the neighbouring business parks as Melton West and Melton Park is considered qualitatively, but no quantitative estimates are provided.
- **Evidence on business park investments:** we also include desk-based research of recent investments in the business park, including those in the time since the POPE report was published. These include material available on the websites of the business park owners, Wykeland for Melton West and St. Mowden for Melton Park.
- **Local and national policy documents:** these outline wider local and national policies that are relevant to understanding the impact of the road investment. These include local growth policies such as the Humber Enterprise Zones, and a Highways England study on the role of strategic road investments in economic growth.

4.4.3 Transmission channels for contributing to economic performance

The nature of the road investment and local economy affect the relevant transmission mechanisms through which the Melton Grade Separated Junction

⁸⁹ Highways Agency (2012), 'Post Opening Project Evaluation: A63 Melton Grade Separated Junction Five Years After Study'

could have contributed to boosting economic performance. We have identified three transmission mechanisms that are most relevant:

- **Trade:** the Melton Grade Separated Junction is located on a key freight route, close to the ports of Hull and the River Humber. The road improvement could therefore be important for boosting trade opportunities by improving access to these ports and freight routes.
- **Investment:** the development of the business park next to the road improvement could increase investment. Depending on the type of businesses locating at the parks, this could potentially include FDI or productivity benefits through clustering effects.
- **Displacement:** It is also important to consider whether the road improvement has caused investment to be displaced, potentially at the expense of surrounding areas.

4.4.4 Evidence of impacts

It is difficult to attribute trade and investment impacts to the road improvement because of a lack of quantitative evaluation evidence on economic impacts. There is evidence that the business park development has attracted investment that would otherwise not have occurred. However, there is very little evidence on the extent of any displacement effects in this investment.

Trade

There is limited evidence available in the sources identified to determine trade affects attributable to the Melton road investment. However, journey time and reliability improvements have been achieved, which are a necessary pre-condition for contributing to trade improvement (and measures of business user benefits would capture most trade benefits). The road is also positioned on strategic freight routes suggesting a potential role for supporting trade growth.

The POPE report finds that journey times and reliability have improved since the Melton road improvement opened. This is found to be the result of removing the delays and congestion occurring at the junctions previously. The journey time improvements identified are outlined in Figure 13. These improvements suggest the potential to help facilitate increased trade opportunities along the A63 and surrounding areas, particularly since business and freight traffic use this junction. However, it should be noted that traffic flows, and monetised benefits, were both found to be lower than forecast. This is thought to reflect the impact of the recession.

Figure 13 Estimated journey time savings

Journey	Approximate time saving
A63 traffic	30 seconds to 1 minute
Swanland - North Ferriby	1 to 2 minutes
Melton Bottom – Gibson Lane	1 minute southbound, no change northbound

Source: Highways Agency (2012), 'Post Opening Project Evaluation: A63 Melton Grade Separated Junction Five Years After Study'

The Melton road improvement is located along a key strategic trade route. Highways England identifies the ports in and around Hull as among the busiest freight routes in the country, representing international gateways for trade. The A63 corridor has easy access to the M62 and M18. Some 75% of the UK's manufacturing base, and 40 million people, are within 4 hours drive of the Humber⁹⁰. The Humber region also provides some of the main eastern ports within the Northern Powerhouse city regions.

The evidence available suggests a strong potential for the Melton road improvements to contribute to economic performance through opening trade opportunities. However, it is not possible to attribute trade benefits to the road improvement given the evaluation evidence available to date.

Investment

The two business parks in Melton have both been developed since the road investment took place. The road improvements appear to have played a crucial role in unlocking this investment by alleviating planning concerns that changes in land use would contribute to congestion. Development has also been supported by local policies to stimulate economic growth as part of the Humber Enterprise Zones network.

The development of the business parks was confirmed by a site visit for the POPE report, although it was found that development had been slower than anticipated. The POPE report found that the development sites could not have occurred without the road improvement in place. This is because planning conditions limiting the number of vehicles onto the A63 had previously restricted development in the area.

Development has since continued. The business parks cover an area of 34.5 hectares and offer warehouse, office and industrial uses. The companies located there include: Heron, Paragon, Allam Marine, House of Townend, Kohler Mira, Needlers Safety, ERYC Supplies, Bluestorm Media, Norman Walker and Claughtons Office Supplies.⁹¹ The business parks are also supported by wider local policies, notably benefiting from Enterprise zone status as part of the network of Humber Enterprise Zones. This allows the business parks to benefit from Business Rate Discounts and the potential for financial support from government as Assisted Areas.⁹²

Displacement

There is little evidence available on the extent to which the business investment could be displaced from elsewhere. Displacement effects can often be greatest from areas immediately surrounding an area of investment.⁹³ However, this issue is not addressed in the POPE report or the wider evidence identified on the Melton investment. It is possible to consider displacement issues anecdotally looking at examples of companies located at the business parks. For instance,

⁹⁰ Humber Local Enterprise Partnership, 'Humber Enterprise Zone: the UK's Energy Estuary'

⁹¹ Humber Local Enterprise Partnership, 'Humber Enterprise Zone: the UK's Energy Estuary'

⁹² Humber Local Enterprise Partnership, 'Humber Enterprise Zone: the UK's Energy Estuary'

⁹³ See for example Chandra and Thompson (2000)

the examples of Heron Food and the manufacturer Allam Marine are outlined briefly below. Both appear to relate to expansion plans rather than a straightforward switching of activity, but further research would be needed to understand if such investments would otherwise have located at other locations nearby, and the potential impacts.

Example investments at Melton business parks

- **Heron Foods** moved to Melton West in 2009 having previously been located in West Hull. The new facility was designed to enable the Company to continue with growth plans, with its previous site described as “ageing”.⁹⁴
- **Allam Marine** opened a new headquarters in Melton West in 2012. This added to the manufacturers existing base on an adjacent site and allowed a doubling of capacity.⁹⁵

4.4.5 Observations

Several lessons can potentially be drawn from this case study.

- **Road investments can unlock business investment where there are specific barriers.** The clearest evidence from this case study for our economic framework is through the role road improvements can play in changing land use to attract investment. Planning permission can restrict development in areas where adding to congestion is a concern. Through addressing congestion concerns, road improvements can therefore help to unlock sites for investment. The POPE report finds that the business park developments in Melton could not have occurred without the road improvement. This is in contrast to a very similar roads investment along the A66 (see section 4.1), where such a specific barrier did not exist and land use changes did not materialise.
- **Transport policy interactions with other policy.** The case study also highlights the important interactions between road investments and wider policies, with local growth initiatives also appearing to play an important role for growing the business parks.

4.5 Interstate 105, Los Angeles

4.5.1 Overview and rationale

Interstate 105 was completed in 1993 to provide an east-west road through central Los Angeles at a cost of \$2.3 billion.⁹⁶ It connects one of the existing main arteries of the city (I-605) to the LAX international airport, and was the last road in a multi-year plan for an interconnecting grid of highways through the Los Angeles urban area.

⁹⁴ <http://www.heronfoods.com/corporate/timeline>

⁹⁵ <http://www.freeofficefinder.com/article/allam-marine-launches-new-head-office-in-hull>

⁹⁶ EconWorks impact study

The main objectives of the road improvement were:

- To reduce congestion of local streets and improve efficiency of the regional freeway network;
- Provide choice between high-speed highway or transit modes;
- Reduce accidents; and
- Enhance economic viability of planned commercial and industrial development.⁹⁷

Interstate 105 runs for 17.3 miles, and is primarily a pass-through route, connecting industries and LAX international airport in the west with residential areas in the east. It was designed to help facilitate freight movements to the aerospace and military industries. Interstate 105 also connects with the network of highways in Los Angeles, improving access to the Port of Longbeach and Hawthorne Municipal airport.

The scheme is shown in Figure 14.

Figure 14 Route of I-105 in California



Source: Wikimedia Commons, 2008

4.5.2 Quality of evidence available

We have identified two main evidence sources on the economic impact of Interstate 105:

- **EconWorks database of transport impact studies:**⁹⁸ provides an assessment of the impact of the road improvement. This includes before and after statistics of key economic performance indicators, but these are not directly attributed to the impact of the Interstate 105 investment. A narrative of the economic impact is also provided, outlining secondary

⁹⁷ EconWorks impact study

⁹⁸ <https://planningtools.transportation.org/223/case-study-search.html>

evidence sources and contextual information on wider economic drivers in Los Angeles following the road improvement.

- **Academic papers:** whilst not directly assessing the impact of Interstate 105, academic papers provide evidence of road impacts in neighbouring areas in and around Los Angeles. There are also papers evidencing the wider changes in Los Angeles that are very important for understanding the context of subsequent economic changes.

4.5.3 Transmission channels for contributing to economic performance

The location of Interstate 105 in a busy metropolitan area, with links to local industry and transport connections, suggests three transmission mechanisms are relevant:

- **Agglomeration:** the road investment is located in a metropolitan area. It aimed to connect the aerospace industry hub and LAX international airport with residential areas to the east of the road. By facilitating greater access to a wider pool of labour, the road improvement could therefore have contributed to agglomeration benefits, increasing productivity.
- **Investment:** Interstate 105 was designed to improve freight movements to the aerospace industry hub. This was intended to enhance economic viability of planned commercial and industrial development, increasing investment.
- **Trade:** the road improvement could also help to encourage trade through improving transport connections. The road runs to LAX international airport, connects (via southbound interstates) with Port of Long Beach, and was the final part of a network of road improvements in Los Angeles.

4.5.4 Evidence of impacts

There is limited evidence on the impact of Interstate 105 on the transmission mechanisms identified above, but a potential role is identified.

Agglomeration

The evidence identified does not include estimations of agglomeration impacts attributable to Interstate 105. However, the EconWorks study assesses whether journey time and congestion objectives were achieved, which are a necessary pre-condition for achieving agglomeration impacts. This evidence suggests a potential for agglomeration effects to have occurred. Economic indicators before and after the road improvement provide a mixed picture, and do not allow attribution of impact because wider changes are not controlled for.

Interstate 105 initially resulted in significant improvements in journey times. Average east-west vehicle speeds improved from 23 to 28 miles per hour (mph) prior to construction, to 45 to 55 mph after construction. However, travel speeds subsequently fell back to 23 to 28 mph, with only taxis and shuttles to LAX airport benefiting from continued congestion reductions because of the use of separate

lanes.⁹⁹ The short-lived journey time improvements were identified by EconWorks as the result of traffic flows significantly exceeding projections. Whilst this does not help congestion, it does suggest the road improvements are facilitating more journeys than could otherwise have been accommodated without Interstate 105.

