Economic Performance Impacts of Road Enhancements

Econometric Findings
November 2026

Ipsos with George Barrett and Tom Worsley

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2 Executive Summary

Ipsos, in collaboration with George Barrett and Tom Worsley was commissioned by the Department for Transport (DfT) to deliver the Economic Performance Impacts of Road Enhancements (EPIRE) project. This technical report sets out the details and outcomes of a series of econometric analyses aiming to quantify the effects of investments in the strategic and local road network on the performance of local businesses as well as on local labour, land, and property markets.

The quantitative assessment provided in this report is complemented by a series of mixed-methods case studies exploring the impacts of individual schemes. These will provide further insight into the underlying explanatory mechanisms driving the patterns identified in this report.

Scope of this report

This project involved an analysis of the local economic impacts of a total of 194 road improvement schemes completed between 2002 and 2021. This included road schemes completed on a mix of local roads and parts of the Strategic Road Network (SRN). A total of 79 DfT funded Local Major schemes and 115 National Highways funded schemes were covered.

It should be noted that the following assessment focuses exclusively on road enhancements where the principal strategic objective is to improve connectivity between places by reducing journey times – either by creating new links on the road network or increasing the capacity of, or otherwise improving, existing links. These schemes are what are referred to as the 'road improvement schemes' throughout this report. A total of 43 road schemes were excluded based upon the above criteria for inclusion. The DfT and National Highways also fund road enhancements that have a wide variety of other objectives, such as facilitating downstream development or regeneration objectives. The findings of this study cannot be generalised to road enhancement schemes with objectives of this nature and should not be taken as an assessment of the local economic impacts of all types of road improvement.

Key findings

Findings were generated through the application of two broad econometric approaches with the results consistent across both. These approaches were a distance decay type approach and accessibility modelling extension that sought to identify the causal impacts of road schemes on local economies. Details of both approaches are described in the main body of the report.

2.1 Impacts on firms

- Road improvement schemes are found to have positive growth impacts on local economies. The average scheme leads to an average on-going expansion in employment of 0.11 to 0.15 percent and Gross Value Added (GVA) of 0.14 to 0.22 percent. Growth impacts are concentrated within areas up to 20km from road enhancements. This finding is broadly consistent with the results of prior studies employing similar methodologies to a smaller sample of road enhancements. Effects on employment and GVA were statistically significant up to 6 years post scheme completion and a general trend was evident in so far as the

impacts are largest 1 to 2 years after a scheme is completed with these gradually declining with time. Note that the effects are small in size and a high degree of variance in estimated impacts means that the confidence intervals become relatively large post 6 years. This means that there may be effects that persist longer, but which cannot be identified in this analysis.

- The local growth impacts of road enhancement schemes are primarily driven by impacts on the manufacturing and transport and storage sectors (and to a lesser degree, the construction sector). There was little evidence that road enhancement schemes stimulate significant growth of the tradable or non-tradable service sectors. This implies that any induced effects are either negligible or that additional demand for these services places upward pressure on wages or prices (leading to offsetting reductions in demand elsewhere in the local economy).

- Local growth impacts are partly driven by the spatial reorganisation of economic activity, with firms apparently opening new or relocating existing plants nearby to take advantage of improved connectivity. Road enhancement schemes led to a net increase in the number of plants located within 1 to 5 kilometres of the improvement. This was partly driven by incumbents relocating more distant operations (i.e. more than 30km from relevant schemes) to areas closer to the enhancements - implying that road infrastructure improvements may lead to some offsetting losses of economic activity in more distant areas. Only new road links, as opposed to improvements to existing links, appeared to encourage the spatial reorganisation of firms.

- There was little evidence that road enhancements lead to long term improvements in the productivity of local firms (GVA per worker). However, there were some evidence of productivity impacts that were present just after a scheme is completed but were no longer significant after 3 years. In the case of GVA per worker, there appears to be an increase of around 0.1 percent in the year an improvement is completed followed by 0.12 the year after and 0.08 the year after that before effects are no longer detected. The lack of long-term impacts is of note given the apparent effects of road enhancements in attracting new plants to proximate locations. One possible explanation may be that road enhancements produce positive improvements in economic efficiency that are capitalised into higher land prices and rental values owing to other constraints preventing property markets from responding to price signals. It should also be noted that these findings do not capture effects on the productivity of road users whose operations may be far from road enhancements (such as national logistics operators). The report contains a comprehensive set of hypotheses with the potential to explain the findings on productivity impacts (a list that DfT can extend in subsequent research).

- Though improved road infrastructure might be expected to reduce the costs faced by manufacturers, there was no evidence that improved road networks led to increased international trade volumes amongst local firms (either in terms of spending on imports or exports).

- There was some evidence that the growth impacts of road enhancements are concentrated in areas that already display high levels of productivity. Additionally, growth impacts principally accrue to major urban agglomerations - and to a lesser degree, rural areas - with no evidence of growth impacts (positive or negative) on suburban zones and smaller towns. This has potential policy implications in that improvements to road infrastructure appear to reinforce - rather than rebalance - existing patterns of economic development and may not be effective in stimulating growth in lagging areas.

2.2 Impacts on the labour market

- Improvements to road connectivity were found to have positive effects on local labour markets. It was estimated that road improvement schemes lead to an average increase in the hourly earnings of workers employed by firms located within 30km of 0.17 to 0.22 percent. It also appears that additional labour demand induced by road improvement schemes supports reductions in unemployment, with the number of unemployed claimants falling by 0.5 to 0.6 percent on average in response to improvements in road connectivity.

- Wage gains for workers employed by firms prior to the completion of road improvement schemes were smaller than found across all workers employed by firms within 30km. This indicates that the overall wage effect may have been driven by incoming workers filling new vacancies associated with higher wages.

- This was consistent with other findings of the study. Road improvement schemes encouraged the relocation of residents, with the resident population of areas within 30km of schemes increasing by 0.29 to 0.32 percent in response to improvements in road connectivity. This was accompanied by an intensification of the supply of higher-level skills – with the share of residents with NVQ level 4 qualifications or higher increasing by 0.09 to 0.15 percentage points as a consequence of improvements to the road network.

- Impacts on both wages and unemployment were concentrated in areas within 5 to 10 kilometres of road improvement schemes. This aligns with the spatial pattern of the local economic growth impacts of road improvement schemes. As average labour productivity (GVA per worker) did not increase in response to improved road connectivity, it is possible that additional demand for labour may be placing upward pressure on equilibrium wages in the presence of supply constraints. This would be unsustainable in the longer term without changes in productivity.

- There was little evidence that road improvement schemes led to increases in labour supply via economic activity rates or by encouraging workers to increase their working hours. Given that many jobs created were in the manufacturing and transport and storage sectors, there may be a mismatch between the preferences of economically inactive residents and the requirements of the roles. It should also be noted that economic activity rates have been rising to historically high levels over the period in question, potentially limiting scope for substantial increases.

- The findings also provided additional evidence that road improvement schemes reinforced existing patterns of economic agglomeration. The wage and population growth impacts of road improvement schemes were concentrated in high productivity areas. However, the effects of road improvement schemes in reducing unemployment tended to be higher in areas characterised by medium and low levels of productivity, suggesting that labour supply constraints may be less acute in these types of area.

2.3 Impacts on land and property markets

- Road improvement schemes increase demand for commercial floorspace in high productivity areas, leading to increases in commercial rents (as far as can be ascertained from changes in the rateable values of premises) of around 0.09 to 0.13 percent per square metre of floorspace. However, it appears that developers are unable to respond to price signals by increasing the supply of commercial and industrial floorspace in these areas. The inelastic nature of the supply of commercial and industrial floorspace may result in the productive advantages created by road improvement schemes being capitalised into rents (rather than being visible in firm level productivity gains).

- Similar patterns are also observed in housing markets. Road improvement schemes increase the value of residential properties within 30km by an average of 0.26 to 0.33 percent. Again, these impacts are concentrated in high productivity areas – which see average increases in house prices of 0.51 to 0.57 percent in response to improvements in road connectivity. Local Major schemes appeared to have had a larger impact on residential property prices. However, road improvement schemes do not induce the construction of additional dwellings, again indicating that the supply of residential property may be inelastic.

- The findings raise possible questions regarding the role of the planning system in constraining the potential local economic impacts of road improvement schemes and determining how the resultant productive advantages are shared between firms, workers, and landowners. Other factors may also play a role in constraining the supply of property such as overall confidence amongst developers, supply chain constraints (which may be more relevant post pandemic) and the presence of local plans/strategies to support scheme aims with complementary investments incentivising development.

- The results of the study again highlight the role of road improvement schemes in reinforcing existing patterns of economic agglomeration. Road improvement schemes do not appear to place pressure on either commercial or residential property markets in areas characterised by medium or low productivity – either because they do not induce significant levels of additional demand or because there is more flexibility on the supply side.

- The findings of the study provide some evidence of the negative social welfare impacts associated with the construction of road improvements. Residential properties within 1km of road improvement schemes lose 9.5 percent of their value following the completion of schemes. Under some strong assumptions, this could be taken as a signal of the value of the negative externalities associated with living in proximity to new road or improved road links

(e.g. as a consequence of the loss of visual amenities or higher levels of traffic, noise, or pollution).

2.4 Issues for future consideration

Future work exploring the economic performance impacts of road schemes will need to account for a number of contextual changes that may have or will influence the local economic impacts of road enhancement schemes. Most recently, the COVID-19 pandemic may have shifted working and commuting patterns with unknown impacts on the range of local economic performance impacts expected from schemes. Whilst the ongoing impacts of the pandemic are not currently known, there may be persistent impacts on commuting patterns relative to before the pandemic. For example, overall traffic levels have risen in recent years but are still below the levels seen in 2019 (motorway traffic in 2023 was still 0.9 percent below pre-pandemic levels[1]). In addition, a Government focus on regional growth gap-based policies and further decarbonisation may alter the makeup of schemes considered moving forwards and have an impact on the wider use of the road network which may result in diverging impacts from those estimated in this report. There are also other wider factors such as the ongoing cost of living crisis and implications of the UK's exit from the European Union that may influence traffic volumes. The direction and magnitude of any effects driven by these factors are uncertain but potential effects may include:

- Fewer overall car journeys as people work from home or reduced number of journeys at peak times from flexible working.
- More/longer car journeys in rural areas (from increased demand for rural housing).
- Increased share of freight journeys, as a result of more freight moving by road or fewer commuter trips in vehicles. This may also be driven by changes in consumer behaviour e.g. through a shift to online retailers with associated logistics and deliveries.

The pandemic may also have altered agglomeration effects where face to face engagement becomes less common. This and reduced demand for urban office space may mean that impacts identified in urban and highly productive economies become smaller or that these characteristics of an area have less influence on the size of impacts.

The behaviour of GVA per worker is one key area for further exploration. This is the only aspect of the economic impacts for which we failed to find a statistically significant effect. On further examination via the events analysis using staggered DiD analysis, the indication is that there is in fact an initial increase in labour productivity, but that this subsides over the first seven years after scheme opening. Whilst GVA and employment also exhibit a similar time-profile of

[1] Road traffic estimates in Great Britain, 2023: Headline figures. DfT. (2024). Available at: https://www.gov.uk/government/statistics/road-traffic-estimates-in-great-britain-2023/road-traffic-estimates-in-great-britain-2023-headline-figures

diminishing effects, they both end-up (at least over the ten-year period post scheme opening covered by the analysis) at higher levels than prior to scheme opening. Consequently, the behaviour of GVA per worker constitutes a potential puzzle.[2]

One potential explanation is that the initial post-opening stimulus to GVA per worker sets in train second order effects associated with knock-on impacts on local service sector businesses with lower labour productivity. This means that this beneficial economic impact 'dilutes' aggregate GVA per worker performance – but reflects economic benefits that include reducing unemployment (especially in lower skilled occupations). The existence of this local 'cosmopolitan' low productive business segment can be a key inward investment attractor. This means that there is the potential for third-order effects of a longer-term nature (such as attracting a high-tech R&D facility). Consequently, the overall chain of causality is long-term, dependent on the second-order effects associated with 'trickle down' to local services businesses, and the manifestation of third-order effects will be contingent on a range of enabling 'strategic fit' considerations such the quality of natural environment, planning system, housing availability etc that the third order effects require.

Ipsos and our expert advisors have developed a more extensive set of hypotheses that may singly, or in combination, explain the productivity puzzle. It would be useful for DfT to consider this set of hypotheses as a draft list and add any missing hypotheses in order to provide a comprehensive list for use in future work.

Table 2.1: Hypotheses for the productivity puzzle

Unlocking latent demand via reduced congestion that attracts further traffic results in dissipation of the initial GVA/worker increase due to positive local growth impacts	**Hypotheses:** An initial boost to GVA/worker associated with the road enhancements results in positive knock-on effects as additional latent demand is stimulated via reduced congestion that boosts local economic performance **Comments:** This hypothesis indicates that there may be broader and more positive effects as second-order consequences which induce traffic beyond aspects modelled in current investment appraisals
Improvements in economic efficiency are capitalised as higher land prices and rental values due to constraints to property supply responses	**Hypotheses:** Road enhancements produce positive improvements in economic efficiency that are capitalised into higher land prices and rental values owing to other constraints preventing property markets from responding to price signals **Comments:** As regards the GVA/worker productivity puzzle specifically this hypothesis relies on more complex indirect relationships between overall business Total Factor Productivity and labour productivity.