The EconWorks study also provides evidence of economic indicators relevant to agglomeration, with comparisons of data before and after the road improvement. For example, population density in the local area increased by 19%, the number of jobs increased by 19% and house prices increased by 106%. However, personal income per capita fell by 29%. These comparisons do not control for important wider changes in the local economy, meaning impacts cannot be attributed accurately to the road improvement from this evidence.

Two academic studies provide estimates of the impacts of separate road investments in nearby areas. A study in Orange County, south of Los Angeles, estimated house price and road use impacts of a separate set of road improvements in the 1990s (Boarnet and Chalermpong 2001). These found evidence of a house price premium for access to improved roads and some evidence of induced travel from improved highway capacity. A study of an extension to Interstate 210 east of Los Angeles also found evidence of house price appreciation caused by the road investment (Chernobai et al 2011). These effects could potentially be associated with agglomeration benefits if they reflect greater access between residential areas and workplaces. However, it is not clear if similar impacts occurred from Interstate 105 given differences in the local areas.

Investment

Interstate 105 was intended to help enhance investment through improving connections with the aerospace industry hub to the west of the road. These impacts did not occur because of a series of wider events. The aerospace industry has declined considerably, with the sites since converted to lighter industry and offices. It is possible the road improvement may have helped to facilitate this change in use following the decline of the aerospace industry. However, assessing the economic impact of the road improvement on investment is very difficult given the substantial wider changes.

The EconWorks study outlines a series of wider changes that impacted the Los Angeles economy following the completion of Interstate 105. These make isolating impacts of the road investment particularly difficult.

- **Decline of the aerospace industry:** there was a major decline in the industry around the time Interstate 105 was completed. The end of the Cold War reduced demand for aerospace and military businesses, and a national recession affected the aerospace industry alongside other sectors. The aerospace industry had comprised 20% of manufacturing jobs in Los Angeles in 1987, but most firms subsequently collapsed or relocated.¹⁰⁰

⁹⁹ EconWorks impact study

¹⁰⁰ EconWorks impact study

- **Riots:** Los Angeles experienced major riots in 1992 and a State of Emergency was declared. The riots are found to have had a lasting impact on local economic performance, with one study estimating a cumulative loss of taxable sales over the 10 years since the riots of at least \$3.8 billion (Matheson and Baade 2004).
- **Northridge earthquake:** a major earthquake occurred in Los Angeles 1994. This disrupted economic activity along the Interstate 105 corridor and across the city.

Trade

The evidence identified does not include trade impacts of Interstate 105, but its location suggests a potential role in facilitating trade opportunities.

Interstate 105 provides access to LAX international airport and is part of a network of road improvements made across Los Angeles. Interstate 105 is also well connected to the Port of Long Beach, via Interstate 710. The Port is the second busiest in the United States, accounting for a third of all loaded containers moving through California and nearly 1 in 5 of those moving through all United States ports.¹⁰¹

4.5.5 Observations

Several lessons can potentially be drawn from this case study.

- **Available evidence on causal impacts is limited.** Interstate 105 provides mixed evidence on contributions to economic performance. The case study also highlights limits in the available evidence, making it difficult to attribute specific economic impacts or transmission effects to the road improvement.
- **Induced traffic limited congestion relief benefits.** The road improvements led to a short-term reduction in congestion and facilitated long-term increases in traffic volumes across a major metropolitan area that over time outweighed many of the congestion benefits.

4.6 US Route 460, Blacksburg, Virginia

4.6.1 Overview and rationale

The US Route 460 bypass provides a direct route between Interstate 81, a major arterial road in Virginia, and Blacksburg, home of Virginia Tech. It improves access from the university and high tech clusters to major urban centres, an export port and a nearby airport. There were two main objectives:

- To provide a direct link between Blacksburg high tech cluster and Roanoke, southwest Virginia's largest city; and
- To resolve congestion that was causing delays and environmental degradation.

¹⁰¹ <http://polb.com/about/facts.asp>

The road improvement was completed in 2002, providing a 12.5 mile bypass at a cost of \$187 million.¹⁰²

4.6.2 Quality of evidence available

The main source identified on the economic impact of US 460 is the **EconWorks case study database**. This provides before and after metrics of key economic indicators and impacts, but evidence attributing changes to the road improvement is limited. The EconWorks study also outlines a number of wider economic impacts for the local area around the US 460 and how these may be related to the road improvement.

4.6.3 Transmission channels for contributing to economic performance

There are a number of potential transmission mechanisms through which US 460 relevant for this case study:

- **Agglomeration:** the road improvement is intended to improve connectivity between a high tech cluster and a large urban area. It also provides improved connections to local universities. This could be expected to improve access to a wider pool of labour, with potential agglomeration benefits.
- **Skilled labour:** the high tech cluster in Blacksburg includes Virginia Tech University and a research centre. US 460 also improves connections to areas with local amenities in Christiansburg, which is a prime shopping destination. The road improvement could therefore lead to economic benefits through helping to attract and retain high skilled labour in the area.
- **Investment:** the road improvement provides better access to several sites: the high tech cluster noted above, business parks, and is intended to reduce congestion that has been seen as a barrier to development. US 460 could therefore be expected to help stimulate investment in these areas.
- **Trade:** US 460 connects to heavy freight routes and a region with three airports. Improvements in these routes could be expected to help facilitate trade opportunities.

4.6.4 Evidence of impacts

The evidence suggests US 460 is likely to have helped contribute to economic performance in Virginia. However, evidence attributing impacts to the specific transmission mechanisms is limited. 'Before and after' indicators show an 18% increase in the number of jobs, 12% increase in population density, 77% increase in house prices, but a fall of 4.5% in income per capita.¹⁰³ However, these changes are not directly attributable to the road improvements. Estimates of the

¹⁰² EconWorks impact study

¹⁰³ EconWorks Impact Study

county impacts from the EconWorks study are shown in Figure 15 below. The majority of job impacts relate to supporting business development sites, although details of the estimation methodology are not provided. Evidence on each transmission mechanism is discussed further in turn below.

Figure 15 Estimated county impacts from the EconWorks study

Measure	Direct	Indirect	Total
Jobs	748	542	1290
Income (\$m)	33.39	24.20	57.59
Output (\$m)	80.96	58.67	139.63

Source: *EconWorks Impact Study*

Agglomeration

Agglomeration impacts are not estimated in the evidence identified. However, the evidence suggests potentially relevant impacts from the road improvements. Previous routes were congested which was impeding traffic flows to the university and commuter traffic. US 460 has since improved connections between:

- Virginia Tech University;
- Business parks such as Falling Branch Corporate Park and Blacksburg Industrial Park, and
- Residential areas such as Blacksburg and Christiansburg.

The EconWorks study also finds that access improvements from US 460 have expanded regional commuting more widely. The improved connections between these sites, and the growth of the High Tech cluster at the university, are likely to have increased access to skilled labour. However, these impacts are not quantified in the evidence identified.

Skilled labour

The EconWorks study finds evidence that the road improvement, alongside wider policy changes, has helped to retain skilled labour in the area. Virginia Tech University and its Corporate Research Park have grown significantly and hence suggest retention of skilled labour.

Wider policies that improve quality of place could also have helped retain skilled labour. US 460 has improved access to local amenities such as the shopping area in Christiansburg. There have also been wider local policies, such as tourism campaigns from local government that are seen as having improved the image of the region.

Investment

There is evidence that the road improvement has also helped to facilitate local investments on a number of sites. The EconWorks study attributes particular impacts to the Falling Branch Corporate Park, and unlocking a football stadium expansion at Virginia Tech:

- Falling Branch Corporate Park is a 175 acre site located near the interchange of US 460 and Interstate 81. The majority of the 748 additional jobs estimated in the EconWorks study relate to this site.
- Virginia Tech football stadium was expanded to add an extra 10,000 seats. The EconWorks study finds that this investment could not have occurred without the road improvements. This is because there were previous concerns of congestion in the local area on match days.
- Virginia Tech Research Centre and Blacksburg Industrial Park are also found to have benefited from improved access as a result of US 460, which could have facilitated investment.

Trade

US 460 appears to play an important role as part of a network for regional freight movements. It may therefore have helped to facilitate trade opportunities, although attributable impacts to the road improvements are not quantified in the available evidence. There have also been wider policies potentially contributing to trade in the region, such as the creation of a Foreign Trade Zone and Customs Port of Entry at New River Valley Airport, which offers tax duty advantages.

The primary freight movements are heavy raw materials, such as clay, lumber and stone. Transportation connections for these freight movements are highlighted as increasingly important to the local economy in the EconWorks study. The region also includes three airports: New River Airport, Virginia Tech/Montgomery Executive Airport and Roanoke Regional Airport. There appears to be a potentially important role for US 460 in facilitating trade movements in the region, alongside wider drivers, but there is a lack of evidence attributing impacts.

4.6.5 Observations

Key observations from the available evidence are:

- **As changes in the economy occur over time, the study highlights that quantification of benefits attributable to a particular road intervention is challenging.** There has been significant economic development in the area of US 460 since the road improvement, notably the growth of a high tech cluster and business parks. The road improvements are seen as having been particularly important for business park investments, though there have been substantial changes in non-transport policies that make attribution of any particular impact to the road investment challenging. Obtaining primary evidence through surveys of local businesses and the drivers of their location decisions could help provide insights in this regard.
- **Interactions between channels can play an important role.** US 460 provides an example of a road improvement that could impact a number of the channels in our economic framework simultaneously. This suggests a potential for a self-reinforcing effect over time as the channels interact.
- **Benefiting multiple sectors lowers the risk of being exposed to a down turn in any particular sector.** The road improvements from US 460

have also benefited more than one sector. Trade routes for heavy freight were improved as well as access to the growing high tech cluster. The road improvements also connect several urban areas and wider transport links. Road improvements motivated by several economic drivers may be more likely to influence economic performance, and could be less exposed to risks from a single driver or sector experiencing a decline.

- **Local policy interacts with transport policy.** The case study highlights interactions between road improvements and wider local policies, such as those aiming to support tourism and trade. This suggests that road improvements can be a necessary, but not always sufficient, condition for enhancing economic performance.

4.7 A249 Iwade to Queensborough Improvement

4.7.1 Overview and rationale for the intervention

The Isle of Sheppey in North Kent is home to over 30,000 people¹⁰⁴ and separated from mainland England by the Swale Estuary. It is a popular spot for bird-watching¹⁰⁵ and caravan holidays, while the Port of Sheerness is an important point of import for cars, forestry products and other dry bulk goods as shown in Figure 16.