[2] When considering this finding, it is useful to bear in mind the fact that road investment business cases typically use a 60-year appraisal period (the assumed asset lifespan). This leaves ample scope for road enhancements to generate longer-term labour productivity impacts that the EPIRE econometrics have been able to capture.

Inward relocations bring down the average GVA/worker value	**Hypotheses:** Incoming firms previously had lower productivity and are moving to areas which enable them to increase their own productivity. However, those new levels of productivity, on average, are not higher than the average for the area they are moving into. **Comments:** Relies on there being a sufficient number of inward re-location firms to influence the average GVA/worker value (an effect only associated in the results with new road links).
Inward relocations are unable to boost the average GVA/worker value	**Hypotheses:** Incoming firms simply do not account for a sufficient share of the local economy to shift the average. **Comments:** If all of the productivity gains are disappearing in the form of higher rents, why would incoming firms go to the expense and risk of relocating?
The average GVA/worker value boost generates beneficial second order effects that 'round out' local economies but reduce average GVA/worker	**Hypotheses:** GVA/worker declines after an initial boost as it is 'diluted' by a broadened lower labour productivity segment as the local economy experiences 'trickle down' effects to local firms. **Comments:** Under this scenario the long-term economic impact of road enhancements will be in more 'rounded' and resilient local economies more able to attract future inward investment and business inward re-location due to a more cosmopolitan business ecosystem.
Employing new workers to meet demand reduces average GDP per worker in the local economy	**Hypotheses:** Businesses need to employ new workers to respond to increased demand, but labour supply characteristics mean that this requires less productive workers to be hired at the margin. **Comments:** This hypothesis requires GVA increases to be sustained alongside GVA per worker performance.

The results for firm location changes suggest that (as expected) road enhancements lead to employment, turnover and GVA increases associated with exploiting improved road connectivity. This effect is particularly strong for manufacturing, transport and storage businesses. As the main focus of the econometric work has been on distance-decay and accessibility aspects, this study was not able to capture the economic impacts associated with improved extended supply chain connectivity (the broader network-level effects). Supply chain connectivity impacts take place because better 'close proximity' roads allow businesses for which extended (non-local) supply chains are important to benefit from access to the strategic road network, and any inter-modal transport benefits. Whilst road investment business cases do pay attention to these more systemically driven benefits this is not currently matched by evaluation studies. It would therefore be useful for follow-up work, to consider this supply chain connectivity/network-level effects dimension. The case study work carried out in this study has examined the supply chain aspect and has demonstrated that it is possible to either collect such data (via survey work) or, potentially, access new datasets that trace business-to-business

(B2B) supply chains via financial payments tracing.[3] The use of such data would go a long way towards addressing this limitation, in so doing enriching future evaluations.

Other aspects requiring attention in future work are as follows:

- Given the importance of housing and labour supply effects, and also commercial floorspace availability, it would be useful for future econometric work to have a stronger focus on these aspects. This may require spending on commercially provided data sources that were not used here. A strengthened analysis of these aspects would be of particular relevance to non-urban economies, and heavily rural economies in particular – where labour supply constraints can inhibit growth.

- Regionalisation and sub-group analyses: this study focussed on the average effects for the average type of scheme for an average type of local economy. This 'vanilla' approach was a sensible first step given the complexity of the issues being considered. The utility of these historical analyses in informing future business cases would be improved if future econometric studies applied some segmentation to the different types of local economy in which road investments will be made in regard to industry structure, workforce characteristic, geographical characteristics and location in the strategic road network. Making progress on this aspect will require the development of a suitable taxonomy for categorising different types of road investment context optimised for future econometric analyses.

- Growth accounting: it might also be useful to explore the use of a regionalised growth accounting framework that de-composes measured changes in GVA into its constituent change drivers using a familiar growth accounting identity framing (including total factor productivity) and related interactive effects between these growth drivers. It would be particularly useful if any such regionalised growth accounting framework explicitly addressed the spatial dimension as this will allow the ways in which road enhancements can increase the size of functional economic areas/geographies via workforce commute time reductions. This spatial aspect could allow future analyses to distinguish between intensive and extensive margin impacts (impacts in a fixed initial functional economic area and the additional impacts from an extended functional economic area). This spatial aspect could be particularly useful in cases where road enhancements result in functional economic areas expanding to overlap with each other, thus amplifying economic impacts.

- Structural changes: as noted above, the COVID-19 pandemic has helped to drive changes in transport use or perhaps bring forward in time changes in transport use likely to have happened anyway. An increased uptake of home and hybrid working take advantage of

[3] These new datasets use data from commercial providers on BACS and CHAPS payments to trace supply chains. The ONS is currently working on experimental data on inter-regional trade using such data. See< Industry-to-industry payment flows, UK - Office for National Statistics (ons.gov.uk)

modern information and communication technologies (ICT) capabilities leading to changes in commuting patterns is a stand-out factor here. Given that this study analysed pre-pandemic era data, it is inevitable that such structural changes may limit the utility of these historical findings. It would therefore be useful to consider the nature and extent of potential structural changes of this type.[4]

- Weak signals analysis for noisy timeline events: Looking to the future regarding further analysis of event timelines, a key technical challenge is that quasi-experimental methods and econometric analyses faces the challenge of noisy data that limits statistical significance. Given the potential importance of event timelines to future analyses it would be useful to assess other statistical analysis methods that could be used, (such as Bayesian updating as used in machine learning, intelligence analysis, clinical research and signal detection analyses (including the analyses of small number events in particle physics)[5]. Consequently, such methods may be worth exploring as solutions to analysing noisy event studies data.

[4] The Ipsos team have developed an initial framework for consulting local authorities on potential structural changes in road use, and a workshop with local authority officers to discuss this challenge is being arranged by the Business Board Network (the successor to the LEP Network). The results from that consultation, conducted on a pro-bono basis outside of the EPIRE project will be fed back to DfT.

[5] Such as early work on neutrino detection (where very few observations were available) for details of intelligence applications see the *Handbook of Bayesian Analysis for Intelligence for the CIA* – available at: https://www.cia.gov/readingroom/docs/CIA-RDP86B00269R001100080001-0.pdf. Bayesian applications in healthcare evaluation (often a source of more generally used evaluation methods) are covered in detail in David Spiegelhalter, (2003) *Bayesian Approaches to Clinical Trials and Health-care Evaluation* (Statistics in Practice. Wiley-Blackwell. A well-regarded introduction to Bayesian approaches is: Jaynes, E.T. (1984) *Bayesian Methods: General Background: An Introductory Tutorial*. Paper presented at the Fourth Annual Workshop on Bayesian/Maximum Entropy, Methods, Calgary, August 1984. For applications of Bayesian signal detection methods, widely used in clinical research, see Swets, J.A., Dawes, R.M., Monahan, J. (2000*)* Psychological Science Can Improve Diagnostic Decisions. *Psychological Science in the Public Interest*: A Journal of the American. Psychological Society.

3 Introduction

Ipsos, in collaboration with George Barrett and Tom Worsley, was commissioned by the Department for Transport (DfT) to deliver the Economic Performance Impacts of Road Enhancements (EPIRE) project. This technical report sets out the details and outcomes of a series of econometric analyses aiming to quantify the effects of investments in the strategic and local road network on the performance of local businesses as well as on local labour, land, and property markets.

The quantitative assessment provided in this report is complemented by a series of mixed-methods case studies exploring the impacts of individual schemes. These will provide further insight into the underlying explanatory mechanisms driving the patterns identified in this report.

3.1 Evaluation aims and objectives

The aim of the EPIRE project is to assess what impacts road enhancements (National Highways, Local Major and Local Growth Fund projects) have had on local economic performance by extracting as much as possible from existing data and filling evidence gaps, in so doing, informing future evaluation strategies and methods. The Invitation to Tender outlined the key questions the project aims to address:

- What has been the impact of road enhancements on local economic performance?
- How do impacts differ in different contexts?
- How do different features of a scheme affect its impact?

These questions were developed further by developing a theory of change describing how road enhancements would be expected to lead to impacts on local and subregional economies in collaboration with the DfT and National Highways. This led to the definition of a set of specific hypotheses to be tested which is set out in Section 2.

3.2 Scope of this report

This project involved an analysis of the local economic impacts of a total of 194 road improvement schemes completed between 2002 and 2021. This included road schemes completed on a mix of local roads and parts of the Strategic Road Network (SRN). A total of 79 DfT funded Local Major schemes and 115 National Highways funded schemes were covered.

It should be noted that the following assessment focuses exclusively on road enhancements where the principal strategic objective is to improve connectivity between places by reducing journey times – either by creating new links on the road network or increasing the capacity of or otherwise improving existing links. The DfT and National Highways also fund road enhancements that have a wide variety of other objectives, such as facilitating downstream development or regeneration objectives. The findings of this study cannot be generalised to road enhancement schemes with objectives of this nature and should not be taken as an assessment of the local economic impacts of all types of road improvement.

Ongoing work on a series of case studies is progressing and seeks to contextualise the findings presented within this report and explore some of the mechanisms through which impacts occur.

3.3 Methodology

The project involved the following steps:

- Scoping and development of evaluation plan: The first stage of the study involved agreeing the analytical framework for the study, identifying hypotheses to be tested, and finalising the methodology.

- Scheme selection and mapping of schemes: As part of the development of the evaluation plan, a list of road improvement projects provided by the DfT was filtered to remove projects that did not involve investments in the road network (for example, bus infrastructure projects) or were not expected to involve significant reductions in journey times (such as road maintenance projects). Scheme documentation (such as Business Cases and Post-Opening Project Evaluation (POPE) studies) and other publicly available details of schemes were then used to identify the specific road links that benefitted from investments. This exercise was undertaken manually using the Ordnance Survey (OS) road network (which was provided by DfT). Additional work was completed to confirm other scheme details, such as their opening dates.

- Generation of accessibility measures: The mapping of relevant road links was used to generate an annual version of the UK road network that only incorporated improvements to capacity resulting from the road improvement schemes in the sample (so as to remove improvements to road accessibility resulting from other projects outside of the sample). This was created by taking the 2011 road network and traffic speeds as a 'baseline' (the earliest year for which traffic speed data was available). New links were added to the network in the year in which they were completed. Traffic speeds on the network were also frozen at their 2011 values to remove the effect of subsequent economic growth on traffic volumes and congestion – except where those links were subject to enhancement by a sampled scheme (in which case, speeds were frozen at their first post-opening value). The resultant road networks were then used to compute LSOA to LSOA Origin-Destination matrices for each year between 2011 and 2020. An employment weighted accessibility index was then generated following the example of recent work by Gibbons et al (2019)[6].

- Data assembly: A variety of work was then completed to finalise datasets included in the evaluation. This included assembling longitudinal data on the outcomes required to test the framework of hypotheses agreed and compiling data on observed traffic speeds required to generate the accessibility measures required for one group of econometric methods proposed.

[6] Stephen Gibbons, Teemu Lyytikäinen, Henry G. Overman, Rosa Sanchis-Guarner, New road infrastructure: The effects on firms, Journal of Urban Economics, Volume 110, 2019, Pages 35-50. Available at: https://www.sciencedirect.com/science/article/pii/S0094119019300105

- Econometric analyses: A distance decay and accessibility modelling approach were then utilised to analyse the assembled data to identify the causal impacts of the road schemes under review. Robustness checks and adaptations to methods were adopted to establish confidence in the methods. Details of the methods and check are described in detail within section 5 of this report.

3.4 Structure of this report

The remainder of this report is structured as follows:

- Section 3: Analytical framework – Presents the overarching theory of change for the project and describes the expected outcomes and impacts motivating the analysis presented thereafter.
- Section 4: Portfolio of schemes in scope – Describes the schemes that were included in the analysis and the process through which these were selected.
- Section 5: Econometric approach – Describes the key methodological approaches taken to the econometric analysis and the main specifications used.
- Section 6: Impacts on local businesses – Presents the results of the econometric analysis focussed upon the impacts for local businesses impacted by completed road schemes.
- Section 7: Impacts on local labour markets – Presents the estimated impacts on local labour markets and the workforce in areas impacted by road schemes.
- Section 8: Impacts on land and property markets – Presents the results of the econometric analysis analysing the impacts on commercial and residential property markets.
- Section 9: Conclusions – Summarises the key findings, discusses policy implications and outlines issues for future consideration.