Figure 16 Port of Medway Cargo v. UK Cargo

Bulk or Commodity Type	Share of UK Volumes (%)	Rank
Forestry products	22.7	1
Iron and steel products	4.4	9
Liquefied Gas	7.6	4
Other dry bulk (exc. coal, ores, iron, steel, forestry and agricultural products)	6.3	4

Source: <https://www.gov.uk/government/statistical-data-sets/port03-key-port-statistics>

Before construction began on the A249 Iwade to Queensborough Improvement in 2004, there was only one road crossing over the Swale estuary. This crossing (the Kingsferry bridge) is a narrow, two-lane road-rail bridge which had to regularly stop traffic to lift up and allow ships to pass (see Figure 17). The key aim of the scheme was to improve the capacity and reliability of the road connection between the Isle of Sheppey and the mainland, so the scheme involved constructing a dual-carriageway bridge over the estuary, next to the Kingsferry Bridge. In addition to a new bridge, the improvement included dualling the road all the way to the town of Queenborough on the Sheppey side, a route which had previously only been single carriageway. The scheme opened in July 2006 and ultimately cost £91.1m.

¹⁰⁴ Calculated using parish figures from 2011 Census

¹⁰⁵ <https://www.elmleynaturereserve.co.uk/about-us>

Figure 17 Kingsferry Bridge opening to allow ships passage

Source: POPE Five Years After report

The new link was expected to:

- Relieve the constrained capacity of the previous crossing;
- Improve journey times and reliability;
- Reduce accidents; and
- Contribute to the broader economic regeneration of the Swale and North Kent area.

4.7.2 Quality of evidence available

The POPE Five Years After report is the main resource for this case study, along with a later report by Highways England on Assessing Economic Growth Impacts. The POPE report is very detailed on traffic and accident impacts, but less so on economic impacts. Their assessment consists of interviews with local stakeholders, including the local Borough council (Swale) and affected economic development authorities. The Assessing Economic Growth Impacts report is more specific on economic statistics, providing information on commuting patterns, industrial mix and quantifying induced investment. We have also drawn on publicly available information regarding freight volumes and population growth.

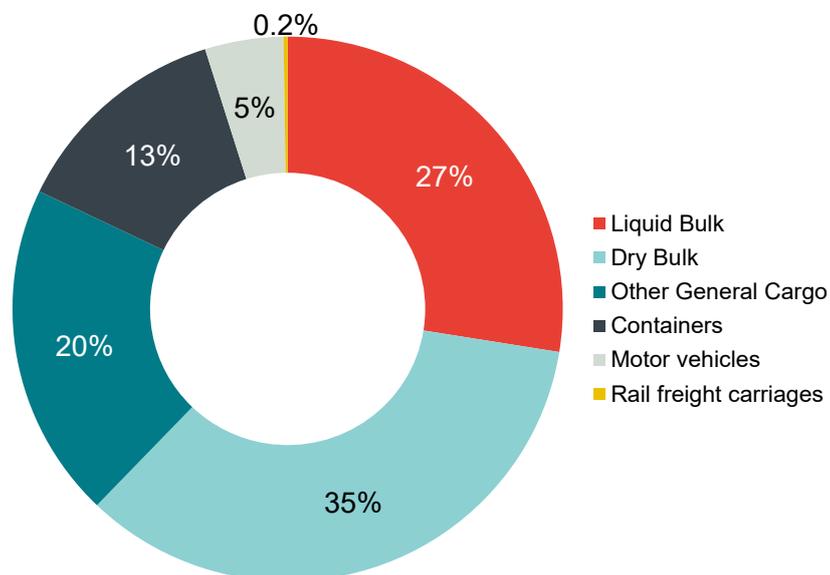
The evidence available is helpful in understanding the economic context of the scheme, and perceptions and characteristics of the area since its opening. It does not, however, provide quantitative estimates of the causal effect of the investment, nor does it allow us to be precise about displacement effects.

4.7.3 Transmission channels for contributing to economic performance

Since the borough of Swale is mostly rural, agglomeration effects are likely to be limited – the entirety of the affected area falls outside the WebTAG definition of a “functional urban region”.¹⁰⁶ However, the Isle of Sheppey itself, and the surrounding areas, could expect changes through the following mechanisms:

- Investment:** Businesses in the area would expect to benefit from lower congestion, better journey times, more reliability and better access to potential customers and workers. Businesses on the Isle of Sheppey (or which wished to establish themselves on the Isle of Sheppey) would expect to be particularly big beneficiaries. The reliability of moving goods on and off the isle would be drastically different, so a major barrier to sustainable, safe investment would be removed.
- Trade:** The Port of Sheerness, located on the Isle of Sheppey, is an international hub for freight travelling by sea. It accepts millions of tonnes of inbound freight, mainly dry bulk and cargo (according to statistics for the Port of Medway, see Figure 18). These goods (such as wood or automobiles) are heavy and costly to transport, meaning the improvements to the A249 would be expected to facilitate further trade volumes.

Figure 18 Port of Medway¹⁰⁷ Freight Volumes 2015



Source: [Department for Transport, Maritime and Shipping Statistics \(2016\)](#)

¹⁰⁶ These are regions where “productivity impacts could be expected to be significant”. See unit A2.4 of DfT 2016 wider economic impacts consultation for a full description of how this classification is used.

¹⁰⁷ The Port of Sheerness itself is incorporated with the Chatham Dockyards into the Port of Medway.

- **Displacement:** There is the potential for displacement. For example, higher trade volumes in Sheerness might have otherwise passed through other ports in the South-East (such as London).

The fundamental change to the economic situation of the Isle of Sheppey following the construction of the Scheme was that road access to and from the island was twice as fast and considerably more reliable. This means that for businesses and people, locating oneself on the island became far less risky and costly, both from the perspective of a commuter and a business which needs to move goods. In the 2001 Census (prior to the scheme), 66% of Sheppey residents who were employed commuted to somewhere else within the Isle. Another 13% commuted across the Kingsferry Bridge to another part of Swale. The bridge therefore offered the potential to increase the effective size of the market of North Kent, and make it more viable for firms to locate on the Isle of Sheppey, especially for those businesses who could benefit from proximity to the port.

The importance of Sheerness as an import hub also implies that better connectivity of the port with the mainland offers the potential to lower the costs of trade.

4.7.4 Evidence of impacts

Investment

In the POPE report, a number of local stakeholders cite business investments that have occurred since the opening of the new Sheppey Crossing. A number of respondents note that new retail stores (including Sainsbury's and Morrisons) were planned for locations on the Isle of Sheppey. This could be interpreted as a response to widening of the effective market (more people are able to shop at these locations) and reductions in logistical costs for the retail companies involved. Another project of particular interest in both the POPE and Assessing Economic Growth Impacts reports was the establishment of a Morrisons distribution centre in Kemsley Fields, on the Kent side of the Swale near Sittingbourne. This too suggests that businesses particularly dependent on road logistics can be attracted by improved road infrastructure.

Beyond retail and logistics services, evidence for improved investment in the area is limited. One example cited in the POPE report is of a Danish wind turbine company (Vestas) that was planning on opening a plant in Sheerness to meet UK demand. The Thames Gateway North Kent group suggested that the proposals for the manufacturing facility would have been unlikely without the improved A249 in place. Ultimately, however, the proposals fell through, and no plant was built. Meanwhile, employment in the Port of Sheerness itself continued to decline and a steel factory on the Isle closed, costing 400 jobs (although that factory has since reopened in a limited way).

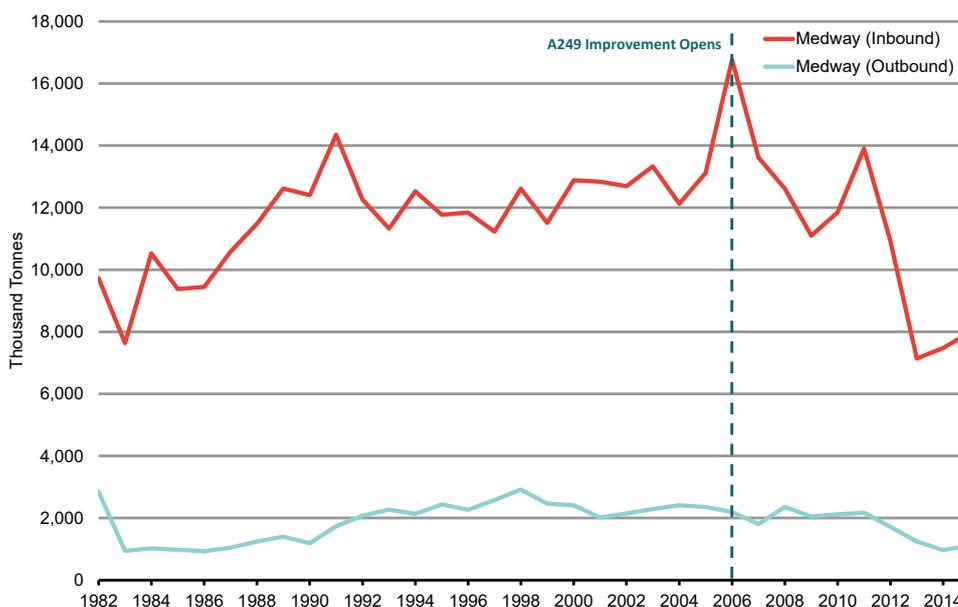
Trade

Neither the POPE report nor the Assessing Economic Growth Impacts report addresses the way trade volumes have changed in response to the

improvements to the A249. While freight volumes at major ports are publicly available, Sheerness figures are combined with those for Chatham, so it is not possible to be precise about how port volumes changed.

With the data available, however, there are observations we can make. For example, in Figure 19 we show the volumes of freight inbound and outbound at Medway. There is a large peak in trade volumes the year the A249 opens, a gain which is quickly removed by the financial crisis of 2007 onwards.