4 Analytical framework

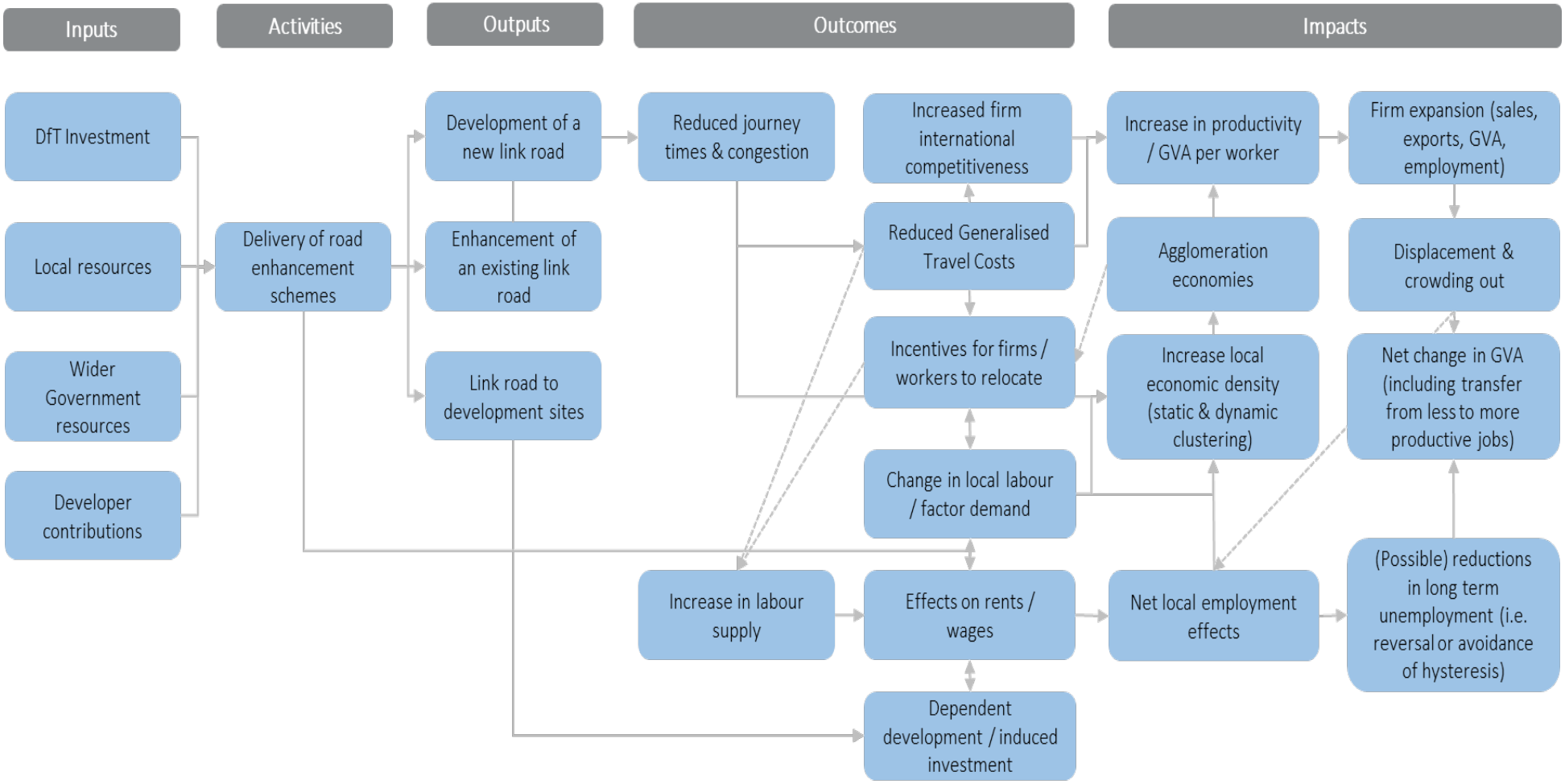
This section provides an overarching analytical framework for the analysis, providing an account of the hypothesised causal processes through which road enhancements would be expected to produce economic impacts at the local level. This includes a discussion of the underlying mechanisms through which these impacts may arise and how they may vary across different contexts. This section concludes with the framework of hypotheses agreed with DfT and National Highways to be tested in the study.

4.1 Theory of change

This section provides an overview of how the inputs and activities of road enhancement schemes would be expected to lead to their intended outputs, outcomes, and impacts. This built upon the work done as part of a scoping study that included a review of key documentation, a review of academic literature and interviews with a small number of stakeholders to generate the logic model.

A visual summary of this analysis is provided in the following figure.

Figure 4.1: Logic model



4.1.2 Inputs and activities

A range of inputs are used to make enhancements to the road network which vary across different schemes. The delivery of road enhancement schemes typically absorbs resources provided by scheme promoters, the UK government more widely, local authorities (LAs), and third-party developers. Scheme promoters also contribute time and resources to support the development and management of schemes (for example, in developing business cases). LAs may also support the scheme planning and development process by supporting planning applications or obtaining legal permissions and coordinating delivery. Some schemes may also receive contributions from third party developers if they offer opportunities to undertake a programme of commercial and/or residential development.

4.1.3 Outputs

Road enhancement schemes will typically produce two types of output of relevance to this study:

- **Provision of new road links:** Road enhancement projects may result in the provision of entirely new links in the road network, enabling new more direct routes to be taken (or providing routes that avoid and / or help to relieve congestion).
- **Improvements to existing road links:** Road enhancements may also result in improvements to existing road links that increase their capacity (e.g., the addition of lanes or the implementation of Smart Motorways) or otherwise increase traffic speeds (e.g., junction redesign).

Some road enhancement schemes may provide new links to specific parcels of lands. These are distinguished from the general provision of new road links because their primary objective is to facilitate access to commercial and/or development sites rather than to reduce journey times for road users. These types of schemes are out of the scope of the quantitative research set out in the report, though their potential effects on local economies are also considered in the following analysis.

4.1.4 Accessibility outcomes

The key first order outcome of road enhancement schemes is increased ‘accessibility’ which can be understood in different ways depending on the nature of the project:

- **Reduced journey times, congestion, and generalised travel costs:** Road network enhancements would be expected to reduce congestion and increase traffic speeds, resulting in more predictable journey times and reducing generalised travel costs. These improvements may generate additional demands on the road network by encouraging marginal road users to make use of the network or by stimulating additional local economic activity. Users may also travel longer distances in response to reductions in travel costs.
- **Access to specific sites:** Some road enhancements will allow specific parcels of land to be accessed by road. These include development sites and major transport hubs such as ports:

- **Access to development sites:** Road enhancements of this type may include a distributor road that opens greenfield or brownfield sites for development, or a new link or a junction improvement which makes access to an existing employment or residential site easier or possible.

- **Access roads to ports**: This could include the creation of new access roads that specifically cater for users of the ports, and enhancements to the surrounding road network to increase the overall capacity of traffic flows at given times. Improved access is expected to result in reduced journey times and improved reliability for port users.

4.1.5 Impacts on firms

Investments in the road network might be expected to deliver a range of outcomes depending on the specifics of the schemes under review and firm characteristics such as sector or size:

- **Reductions in costs:** Reductions in journey times would be expected to reduce the costs associated with freight logistics and business travel. These effects may feed through into higher GVA per worker if workers spend less time travelling and allocate more time to production, if savings on freight logistics are not fully passed on to consumers, or if firms reorganise themselves more efficiently in response to more reliable or rapid journey times. These effects might be expected to be more important for firms located near and/or making the most use of the road infrastructure in the areas most affected by the schemes (such as logistics, construction, and manufacturing industries).

- **Firm expansion**: If firms reduce prices in response to lower costs, enhanced competitiveness may allow them to acquire new customers or expand sales to existing customers, leading to higher levels of local output (GVA). Firms may need to recruit new workers to meet the additional demand, resulting in increases in local employment. On the other hand, increased exposure to competition may negatively affect local firms, resulting in contractionary effects. This could also occur if more distant firms reconfigure their operations to serve areas made more accessible by schemes.

- **Firm entry, exit and formation:** Road enhancements may also make the areas concerned more attractive to firms looking to expand or relocate or to those considering starting a business, leading to new investment and the creation of jobs and GVA within the local areas concerned. A focus of the evaluation will be to understand the extent to which these changes are driven by (1) the enhanced road infrastructure itself, (2) other aspects of the relocation that were not directly related to the road infrastructure (e.g. local broadband infrastructure or features of premises), and (3) how far incoming firms are merely more productive than incumbents. Improvements to accessibility may also change the structure of the local economy by attracting firms that are more dependent on transport links. However, the entry of new firms into an area may displace revenues and output from incumbents.

- **Labour specialisation:** Changes in the road network may also make it more efficient for a firm to serve multiple locations from a single location, rather than multiple sites. As such, a

firm may choose to close less efficient plants, producing specialisation (e.g. where some geographic areas focus on the production of a smaller set of goods and services).

- **International trade effects:** Where firms realise productivity gains, they could be expected to increase their competitiveness in international markets (at least those in the tradable goods sector). By achieving journey time savings, those businesses that are most reliant on the road network may become more competitive, because they can supply, and potentially export, more goods in a given time period than was previously possible or reduce process to reflect lower costs. Improvements in the road network may also result in overseas firms reducing their travel costs when exporting to the UK (reducing import costs). A subset of schemes aims to enhance access to ports. Improving access to port sites, either through new or existing link enhancements or facilitating the development of employment land proximate to ports, may also decrease the costs of imports and exports, potentially resulting in increased trade volumes.

4.1.6 Labour markets impacts

The impacts of road enhancements may also be visible in effects on the land market:

- **Direct effects on labour supply:** Improvements in the road network may cause economically inactive individuals to enter the labour market, typically by increasing their returns to labour. This could be driven by higher wages (as a result of being able to access more productive employment opportunities) or a decrease in the costs of accessing employment opportunities. For example, improvements in accessibility will reduce commuting times to employment centres, increasing workers' areas of job search and encouraging greater labour market participation or increased hours worked. This may also have benefits in alleviating labour supply constraints on firms and improving matching between the supply and demand for skills. Local impacts for firms may not always be positive, if local firms may face increased competition for labour from firms based elsewhere. An increase in local labour supply may also place downward pressure on wages and GVA per worker, should demand for workers not change, negatively affecting existing workers but positively affecting firms.

- **Sorting effects:** Where road investment schemes have acted as a spur for residential development, they have the potential to attract new residents and households to the areas involved (provided new housing is not purchased or rented by 'latent' households already resident in the area). New residents may alter the composition of local skills supply. If housing schemes attract more productive residents (who may not fill local jobs), then this may be observed in increases in the average wages of residents following the completion of construction activity. Similar outcomes may also occur without additional residential development – for example, if households are attracted by enhanced connectivity[7]. Such effects may accelerate further local economic growth through positive consumption effects in

[7] Though without additional housing, this may merely place pressure on rents and/or house prices, potentially forcing lower income residents elsewhere.

secondary markets. In addition, population growth will be accompanied by an increase in local labour supply. In tight local labour markets this could help alleviate constraints on local growth. In other cases, it could create downward pressures on local wage levels, at least in the short run (and likely accompanied by offsetting effects elsewhere).

- **Unemployment impacts:** As noted, road enhancements have the potential to result in the creation of new jobs at the local level. This may result in reductions in the rate of local unemployment should residents have the required skill sets to access the employment opportunities created and there is sufficient slack in the labour market to support these types of reduction.

4.1.7 Land use impacts

Developments will either be primarily commercial, industrial or residential in nature and effects could be direct or indirect:

- **Direct effects in commercial and residential property markets**: A subset of schemes have features that facilitate access to land supply. These schemes will increase the supply of developable land and ultimately result in the development of new commercial and industrial floorspace. This may alleviate supply constraints on the development of local firms with beneficial impacts on local investment, GVA and employment. There may also be effects in retaining firms within the area which might have otherwise chosen to relocate, in whole or in part, to other areas. To the extent that any increase in the supply of land with residential planning designation addresses constraints on the availability of suitable plots, such schemes should increase starts and completions of new homes. However, there is a possibility that this is accompanied by offsetting effects via crowding out of development on less attractive plots.

- **Indirect effects in commercial and residential property markets**: Increased demand for commercial floorspace or residential property may also place upward pressure on local rental/land values, which may create incentives for additional development.

4.1.8 Agglomeration effects

Further positive impacts on firms' performance may arise if the improvements widen the areas which firms can serve from the localities affected or increase the density of their business networks. Increases in economic density are likely to produce several knock-on effects:

- **External economies of scale:** Increases in economic density may benefit the economy more widely by creating positive external economies of scale. Local firms may become more productive by being in closer proximity to other firms, factors of production or infrastructure (static clustering). Changes in the size of local clusters as a result of induced investment by firms (dynamic clustering) may also boost productivity. The size of these effects is likely to be dependent on the scale of the economic masses involved, and the type and scale of connectivity enhancement delivered, or in some cases, the characteristics of the development sites made available.

- **Competition effects**: There may also be offsetting effects, however, resulting from increasing rentals and land prices or other pressures on factors in fixed supply, particularly if there are significant constraints on the local availability of development land/premises (as highlighted above).

- **Disagglomeration effects**: On the other hand, road investments may produce 'disagglomeration' effects if firms are incentivised by schemes to move from more to less economically dense areas (though such effects may be temporary if the resources made available by the relocation are quickly redeployed). While these decisions may benefit the firms concerned, there may be negative impacts on firms and residents that do not relocate.

4.1.9 Other impacts

Changes in journey times, travel costs, development and economic performance as described above are likely to result in a range of wider, indirect effects in the economy:

- **Displacement**: Displacement effects could occur through two mechanisms. Firstly, if the connectivity improvements or newly accessed development sites offer users a relative advantage over their competitors, the scheme may result in the displacement of output and jobs from other locations in the area served elsewhere in the economy. Secondly, if firms are attracted to the area, there will be some corresponding losses of employment and output from the areas from which those firms originate.

- **Multiplier effects**: The various potential direct effects on local economic performance will also potentially create positive multiplier effects on the growth of other firms in the area through a combination of increased purchases of inputs by firms from local suppliers (indirect effects) and increased consumers' expenditure by those who derive increases in their income through the various direct effects (induced effects). However, these effects may typically be constrained by supply-side factors, as noted below.

- **Equilibrating effects:** The outcomes produced by accessibility improvements may be dampened by the upward pressures these create on local prices of labour and other factors of production. The extent of such effects will depend on the significance of the local supply constraints and on the ways in which local firms respond to the cost increases involved. In the case of creating access to commercial development sites, the various effects described may be dampened by offsetting increases in the prices of existing and proposed designated employment land and commercial space as a result of the effects in stimulating local economic activity. Similarly, the increases in economic activity may create pressures on other factor prices which may dampen the initial stimulus effects. Overall, if the economy is in a long-term equilibrium any changes in employment and other factors will likely be offset by losses elsewhere in the economy (though these effects may not be observed at the local level).