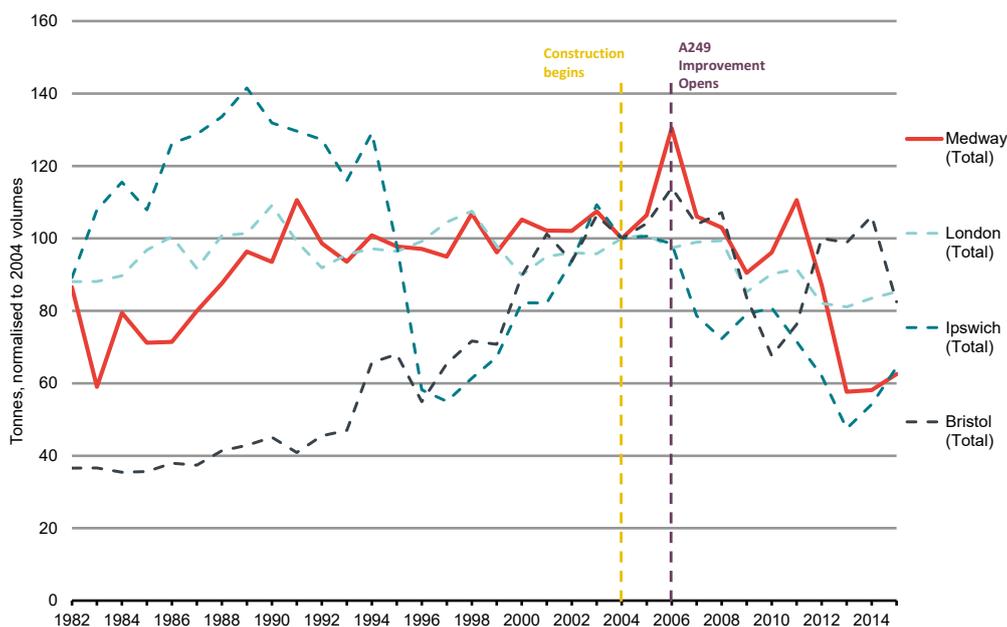
Figure 19 Port of Medway Freight Volumes over time



Source: [Department for Transport, Maritime and Shipping Statistics \(2016\)](#)

Note: The Port of Medway (owned by Peel Ports) incorporates the Ports of Sheerness and Chatham Docks

Figure 20 shows the proportional changes in volume for other ports in the UK: London (nearby), Ipswich (nearby) and Bristol (similar composition of cargo). With volumes normalised to 2004 (when construction began), we can see a big growth in freight volumes for Medway that is not experienced by other comparable ports. After 2010, however, it is difficult to see any lasting positive effect of the A249 on trade volumes for the Port of Medway.

Figure 20 UK Port Volumes

Source: [Department for Transport, Maritime and Shipping Statistics \(2016\)](#)

Note: For each port, the 2004 value is normalized to 100

Displacement

There is not enough evidence to accurately describe or quantify the displacement of trade and investment from elsewhere in the UK. We can nonetheless note that, for example, the logistics and distribution centres built near the scheme would likely have been built somewhere else nearby without it.

4.7.5 Observations

Key observations are the following:

- **Quantification of a contribution to economic performance is challenging.** Evidence of economic impacts of the A249 is limited. However, the finding that access to and from the island was twice as fast and more reliable suggests benefits to all business and freight traffic using that route were material, and these would percolate to the economy.
- **Logistics firms may be more sensitive to roads investment.** The construction of new distribution centres in the area and better availability of retail providers who rely on those services suggests the road investment could have played a part in these location decisions.

4.8 Oresund Bridge

4.8.1 Overview and rationale for the intervention

The concept of a fixed link between Sweden and Denmark had been discussed long before the Oresund Bridge was ultimately built over the course of the 1990s. When it was opened in 1999, it was expected to:

- Link two of the largest cities in the region;
- Improve the development and economic potential of the region; and
- Provide better strategic transport links across Northern Europe (for example from Hamburg to Stockholm).

The scheme is shown in Figure 21.

Figure 21 Oresund Bridge



Source: *Wikipedia*

Note: *View from a plane taking off from Copenhagen airport*

The project cost was €2.6 billion, financed by loans from the Danish and Swedish governments that are currently being repaid through tolls. The scheme involved construction of a four lane road, of which 5 miles was a bridge and 2.5 miles was a tunnel, alongside which runs a dual track rail line. The scale of this scheme makes it difficult to be precise about the individual effects of the road link (it will not be separate from the rail link and other complementary policies), but it does

provide some insight into the potential gains from a transformative improvement between two city centres.

4.8.2 Quality of evidence available

Evidence includes traffic figures, commuting figures, qualitative and anecdotal evidence, region-level statistics and econometric estimations of the causal impact of the scheme.

We draw on all of this evidence in the assessment that follows.

4.8.3 Transmission channels for contributing to economic performance

The size, the economic mass and geographical proximity of the connected cities (Copenhagen and Malmö) mean that all of the outlined mechanisms are relevant to consider.

- **Agglomeration:** Since the bridge linked two large urban centres, agglomeration effects are expected to be observed. Both cities have large universities, high-tech sectors and well-educated populations. There are cultural barriers to integration and learning, given the language is different in each city, but the language can generally be understood both ways.
- **Investment:** the improved connectivity between these cities suggests that firms may have an increased incentive to choose the Copenhagen-Malmö conurbation over other urban centres in Scandinavia. This could be particularly true of those firms that stand to benefit from the high-knowledge sector, or have particular demand for the cross-border hub that the new bridge provides.
- **Labour effects:** the improved connectivity between the two urban centres would be expected to provide firms with increased accessibility to a larger labour pool, and workers with greater accessibility to jobs for which they are better suited. Malmö in particular has become a high profile centre of immigration, which is driven in large part by the employment opportunities across the bridge.
- **Trade:** reducing the cost of moving goods between the two regions would make importing and exporting more worthwhile for consumers and firms on either side. Furthermore, increasing the effective size of the market would give companies on both sides greater capacity for specialization.

4.8.4 Evidence of impacts

In terms of agglomeration, there are a number of reasons to believe that workers and firms in the Oresund Region have become better at sharing inputs, matching and learning from the activity around them. Since the bridge was built, the Lund and Copenhagen universities have formed the Oresund university alliance, with a focus on joint programmes and research, centred primarily on life sciences. An already successful biomedical science cluster has also continued to grow and unemployment levels across the two cities have both improved. In 2000, the

unemployment rates in Copenhagen and Malmö were 3.6% and 5.6% respectively; by 2007 those figures were 2.5% and 3%. Productivity growth statistics also suggest an improvement. Productivity in the region grew by 5.3% between 2000 and 2009, compared to 4.2% for the EU27¹⁰⁸. This is slightly above average for the area but not when compared to other cities in Scandinavia.

There is also evidence to suggest that firms and workers have responded positively to the improvements brought about by the new road. Firm creation in the Öresund area is better than the national average in either Sweden or Denmark. In 2009, 22,500 new companies were launched in the Öresund region, accounting for 26% of all new businesses in Sweden and Denmark.¹⁰⁹ The science and high-tech manufacturing industries have been particularly successful in attracting investment and expanding their operations. A number of foreign firms have opened branches in the area which might otherwise have chosen nearby cities – the American biomedical research company Biogen chose Copenhagen as the location for its first non-US office.¹¹⁰

The large, single pool of labour created by the construction of the bridge has benefited employers, and the area has also been successful at attracting outside labour. The population of the area has grown by 270,000 since the opening of the scheme, with much of the growth focused on the Swedish side. Education levels have also risen slightly faster than national averages, meaning higher levels of skilled labour available to firms.¹¹¹

The Öresund area has also improved as a trade hub, benefiting the region through improved scope for specialisation and improved investment. The port has become a key point for importing cars from the US, Japan and elsewhere, acting as a distribution point for much of Northern Europe. The area has also been able to expand its already highly specialised industries due to the greater scope for export.

Quantitative estimates of the economic benefits of the Öresund Bridge show substantial benefits from the investment. One paper finds improvements in income of up to 7% on the Swedish side of the bridge, with positive welfare effects all around (Sundberg, 2005). Another estimate suggests that approximately 20% of growth in the region can be attributed to the bridge, contributing over 30,000 jobs since the start of construction.¹¹²

However, there remain barriers to trade and integration, specifically tolls, culture and politics. One study suggests that the \$2 Billion USD a year are lost to the region due to the high tolls for crossing the bridge (over 40 EUR), compared to a hypothetical crossing without tolls (Sundberg, 2005). Other researchers note that differences in policies across borders, non-transferability of qualifications and other cultural differences continue to prevent the realisation of the full potential of economic benefit.¹¹³

¹⁰⁸ See <http://www.orestat.se/en/analys/economic-developments>

¹⁰⁹ See <http://www.orestat.se/en/analys/business-structure>

¹¹⁰ EconWorks Case Study

¹¹¹ See <http://www.orestat.se/en/analys/demographics>

¹¹² Cited in EconWorks Case Study

¹¹³ McEwen and Petersohn; OECD Regional Development Paper Series

4.8.5 Observations

Key observations are:

- **Connecting two isolated urban centres can benefit both cities.** In this particular case, both cities that were better connected appeared to benefit from the improved connection, particularly in terms of employment, business investment and trade opportunities.
- **Composition of the local economy and labour market are critical factors.** The characteristics of the two cities that were better connected are likely to have played a key role in the extent to which the scheme contributed to economic performance. In this case both cities have large universities, high-tech sectors and well-educated populations, along with international connectivity infrastructure, such as the port.

4.9 Wisconsin State Road 29

4.9.1 Overview and rationale for the intervention

Wisconsin State Road 29 was the expansion of a dual carriageway into a 4 lane motorway along a 182 mile stretch between Green Bay and Chippewa Falls in the United States, costing \$617.5m¹¹⁴. Construction began in 1988 and the full road was opened in August, 2000. In the intervening 12 years, the road was expanded piece-by-piece in sections, gradually linking communities together.

The key motivation for expansion was safety. Before improvement, the road was a hilly, curvy two-lane highway commonly referred to as “Bloody 29”, with a fatality rate almost twice as high as the average for two-lane highways in the state (WisDOT report, 2004). Problems included poor visibility due to curves and hills; at-grade junctions; and high volumes of heavy trucks. Even before expansion, the route was an important east-west transportation link from many major Wisconsin communities along the Green Bay-Chippewa Falls corridor out to domestic and international markets such as Twin Cities (in Minnesota) and Canada. As this area grew, so did commuter and freight traffic, increasing the volumes of cars and trucks travelling through small communities and exacerbating the already serious safety problems.

The scheme is shown in Figure 22.

¹¹⁴ In 2013 USD

Figure 22 Routes of SR-29 and US-10

Source: Wisconsin Department of Transportation

4.9.2 Quality of evidence available

Due to funding from a number of federal sources, the Wisconsin state Department of Transport (WisDOT) was able to conduct a detailed study of the impacts of Highway 29 on the economy of the region.