- **Hysteresis effects:** The conclusion of the preceding bullet depends on an assumption that the relevant local economies are operating at full employment. However, it is possible that road enhancements stimulate demand in areas where workers have been less able to

respond to past economic shocks and wider structural changes (e.g. areas of high unemployment affected by the decline of traditional manufacturing industries). In these cases, the output produced by those filling the vacancies created has potential to be additional at the national level, providing any vacancies produced (or vacancies released by the uptake of new opportunities created) are filled by those that would have otherwise been long-term unemployed.

4.2 Hypotheses tested

The table below outlines the hypotheses to be tested, as agreed with the Project Steering Group. Owing to changes in the availability of claimant statistics resulting from the introduction of Universal Credit, it was not possible to explore the impacts of the programme on long-term unemployment. Additionally, no usable data could be obtained on land use.

Table 4.1: Table of hypotheses to be tested

Impacts on firms	
1	Enhanced connectivity and/or downstream development induced by road enhancements increases firm formation in nearby areas
2	Enhanced connectivity and/or downstream development induced by road enhancements encourages firms to locate/relocate to nearby areas
3	Enhanced connectivity and/or downstream development induced by road enhancements increases the productivity of firms located in nearby areas
4	Increased local productivity is driven by the relocation of more productive firms to nearby areas and/or exit of less productive firms (i.e. displacement)
5	Increased local productivity is driven by improvements in the efficiency of incumbent (spatially stable) firms
6	Increased local productivity is driven by increases in economic density (i.e. agglomeration effects)
7	Enhanced connectivity and/or downstream development induced by road enhancements facilitate the expansion of firms in nearby areas (turnover and jobs)
8	Enhanced connectivity and/or downstream development induced by road enhancements facilitate expansions in trade (imports and exports)
9	Enhanced connectivity and/or downstream development induced by road enhancements stimulate capital investment
10	For hypotheses 1-9, the effects of road enhancements vary across sectors of the economy, and the productivity and degree of urbanisation of the sub-region
Impacts on the labour market/workers	
11	Enhanced connectivity and/or downstream development induced by road enhancements stimulates population growth in nearby areas
12	Enhanced connectivity and/or downstream development induced by road enhancements alters the composition of local skills supply
13	Enhanced connectivity and/or downstream development induced by road enhancements increases the wages of the working population
14	For hypothesis 13, the effects of road enhancements vary across occupational groups
15	For hypothesis 13, wage gains are experienced by incumbent workers
16	For hypothesis 13, wage gains are experienced by incoming workers
17	Enhanced connectivity and/or downstream development induced by road enhancements reduces the number of unemployed claimants in nearby areas
18	Enhanced connectivity and/or downstream development induced by road enhancements reduces the no. of long-term unemployed claimants in nearby areas
19	Enhanced connectivity and/or downstream development induced by road enhancements increases economic activity rates of local workers
Impacts on land and property markets	
20	Enhanced connectivity and/or downstream development induced by road enhancements increases commercial and/or industrial rental values in nearby areas
21	Enhanced connectivity and/or downstream development induced by road enhancements stimulates the development of additional commercial and industrial floorspace in nearby areas
22	Enhanced connectivity and/or downstream development induced by road enhancements increases house prices and residential development in nearby areas
23	Enhanced connectivity and/or downstream development induced by road enhancements leads to changes in land use

5 Scheme portfolio

This section provides an overview of the sample of road enhancement schemes included within the scope of the analysis.

5.1 Schemes in scope

Testing the hypotheses requires the selection of a sufficiently large sample of road enhancement schemes. The process of identifying a sample of suitable schemes began with an analysis of scheme documentation[8] provided by DfT and National Highways. In total, the DfT and National Highways provided documents relating to a sample of 235 transport investment schemes. This sample was comprised of 120 Local Major projects and 115 National Highways schemes that opened between 2002 and 2018.

An analysis of this documentation identified a subset of these schemes that formed the focus of the quantitative analysis. This involved consideration of:

- **Out of scope schemes:** Only schemes providing new road links or enhancing existing links were considered in the scope of the study. Schemes that did not involve investments in the road network or schemes with predominantly non-economic objectives were considered out of scope as follows:
  - Non-road schemes: Thirty-eight Local Major schemes were excluded because they did not involve investment in the road network. These schemes predominately involved improvements to bus infrastructure, and road maintenance and safety improvements.
  - Road schemes with non-economic objectives: Five Local Major schemes were excluded because they involved the introduction of new transport systems. These schemes sought to improve the management of traffic and junctions. They were then excluded given the challenges in assessing changes in accessibility and the likely small magnitude of any wider economic benefits achieved.

    A total of 194 schemes remained (115 National Highways schemes and 79 Local Major projects) following these exclusions.
- **Scheme classification:** Each remaining scheme was categorised in terms of its characteristics (i.e., the type of scheme, the nature of the objectives of the scheme, and the types of areas linked by the schemes).

The DfT and National Highways were only able to provide information if it had been retained and there was some variability in the documentation available for each scheme. Business Case documentation was not available for 18 schemes and for others only an appraisal summary

[8] Including Businesses Cases, forecast and actual spending profiles, economic appraisals, project reports, and evaluation reports

table was available. Where appraisals or ex-post evaluations were not available, judgements had to be made on the objectives and expected impacts of the scheme based on the available information. It was challenging to identify the budget allocations of road components of larger schemes that included more than one investment and the expected magnitude and type of their anticipated benefits.

Scheme locations

The locations of the road improvement schemes were identified by taking information on the road links subject to construction and enhancement provided in scheme documentation and mapping these to the corresponding links in the Ordnance Survey Road Network file. This exercise was completed manually as the DfT and National Highways had no electronic GIS files recording the geographical scope of schemes.

The locations of schemes included in the scope of the analysis are mapped in Figure 3.1 (with National Highways schemes highlighted in orange, and Local Major schemes highlighted in yellow). Considered at the ‘system’ level, the schemes sampled focused predominantly on facilitating more rapid transit on the north-south spines of the road network connecting London with large cities in the Midlands, the North-West and the North-East (although Local Major schemes were more dispersed). It should be noted that in some cases, road improvement schemes involved sequential improvements to stretches of major roads (e.g. the stretch of the A1 between Worksop and Peterborough).

Figure 5.1: Location of road improvement schemes



Source: Ipsos analysis of schemes documentation and Ordnance Survey ITN. National Highways schemes are highlighted in black while DfT Local Majors are highlighted in red.

5.2 Scheme characteristics

The schemes included in the sample were characterised in terms of their objectives, the type of project, and the types of areas benefitting from improved connectivity. This section provides a descriptive analysis of the 194 schemes that were reviewed in detail.