In every town and city linked or bypassed by the highway, the WisDOT Economic and Land Use Impacts report details the land use change and impacts on property values. It also presents survey evidence from community members and representatives to establish their perception of how the road has affected the area. In addition, they collect representative surveys of industries, workers and communities from along the entirety of the corridor, as well as providing statistics on employment, incomes, business expansion, property values and more.

To establish how much of this activity was *caused* by the expanded four-lane highway, the WisDOT report compares many of the metrics for the SR 29 to the nearby, parallel US-10 – a two-lane highway travelling East-West from Appleton to Osseo. This “control” road was selected by local transport experts, and allows an interpretation of the impacts of the four-lane highway relative to a do-nothing baseline. The US-10 comparison does not, however, provide a clear insight into the additionality of induced economic activity, since it is unclear if new economic activity is displaced from elsewhere in the region.

Beyond the comprehensive WisDOT study, there are also local tourism and development plans and an EconWorks Case Study developed by Cambridge Systematics, Inc.

4.9.3 Transmission channels for contributing to economic performance

The SR-29 corridor is 182 miles long and mostly rural, and is therefore unlikely to materially contribute to agglomeration (though it does improve links between urban centres, albeit far apart). We have however identified the following mechanisms of economic impact as most relevant:

- **Investment:** businesses who value the local resources of Wisconsin (agricultural and food processing industries); businesses who need access to customers (retail and services) and businesses who rely on cheap and efficient transport (manufacturers) could be more likely to establish and expand around an improved SR-29.
- **Trade:** the city of Green Bay, at one end of the SR-29, has a port that provides access to shipping across the Great Lakes. It also has a major packaging and distribution industry, providing a gateway for the raw and intermediate materials used by manufacturers across the Midwest. At the other end of the SR-29, access to the Twin Cities of St. Louis and Minneapolis provides routes to the rest of the U.S. and other international markets. The major improvements to efficiency and reliability along the expansion corridor would be expected to increase the viability of trade.
- **Displacement:** we would expect the increase in economic activity along the expanded corridor to come at the expense of other parts of Wisconsin and the Midwest. The road would not be likely to increase productivity, but could focus economic activity around it.

4.9.4 Evidence of impacts

By 2004, preliminary traffic data for Wisconsin SR 29 indicated a 75% increase in vehicle miles travelled and a 50% drop in the fatality rate.

Trade

The WisDOT report finds that traffic along the corridor has increased significantly. This is driven primarily by more trucks and heavy goods vehicles transporting goods. Much of this is attributable to the increase in industry driven by the road investment, but given the presence of Green Bay at one end of the road, broader trade effects could be likely. The importance of ports along the Great Lakes has been in decline for years and, while the EconWorks summary finds the importance of SR-29 in transporting wind turbines out of Green Bay to Minnesota and Iowa, tonnage at Green Bay continues to fall. This is unlikely to be related to the road – dry freight carried on the Great Lakes has traditionally been the raw materials for the automobile industry which is declining for external macroeconomic reasons. It is however possible that the road investment has preserved Wisconsin trade volumes at the expense of other ports in the region.

Freight traffic on the road itself has nonetheless increased, but this is driven by improved production along the corridor and greater scope for export, not port trade.

Specialisation has been aided by the improved accessibility along the corridor. A number of communities noted that retail activity increasingly took place in centralised retail parks outside of the downtown area. Food processing industries in particular noted the importance of faster, more reliable transport in allowing them to sell their products in a more perishable form. Where previously dairy processors had to sell their products as part of a preserved food, they were more able to ship perishable cheeses, butters and creams directly to consumers. The WisDOT report unfortunately does not provide detailed trade volumes and they are not readily available elsewhere.

Investment

Between 1995 and 2003, the number of businesses in communities along the Highway 29 corridor increased by 55% from 10,464 to 16,256. Between 1990 and 2001, 151 manufacturing plants were either built or expanded. These statistics could suggest that the road project contributed to business investment. Furthermore, these improvements are robust to comparison with the “control” road provided.

Figure 23 Business Growth in WI Highway Corridors

Wisconsin Highway 29	US Highway 10	Difference
5,972 new businesses, growth of 55%	1,747 new business, growth of 17%	4224 more new businesses, 38% more growth
151 manufacturing expansions accounting for 6,269 jobs	186 manufacturing expansions accounting for 5,501 jobs	768 more jobs from new and expanded manufacturing plants

Source: WisDOT Report

The reasons cited in surveys¹¹⁵ for these improvements to business were varied, but included common themes. For example, a number of businesses noted the reduction in transport costs and improvement in reliability as a benefit for business. This is backed by evidence that for-hire trucking services began listing lower prices after the improvement to the road. Food processing and manufacturing industries benefited greatly due to their products being heavy relative to their value, and the importance of transporting it in a safe and reliable manner. Service industries, such as repair shops, noted significant improvements in business, since they were able to reach clients further afield more reliably.

Just as travel time for freight fell, so too did travel time for commuters, providing all firms with better access to a deeper labour market. This effect was cited in particular by high-skilled service firms, who rely heavily on skilled labour.

¹¹⁵ WisDOT report

Displacement

The detail of the WisDOT report unfortunately does not extend to the question of additionality and displacement. It is feasible that some level of displacement occurred but it is not possible to say how much or where from.

4.9.5 Observations

Key observations are:

- **Savings in business and freight travel costs are critical:** Evidence suggests the road improvement has been very effective at attracting new businesses and manufacturing capacity. It has also facilitated access to new markets and opened market opportunities (e.g. the ability to produce and transport perishable products). Businesses surveyed noted transport cost savings and improved reliability as a critical factor.
- **More research is needed to understand displacement.** The Wisconsin SR 29 was effective in stimulating economic activity along the corridor on which it was located. It is nonetheless not clear how much of that might have occurred elsewhere and that is a question the available analysis does not attempt to answer.

4.10 Dublin-Galway M4/M6 motorway

4.10.1 Overview and rationale for the intervention

The M4 and M6 together connect Dublin and Galway, two major cities on the east and west coasts of Ireland respectively. Prior to its construction, the two cities were linked by poor quality regional roads, often going directly through towns and communities in rural Central Ireland. The key aims of the project were to relieve increasing congestion between the two cities and form part of a national inter-urban strategic road network.

The scheme was announced in 1999, began construction in 2004 and was formally completed in 2009. Ex-post evaluation by the Irish Department of Transport, Tourism and Sport (DTTS) found that journey time and accident savings outweighed expected costs, which were €500m over the €1.1bn estimates¹¹⁶. Since opening, mid-week off peak travel times between Dublin and Galway have fallen almost an hour from 157 to 104 minutes, and reliability has improved.

4.10.2 Quality of evidence available

Evaluation for the Dublin-Galway route was undertaken by the DTTS in partnership with AECOM, an engineering and construction management firm who focused primarily on cost and traffic outturns. In addition, as part of its Strategic Framework for Investment in Land Transport (SFILT) project, the DTTS commissioned AECOM to provide details on the economic impacts of the M4/M6,

¹¹⁶ SFILT background paper 8

which is the main source for this case study. They conducted interviews with representatives of industry, business, local government, unions and airports, which they use to draw qualitative conclusions on changes to the economy.

No further academic literature on the scheme was found.

4.10.3 Transmission channels for contributing to economic performance

The investment in the M4/M6 motorway is inter-urban, linking two large economic centres, but they are not close enough for the productivity enhancements of agglomeration to be likely to be material. We nonetheless would expect the following:

- **Investment:** as this will improve reliability of transport, we would expect businesses to be attracted to the motorway corridor, and to the cities at either end.
- **Trade:** by lowering the cost of moving between the markets of Dublin and Galway, competition ought to improve and movement of goods ought to become more common. This will be particularly true given the presence of major ports in both Dublin and Galway.
- **Displacement:** since the road connects two urban markets, it is likely that displacement is likely to be an issue if the number of businesses increases as a result of the scheme.

4.10.4 Evidence of impacts

Since the evidence available is qualitative and anecdotal, it is hard to be definite about the scale of impacts we identify, but they can nonetheless show the existence of those mechanisms at work.

Investment

Interviews with the Chambers of Commerce of Dublin and Galway show a consensus on the positive effects of the new road on business. The South Dublin Chamber of Commerce noted that accessibility, previously a major issue for its member businesses, was rarely mentioned as a problem any longer. Galway Chamber of Commerce representatives noted that accessibility had improved but that it was constrained by continued congestion within the city of Galway. The Ireland Business and Employer's Confederation (IBEC) noted that the effective increase in the depth of the labour pool (for example between Galway and Athlone) had been particularly attractive to business. The qualitative evidence of the benefit to businesses of easy access to workers is backed up by the 2011 Ireland Census commuting statistics, which show workers increasingly commuting by car to Dublin and Galway along the central M4/M6 corridor. This would not have been feasible before the scheme was built.

Ireland has considerable incentives for foreign direct investment that go beyond physical infrastructure. An active programme of encouragement and generous corporate tax rates encourage a number of foreign businesses to locate in Ireland

for other reasons. As the Industrial Development Authority notes in the SFILT report, however, a well-functioning motorway system is seen as an essential condition for investment in the area. It may not be the case that potential investors are attracted by a motorway alone but it does appear to have been a necessary but not sufficient condition.

Trade

The most prominent aspect of the Dublin-Galway case study is the expansion and connectivity of the two previously separate urban markets. Where firms in the individual markets might have operated as natural monopolies or benefited from network effects, the reduction in travel time exposed them to competitive pressure. One particular example is the closure of the Galway airport, which a number of respondents (including the Galway Chamber of Commerce and Knock Airport) believe is directly attributable to the improvement in road connections. Dublin Airport's superiority in links and capacity made it a more natural choice for consumers who could now choose between the two.

A similar dynamic is noted by the South Dublin Chamber of Commerce, who gave the example of a firm which promised its customers a three hour response time. The improved reliability and travel time of roads allowed it to shut down its operations in Athlone and Cork. Representatives of Galway commerce noted that those who live on the East side of Galway increasingly travelled further east to Athlone for shopping in larger retail parks – a form of geographical specialisation.

Displacement

The patterns of investment and improved competition above are benefits to consumers and business: people are choosing their preferred goods and services; and businesses are running more efficiently. However, the distribution of the new economic activity is of interest. Some activity and employment opportunities have shifted away from Galway (the Galway airport closed for example), which does not sit well with broader goals to improve economic outcomes in the West of Ireland. The Western Development Commission states in the report that they are concerned radial links to Dublin (such as the M4/M6) would have the effect of weakening regional economic development, especially if infrastructure north and south of Galway was not improved.

4.10.5 Observations

Key observations are:

- **Many stakeholders suggest that road investment is a necessary but not sufficient condition to contribute to economic performance.** Businesses and development groups note that a well-functioning motorway system is something investors consider fundamental and necessary, but other policies have played a notable role in attracting business investment to the area (such as attractive tax rates, for example).
- **Improved connections between urban centres can increase economic activity at one at the expense of the other:** The reduction in travel time

exposed both urban areas to competitive pressure. A number of respondents, including the Galway Chamber of Commerce and Knock Airport, believe the closure of Galway Airport is directly attributable to the improvement in road connections. Dublin Airport's superiority in links and capacity made it a more natural choice for consumers who could now choose between the two. This highlights the trade-off between boosting economic efficiency and equity.

- **Evidence is limited and there is more to learn.** The analysis available at this time is entirely qualitative and fully understanding the effects of this road would require further research, with a substantial quantitative focus.

4.11 Summary of case studies and lessons learned

While the case studies cover a variety of settings and contexts, there are several observations that are apparent from synthesizing them and can be translated into overall lessons learned. We present an overview of these below, and go into more detail in section 5, which covers policy implications.

Limitations of existing evidence

One of the strongest conclusions that can be drawn from the review of existing case studies is that there is a limited amount of robust evaluation evidence on the economic impacts of specific roads investment projects. While the study of traffic, safety and other transport-specific outcomes is very well developed (such as in Highways England POPE studies), most evaluations make no attempt to robustly and quantitatively assess the impact of projects on employment, productivity, trade, or other economic outcomes.¹¹⁷

There is a particular evidence gap relating to long-distance road investments. This could be for a number of reasons, including the need to include wide geographical areas in such studies; the challenges associated with attributing impacts to a specific road scheme when there are so many local factors at play along the route; and the complexity of defining what would have happened absent the scheme given the need for local context specificity in any modelling exercise.

There is some quantitative evaluation evidence, but much of it tends to focus on before/after comparisons rather than on producing well-constructed counterfactuals (i.e. what would have happened absent the intervention).

Interactions with other policy areas and local context

It is clear from the case studies that delivering user benefits to freight and business travellers is a fundamental pre-condition for any impacts on the economy to be realised.

Furthermore, roads are often a necessary, but not sufficient, condition for enhancing economic performance. Investment in other drivers related to skills,

¹¹⁷ This is addressed in the POPE meta-report by Highways England (2016), as well as in a comparative study of POPE reports by Sloman, Hopkinson and Taylor (2017).

business environment, innovation, non-transport infrastructure and quality of place is often crucial for the economic potential of road improvements to be realised.

Given local and national drivers of economic performance rest under the control of a range of different institutions, it is important that those institutions are a part of the decision-making process in relation to roads so that the full economic potential can be realised. For example, the extent to which road investment can unlock housing development opportunities is dependent on the planning system, which is controlled by local authorities.

Understanding the local context is essential to be able to consider how user benefits percolate to the rest of the economy; and the extent to which other benefits such as agglomeration are likely to be realised.

The local (and national) context is also important when considering the potential for displacement – this phenomenon is at present little understood.

Future-proofing the road investment

There are several case studies of roads investment projects which had not been shown to bring about the anticipated gains in economic performance. Common to some of these was that they had intended to derive significant benefits from their ability to boost a particular sector or cluster. When external factors (such as economic downturns) affected the economic performance of those sectors, the return on the road investment was significantly dampened.

These cases imply that the most robust roads investments are the ones which are able to derive benefits from diverse local economic activity.

5 POLICY IMPLICATIONS

This chapter brings together the evidence we have examined as part of the literature review and case studies to provide policy insights to inform DfT's Road Investment Strategy. We deliberately do not seek to make recommendations about particular schemes, but rather offer observations about the characteristics of major road investments that are most likely to contribute to increases in economic performance across England and Wales.

5.1 Observations from the evidence and policy implications

The literature review and case study work has allowed us to identify a number of observations. These are discussed below.

1. User benefits to business, freight or commuters are a critical pre-condition for gains in economic performance to be realised.

Road user benefits to business and freight directly translate into reduced costs and increased output and productivity. These benefits are particularly important on the SRN where most business and freight travel is made. However, user benefits are also a pre-condition for the realisation of benefits to the economy through other channels of agglomeration, business investment and FDI, labour market and trade effects and induced housing investment.

Unless user benefits are realised for business, freight or commuters, gains in economic performance cannot follow. This suggests that policy makers should target strategic road investment where there is currently (or a high likelihood of future) high demand from those users and where there are constraints on economic activity arising from congestion or unreliability, the relief of which would benefit business, freight or commuters.

2. It is critical to consider policy interdependencies to realise the full economic potential of investment in roads.

Adequate major road infrastructure is a necessary but not sufficient condition for gains in economic performance to be realised. The ability of road improvements to deliver their economic potential is affected by the adequacy and extent of complementary policy and local drivers of economic performance. For example, the ability of a road improvement to attract business investment will be affected by the availability of housing (and hence the importance of local planning policy); the availability of skilled labour (and hence local or national education and training policies); the condition of complementary infrastructure (such as local transport, schools, hospitals, utilities); local business environment (such as local business support) etc.

This suggests that because responsibility for these policies is often split across national and local government, a coordinated approach to investment decisions by national and local policy makers, as well as private investors, is needed so

that policy interdependencies can be accounted for and opportunities to deliver gains in economic performance can be maximised.

The importance of policy interdependency also suggests a valuable role for local authorities to co-ordinate with Highways England in the development of local economic plans, where strategic roads may play an important role in facilitating gains in local economic performance.

3. Local economic conditions are critical to understand.

The scale of potential contribution of major road improvements to economic performance is highly context specific. Important factors include the composition of local businesses; the skills composition of the local labour force; local policies that could facilitate or act as a barrier to gains in economic performance being realised; travel conditions in the local urban centres; geographical location of economic activity (density); the adequacy of complementary infrastructure; etc.

This suggests that to inform investment decisions, an in-depth understanding of the local context surrounding any proposed road investment is essential. This includes a detailed articulation of the local economic geography and the performance of local transport and other infrastructure, as well as an assessment of current and planned local and national policies or investments that could facilitate or hinder the gains in economic performance. Key to this is therefore not only considering the travel conditions along the route of interest, but also all the other factors that can impact on the ability of the investment to deliver economic returns.

4. Future-proofing road investments.

The contribution to economic performance of road improvements is dependent on local economic conditions, as explained above. However, because those conditions can change over time – such as if changes in technology or other factors fundamentally change the composition of economic activity away from sectors that are reliant on transport – there are risks to the ability of the road to deliver anticipated gains in economic performance.

This suggests that investment decisions should be informed by an assessment of changes in the economy at large that could impact on the economic returns from the investment. Given the significant uncertainty around future economic activity and the longevity of infrastructure, this suggests exploring:

- A number of feasible future scenarios relating to the economic composition of the relevant areas, along with the implications for potential travel demand (with a particular focus on business, freight and commuters); and
- An assessment of the risk that the anticipated gains in economic performance are exposed to changes in the economic activity of any particular sector or sectors.

5. Costs are essential to consider

Although the focus of this study has been the channels through which gains in economic performance are likely to materialise, the costs of investment are a critical element of the appraisal and decision-making process about where to invest.

6. Unintended consequences, particularly displacement

Investments in major roads have the potential to boost economic performance in a number of ways. However, there is a risk of unintended consequences: namely that a boost to economic performance in one area holds back others in a way which would be contrary to government objectives. There is also the potential for some of the local population to be displaced if, in response to a road improvement, house prices increase to levels that are unaffordable for some. Evidence on the extent to which such issues occur in practice is currently not well developed, but this is an important issue from the perspective of the national investment decisions.

This suggests that policy makers need to be mindful of the potential trade-offs between achieving gains in economic performance that may be at the expense of other areas, and the potential for conflict across government objectives (notably economic efficiency and social equity).

6 GAPS IN THE EVIDENCE FOR FURTHER STUDY

This chapter provides an overview of the gaps in the evidence that have been identified as part of our work. It also offers some views on how such gaps could be filled.

6.1 Gaps and suggestions to address them

Ex post evaluation evidence

As the What Works Centre for Local Economic Growth (WWC, 2015) and Frontier Economics (2016) found, there is a lack of robust ex post evaluation evidence of road interventions. Although large programmes of evaluation are undertaken by Highways England on its major road investments (the POPE programme), this evaluation activity was neither intended nor designed to explore in depth the impacts on economic performance of every major road investment, so evidence is therefore very limited, and often absent.

Across the wider evidence base, a particular gap relates to the lack of evaluation evidence on the impacts on economic performance of long-distance intercity road investments. This is of course particularly important given the context for this study to inform the Road Investment Strategy.

Given the extensive evaluation activity already undertaken by Highways England in the form of the Post Opening Project Evaluation (POPE) of major schemes, this programme could be reviewed to identify where it could add additional value in terms of filling important evidence gaps. In particular in relation to:

- **Scheme level evaluation:** the feasibility of enhancing the evaluation programme to include an assessment of the impacts on economic performance could be considered. Such evaluation could be targeted only on the relevant schemes, i.e. those for which delivering gains in economic performance is a key objective. Such evaluation could helpfully explore particular aspects such as the timing of when particular impacts are observed; the scale of the effects; and the role of other policies (local and national) in facilitating or hindering gains in economic performance from being realised. Issues around displacement should also be considered to the extent feasible.
- **Programme level evaluation:** every 10-years or so, a larger-scale evaluation exercise could be carried out to assess the extent to which the investments delivered through the RIS have delivered gains in economic performance.

Importantly, there are widely acknowledged challenges in attributing any changes in economic performance to a particular road investment or set of road investments. However, there is likely to be substantial value in systematically carrying out more qualitative research with businesses to understand key factors such as:

- The drivers of their location or investment decisions: the extent to which businesses would say that a road investment has impacted on their location or expansion decisions, and the role that other factors also played in those decisions;
- Their degree of responsiveness to road investments: the extent to which they were able to respond to the road investment, over what timeframe, and what the barriers and facilitators were; and
- Their perceived alternative choices: if they were not located where they are now, what else would they have done.

Such evidence would be valuable to inform any interpretation of quantified evaluation evidence, but it could also helpfully inform assumptions used in land-use transport interaction modelling.

Land use transport interaction modelling

Transport modelling techniques and capability continue to advance at a rapid pace. In particular we note that Land Use Transport Interaction models (LUTI) have expanded in use considerably in recent years. Given the importance of such models in underpinning major investment decisions, there is value in carrying out research to:

- Validate input assumptions: these models aim to capture the dynamic aspects of a local economy and the interactions with transport, and therefore rely on a complex system of models and assumptions. There is however, relatively limited evidence available to inform some of the required input assumptions, such as those relating to business location decisions. Research to increase the evidence base to inform key assumptions would therefore be valuable.
- Validate outputs: given the increasing role of such models in transport appraisal, it will be increasingly important to find ways to validate the forecasts produced by such models so that accuracy can improve over time.

Data

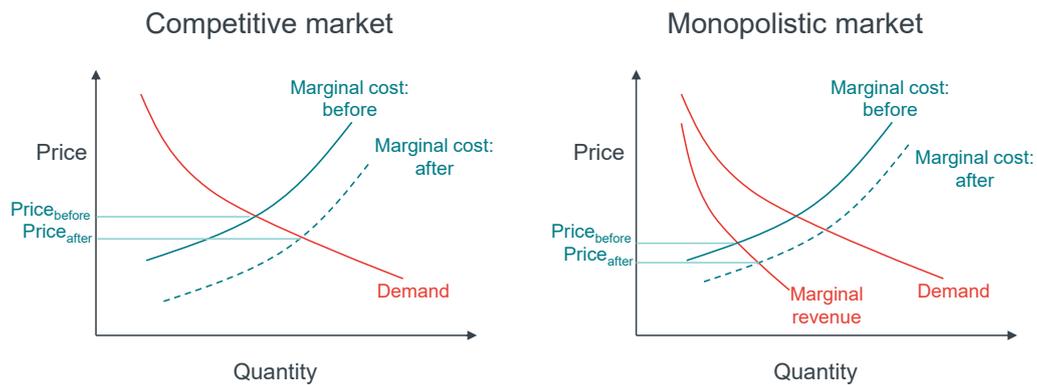
There are some fundamental gaps in the evidence base currently available to policy makers that, if filled, would support improved decision making with respect to road investments. The following highlights some examples where improved data would add value:

- SRN road usage: data on who uses the trunk road network, how and when they use it would be valuable to inform ex ante and ex post analysis; and
- Inter-regional trade: little information exists on domestic inter-regional trade but this would be valuable to inform decisions about how the trunk network could be better equipped to support this important activity.

7 ANNEX

Figure 24 presents a stylised diagram of how changes in transport costs can feed through to change the price and level of output produced by firms, whether they are in a competitive market (left hand side) or in an imperfectly competitive market (right hand side).

Figure 24 Stylised theoretical effects of cost reductions for firms



Source: Frontier Economics

8 REFERENCES

- Accetturo, A., Di Giacinto, V., Micucci, G. and Pagnini, M. (2013) 'Geography, productivity and trade: does selection explain why some locations are more productive than others?'.
 AECOM, Dublin (2014). Investing in Our Transport Future: A Strategic Framework for Investment in Land Transport, Background Paper Nine, Wider Economic Impact of Transport Investment: Case Study Analysis
- Aghion, P., Besley, T., Browne, J., Caselli, F., Lambert, R., Lomax, R., Pissarides, C., Stern, N. and Van Reenen, J. (2013) 'Investing for Prosperity: Skills, Infrastructure and Innovation, Report of the LSE Growth Commission', London: LSE.
- Andersson, M., Klaesson, J. and Larsson, J. P. (2014) 'The sources of the urban wage premium by worker skills: Spatial sorting or agglomeration economies?', *Papers in Regional Science*, 93(4), pp. 727-747.
- Atalay, E., Hortacsu, A. and Syverson, C. (2012) *Why Do Firms Own Production Chains?* : National Bureau of Economic Research.
- Baldwin, R. E. and Okubo, T. (2006) 'Heterogeneous firms, agglomeration and economic geography: spatial selection and sorting', *Journal of Economic Geography*, 6(3), pp. 323-346.
- Banerjee, A., Duflo, E. and Qian, N. (2012a) *On the road: Access to transportation infrastructure and economic growth in China*: National Bureau of Economic Research.
- Baum-Snow, N. (2007) 'Did highways cause suburbanization?', *The Quarterly Journal of Economics*, 122(2), pp. 775-805.
- Baum-Snow, N. and Turner, M. (2012) 'Transportation and the decentralization of Chinese cities', *Providence, RI: Brown University*.
- Behar, A. and Venables, A. J. (2011) 'Transport costs and international trade', *Handbook of transport economics*, pp. 97-115.
- Beine, M., Bertoli, S. and Fernández-Huertas Moraga, J., 2015. A practitioners' guide to gravity models of international migration. *The World Economy*.
- Berechman, J. and Paaswell, R., 2001. Accessibility improvements and local employment: an empirical analysis. *Journal of transportation and statistics*, 4(3).
- Berliant, M., Reed, R. R. and Wang, P. (2006) 'Knowledge exchange, matching, and agglomeration', *Journal of Urban Economics*, 60(1), pp. 69-95.
- Bernard, A.B., Moxnes, A. and Saito, Y.U., 2015. *Production networks, geography and firm performance* (No. w21082). National Bureau of Economic Research.
- Boarnet, M.G. and Chalermpong, S., 2001. New highways, house prices, and urban development: A case study of toll roads in Orange County, CA. *Housing policy debate*, 12(3), pp.575-605.

Buzard, K., Carlino, G. A., Hunt, R. M., Carr, J. K. and Smith, T. E. (2016) 'Localized knowledge spillovers: Evidence from the agglomeration of American R&D labs and patent data'.

Carlino, G., Kerr, W., (2015). Agglomeration and innovation. In: Duranton, G., Henderson, V., Strange, W. (Eds.), *Handbook of Urban and Regional Economics*, vol. 5A. North-Holland, Amsterdam.

Chandra, A. and Thompson, E. (2000b) 'Does public infrastructure affect economic activity?: Evidence from the rural interstate highway system', *Regional Science and Urban Economics*, 30(4), pp. 457-490.

Chernobai, E., Reibel, M. and Carney, M., 2011. Nonlinear spatial and temporal effects of highway construction on house prices. *The Journal of Real Estate Finance and Economics*, 42(3), pp.348-370.

Clark, X., Dollar, D. and Micco, A. (2004) 'Port efficiency, maritime transport costs, and bilateral trade', *Journal of development economics*, 75(2), pp. 417-450.

Combes, P. P. and Gobillon, L. (2015). The Empirics of Agglomeration Economies. In: Duranton, G., Henderson, V., Strange, W. (Eds.), *Handbook of Urban and Regional Economics*, vol. 5A. North-Holland, Amsterdam.

Combes, P. P., Duranton, G. and Gobillon, L. (2008) 'Spatial wage disparities: Sorting matters!', *Journal of Urban Economics*, 63(2), pp. 723-742.

Combes, P. P., Duranton, G., Gobillon, L., Puga, D. and Roux, S. (2012) 'The productivity advantages of large cities: Distinguishing agglomeration from firm selection', *Econometrica*, 80(6), pp. 2543-2594.

Commission, C. G. (2014) *Unleashing metro growth: Final recommendations of the City Growth Commission*.

D'Costa, S. and Overman, H. G. (2014) 'The urban wage growth premium: Sorting or learning?', *Regional Science and Urban Economics*, 48, pp. 168-179.

De Bok, M. and Sanders, F., 2005. Firm relocation and accessibility of locations empirical results from the Netherlands. *Transportation Research Record: Journal of the Transportation Research Board*, (1902), pp.35-43.

Department for Transport (2014). *Transport Resilience Review, A review of the resilience of the transport network to extreme weather events*.

Department for Transport (2016). *Understanding and valuing the impacts of transport investment: wider impacts transport appraisal guidance (WebTAG)*. DfT, 2016

Department for Transport (2016), 'TAG UNIT A2.2: Appraisal of Induced Investment Impacts' and Department for Transport (2015), 'TAG UNIT A2.3: Transport Appraisal in the Context of Dependent Development'

Donaldson, D. (2010) *Railroads of the Raj: Estimating the impact of transportation infrastructure*: National Bureau of Economic Research.

Duranton, G. and Puga, D. (2004) 'Micro-foundations of urban agglomeration economies', *Handbook of regional and urban economics*, 4, pp. 2063-2117.

- Duranton, G. and Puga, D. (2005) 'From sectoral to functional urban specialisation', *Journal of Urban Economics*, 57(2), pp. 343-370.
- Duranton, G. and Turner, M. A. (2012) 'Urban growth and transportation', *The Review of Economic Studies*, 79(4), pp. 1407-1440.
- Duranton, G., Henderson, V. and Strange, W. (2015) *Handbook of Regional and Urban Economics*, vol. 5B. Elsevier.
- Duranton, G., Morrow, P. M. and Turner, M. A. (2014) 'Roads and Trade: Evidence from the US', *The Review of Economic Studies*, 81(2), pp. 681-724.
- Eddington, R. (2006). The Eddington Transport Study. *Department for Transport*.
- Einio and Overman (2016), 'The (Displacement) Effects of Spatially Targeted Enterprise Initiatives: Evidence from UK LEGI'
- Eurostat (2012). Modal split of inland freight transport
- Fajgelbaum, P. and Cosar, A. K. (2013). 'Internal Geography, International Trade, and Regional Outcomes. 2013 Meeting Papers: Society for Economic Dynamics.
- Fallick, B., Fleischman, C. A. and Rebitzer, J. B. (2006) 'Job-hopping in Silicon Valley: some evidence concerning the microfoundations of a high-technology cluster', *The Review of Economics and Statistics*, 88(3), pp. 472-481.
- Fingleton, B. (2008) 'Testing the NEG model: further evidence from panel data'.
- Freedman, M. L. (2008) 'Job hopping, earnings dynamics, and industrial agglomeration in the software publishing industry', *Journal of Urban Economics*, 64(3), pp. 590-600.
- Frontier Economics (2016). Assessing the productivity benefits of improving inter-city connectivity in Northern England. *Frontier Economics*.
- Frontier Economics (2016b) Strengthening the Links between Appraisal and Evaluation”
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/540733/strengthening-the-links-between-appraisal-and-evaluation.pdf
- Funderburg, R. G., Nixon, H., Boarnet, M. G. and Ferguson, G. (2010) 'New highways and land use change: Results from a quasi-experimental research design', *Transportation research part a: policy and practice*, 44(2), pp. 76-98.
- García-López, M. À. and Muñoz, I. (2013) 'Urban spatial structure, agglomeration economies, and economic growth in Barcelona: An intra-metropolitan perspective', *Papers in Regional Science*, 92(3), pp. 515-534.
- García-López, M.-À. (2012) 'Urban spatial structure, suburbanization and transportation in Barcelona', *Journal of Urban Economics*, 72(2), pp. 176-190.
- García-Mila, T. & Montalvo, J. G. (2013) A New Approach to Measure the Impact of Highways on Business Location with an Application to Spain,” Universitat Pompeu Fabra, Barcelona GSE and IVIE.
- Gaubert, C. (2014) *Firm sorting and agglomeration*: March 2015. mimeo.
- Gerlach, H., Rønde, T. and Stahl, K. (2009) 'Labor pooling in R&D intensive industries', *Journal of Urban Economics*, 65(1), pp. 99-111.

- Gibbons, S., Lyytikäinen, T., Overman, H. G. and Sanchis-Guarner, R. (2012) 'New road infrastructure: the effects on firms'. Spatial Economics Research Centre Discussion Paper 117
http://eprints.lse.ac.uk/58527/1/lse.ac.uk_storage_LIBRARY_Secondary_libfile_shared_repository_Content_SERC%20discussion%20papers_2012_sercdp0117.pdf
- Gibbons, S., Overman, H. and Tucci, A. (2009). The Case for Agglomeration Economies. *Manchester Independent Economic Review*.
- Glaeser, E. L. and Kohlhase, J. E. (2004) 'Cities, regions and the decline of transport costs', *Papers in regional Science*, 83(1), pp. 197-228.
- Glaeser, E. L. and Ponzetto, G. A. (2007) Did the death of distance hurt Detroit and help New York?, *National Bureau of Economic Research*.
- Goodwin, P. (2004). The economic costs of road traffic congestion.
- Gould, E. D. (2007) 'Cities, workers, and wages: A structural analysis of the urban wage premium', *The Review of Economic Studies*, 74(2), pp. 477-506.
- Graham, D. J. (2006) 'Investigating the link between productivity and agglomeration for UK industries', *Report prepared for the UK Department for Transport*.
- Graham, D. J. (2007) 'Variable returns to agglomeration and the effect of road traffic congestion', *Journal of Urban Economics*, 62(1), pp. 103-120.
- Graham, D. J. and Melo, P. C. (2009a) 'Agglomeration economies and labour productivity: evidence from longitudinal worker data for GB's travel-to-work areas'.
- Graham, D., Gibbons, S., and Martin, R., (2009b). Transport Investment and the Distance Decay of Agglomeration Benefits. Working Paper
- Guimaraes, P., Figueiredo, O. and Woodward, D. (2000a) 'Agglomeration and the location of foreign direct investment in Portugal', *Journal of Urban Economics*, 47(1), pp. 115-135.
- Head, C. K., Ries, J. C. and Swenson, D. L. (1999a) 'Attracting foreign manufacturing: Investment promotion and agglomeration', *Regional Science and Urban Economics*, 29(2), pp. 197-218.
- Helsley, R. W. and Strange, W. C. (1991) 'Agglomeration economies and urban capital markets', *Journal of Urban Economics*, 29(1), pp. 96-112.
- Highways England, Post Opening Project Evaluations of Major Schemes, multiple years.
- Hillberry, R. and Hummels, D. (2008) 'Trade responses to geographic frictions: A decomposition using micro-data', *European Economic Review*, 52(3), pp. 527-550.
- Holl, A. (2004). Transport Infrastructure, Agglomeration Economies, and Firm Birth: Empirical Evidence from Portugal*. *Journal of Regional Science*, 44(4), 693-712.

Humber Local Enterprise Partnership, 'Humber Enterprise Zone: the UK's Energy Estuary'

Kim, S. (1989a) 'Labor Specialization and the Extent of the Market', *Journal of Political Economy*, 97(3), pp. 692-705.

KPMG (2013). High Speed Two (HS2) Limited: HS2 Regional Economic Impacts. *KPMG*

Laird, J.J. and Mackie, P.J., 2014. Wider economic benefits of transport schemes in remote rural areas. *Research in Transportation Economics*, 47, pp.92-102.

Lee, J., Nicholas, T., (2012). The Origins and Development of Silicon Valley. *Harvard Business School Case*, pp. 813–1098.

Leong, D., Marcos, F., Michelson, K., & Russell, R. (2004). *Economic and Land-Use Impacts of Wisconsin State Trunk Highway 29* (No. 0092-03-06).

Limao, N. and Venables, A. J. (2001) 'Infrastructure, geographical disadvantage, transport costs, and trade', *The World Bank Economic Review*, 15(3), pp. 451-479.

Lyons, G., Musselwhite, C., Dudley, G., Goodwin, P., & Wiltshire, P. (2009). *Business attitudes to transport: Knowledge review of existing evidence*. Department for Transport.

Mackie, P., Nash C., Whiteing, T, Worsley, T. (2015). Response to National Infrastructure Commission Northern Connectivity Consultation. *Institute for Transport Studies, University of Leeds*.

Márk, L., 2013. The effect of highways on nearby residential property prices in Hungary (Doctoral dissertation, Central European University).

Matano, A. and Naticchioni, P. (2011) 'Wage distribution and the spatial sorting of workers', *Journal of Economic Geography*, pp. 1br013.

Matheson, V.A. and Baade, R.A., 2004. Race and riots: A note on the economic impact of the Rodney King riots. *Urban Studies*, 41(13), pp.2691-2696.

Mayer, T., Mayneris, F. and Py, L. (2012a) 'The impact of urban enterprise zones on establishments' location decisions: Evidence from French ZFUs'.

Mayer, T., Mayneris, F. and Py, L. (2012b) 'The impact of urban enterprise zones on establishments' location decisions: Evidence from French ZFUs'.

McEwen, N. and Petersohn, B. (2014). *Insights from the border between Sweden and Denmark* (Scottish Centre On Constitutional Change).

McQuaid, R. W. (2004). *The importance of transport in business' location decisions*. Department for Transport.

McQuaid, R. W. and Lindsay, C. (2005a) 'The concept of employability', *Urban studies*, 42(2), pp. 197-219.

Melitz, M.J., 2003. The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, 71(6), pp.1695-1725.

Melo, P. C., Graham, D. J. and Brage-Ardao, R. (2013a) 'The productivity of transport infrastructure investment: A meta-analysis of empirical evidence', *Regional Science and Urban Economics*, 43(5), pp. 695-706.

Melo, P. C., Graham, D. J. and Noland, R. B. (2009) 'A meta-analysis of estimates of urban agglomeration economies', *Regional science and urban Economics*, 39(3), pp. 332-342.

Michaels, G. (2008) 'The effect of trade on the demand for skill: Evidence from the interstate highway system', *The Review of Economics and Statistics*, 90(4), pp. 683-701.

Mion, G. and Naticchioni, P. (2009) 'The spatial sorting and matching of skills and firms', *Canadian Journal of Economics/Revue canadienne d'économique*, 42(1), pp. 28-55.

Neumark, D. and Simpson, H. (2014a) *Place-based policies*: National Bureau of Economic Research.

Office for National Statistics (2013). National Travel Survey statistics 2013; See <https://www.gov.uk/government/collections/national-travel-survey-statistics>

Office for National Statistics (2015). Family Spending, 2015 Edition; See <http://visual.ons.gov.uk/households-spend-the-most-on-transport/>

Office for National Statistics (2015). Labour Productivity, Q3 2015.

Ottaviano, G. I., Combes, P.-P., Mayer, T. and Thisse, J.-F. (2009). *Economic Geography: The Integration of Regions and Nations*. JSTOR.

Overman, H.G., Gibbons, S., D'Costa, S., Mion, G., Pelkonen, P., Resende, G. and Thomas, M. (2009). *Strengthening economic linkages between Leeds and Manchester: feasibility and implications: full report*.

Overman, H.G. and Rice, P., 2008. *Resurgent cities and regional economic performance*. Spatial Economics Research Centre.

Ozbay, K., Ozmen, D. and Berechman, J. (2006). Modeling and analysis of the link between accessibility and employment growth. *Journal of Transportation Engineering*, 132(5), pp.385-393.

Prideaux, B. (2000). The role of the transport system in destination development. *Tourism management*, 21(1), pp.53-63.

Puga, D. and De la Roca, J. (2012) 'Learning by working in big cities', *Review of Economic Studies*.

Pugh, G. and Fairburn, J., 2008. Evaluating the effects of the M6 Toll Road on industrial land development and employment. *Regional Studies*, 42(7), pp.977-990.

Redding, S. J. (2012) *Goods trade, factor mobility and welfare*: National Bureau of Economic Research.

Redding, S. J. and Turner, M. A. (2014) *Transportation costs and the spatial organization of economic activity*: National Bureau of Economic Research.

- Rephann, T. and Isserman, A. (1994). New highways as economic development tools: An evaluation using quasi-experimental matching methods. *Regional Science and Urban Economics*, 24(6), pp.723-751.
- Rice, P., Venables, A.J. and Patacchini, E. (2006). Spatial determinants of productivity: analysis for the regions of Great Britain. *Regional Science and Urban Economics*, 36(6), pp.727-752.
- Rosenthal, S. S. and Strange, W. C. (2001) 'The determinants of agglomeration', *Journal of urban economics*, 50(2), pp. 191-229.
- Rotemberg, J. J. and Saloner, G. (2000) 'Competition and human capital accumulation: a theory of interregional specialization and trade', *Regional Science and Urban Economics*, 30(4), pp. 373-404.
- Saxenian, A. (1994) 'Regional Advantage: Culture and Competition in Silicon Valley and Route 128', Harvard Univ, Press, Cambridge.
- Sloman, L., Hopkinson, L. and Taylor, I. (2017) The Impact of Road Projects in England Report for CPRE. *Transport for Quality of Life*
- Sundberg, M. (2005). Spatial computable general equilibrium modelling: static and dynamic approaches (Doctoral dissertation, KTH).
- Taniguchi, E., & Van Der Heijden, R. E. (2000). An evaluation methodology for city logistics. *Transport Reviews*, 20(1), 65-90.
- Taniguchi, E., Noritake, M., Yamada, T., & Izumitani, T. (1999). Optimal size and location planning of public logistics terminals. *Transportation Research Part E: Logistics and Transportation Review*, 35(3), 207-222.
- Vadali, S., 2008. Toll roads and economic development: exploring effects on property values. *The Annals of Regional Science*, 42(3), pp.591-620.
- Venables, A., Laird, J. and Overman, H. (2014) 'Transport investment and economic performance: Implications for project appraisal'.
- What works centre for local growth (2015), 'Evidence review 7: transport'