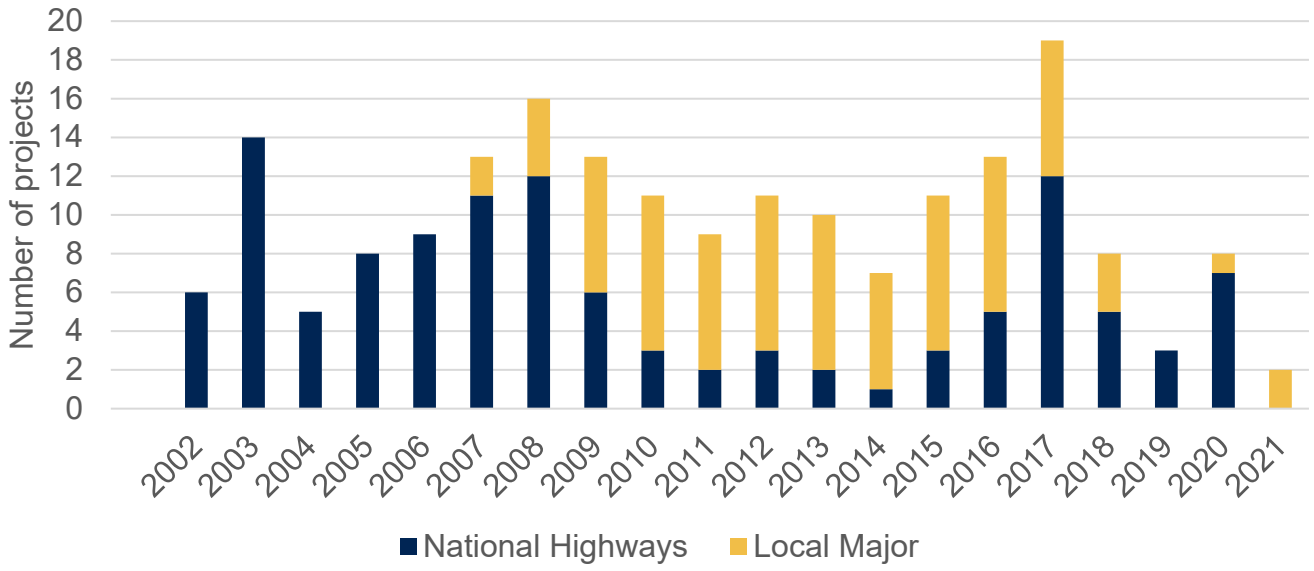
Opening year

Data on the actual opening dates of schemes were derived from DfT monitoring data or POPE studies. There was some annual variation in the number of schemes completed, though the most significant pattern is the growing share of DfT Local Majors in the sample between 2007 and 2017. As highlighted in the preceding chart, DfT Local Majors were more dispersed than National Highways schemes and if they were in areas with systematically different

characteristics then this could introduce possible biases in the econometric analysis. To account for this, analysis also needed to be completed separately for Local Major and National highways schemes.

It should be noted that the portfolio of schemes included in this analysis does not represent the full population of DfT and National Highways schemes funded over the period (which drives some of the apparent volatility in annual completions). This could create some possible issues in relation to the external validity of findings from the proposed econometric analysis (i.e., how far any results can be generalised across all investments made by the DfT and National Highways in improving the network) if the portfolio of schemes included are not representative of the broader population. However, information on the overall population of schemes was not available and the representativeness of the sample could not be assessed.

Figure 5.2: Number of road improvement schemes by opening year, 2002 to 2021



Source: DfT and National Highways scheme documents, Ipsos analysis

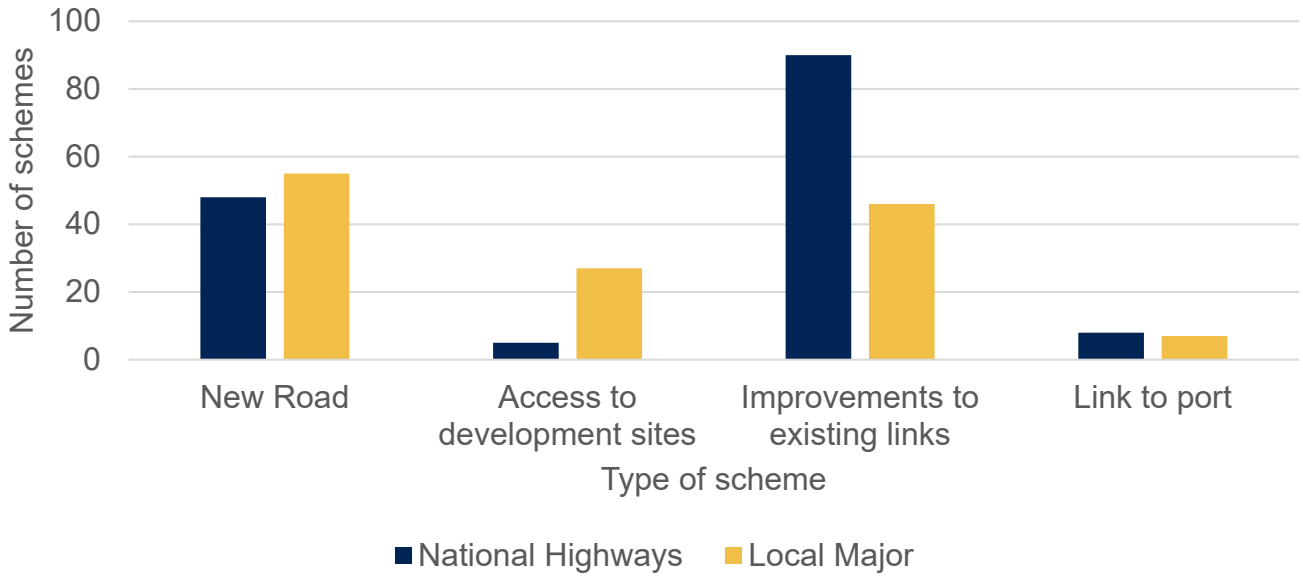
Type of scheme

The 194 schemes were classified in terms of how far they involved the provision of new road links, improvements to existing road links, whether they provided links to development sites, and whether they provided links to ports. Any single scheme could include one or more of these features:

- Most schemes (136) involved improvements to existing links, although over half (103) involved the creation of new road links.
- Only a small share of projects (32 of 194) involved providing access roads to development sites, and a minority (15 of 194) had an explicit focus on improving access to ports. It should be noted that this classification was based on the available narrative describing the key features of each scheme and some details may have been omitted.

- There appeared to be systematic differences in the characteristics of National Highways and Local Major schemes. The former involved a substantially higher share of improvements to the existing road network, reflecting the focus on enhancing the Strategic Road Network. Local Major schemes were more likely to involve the provision of new roads and have an explicit focus on enabling downstream development by providing access roads to development sites.

Figure 5.3: Number of schemes by type



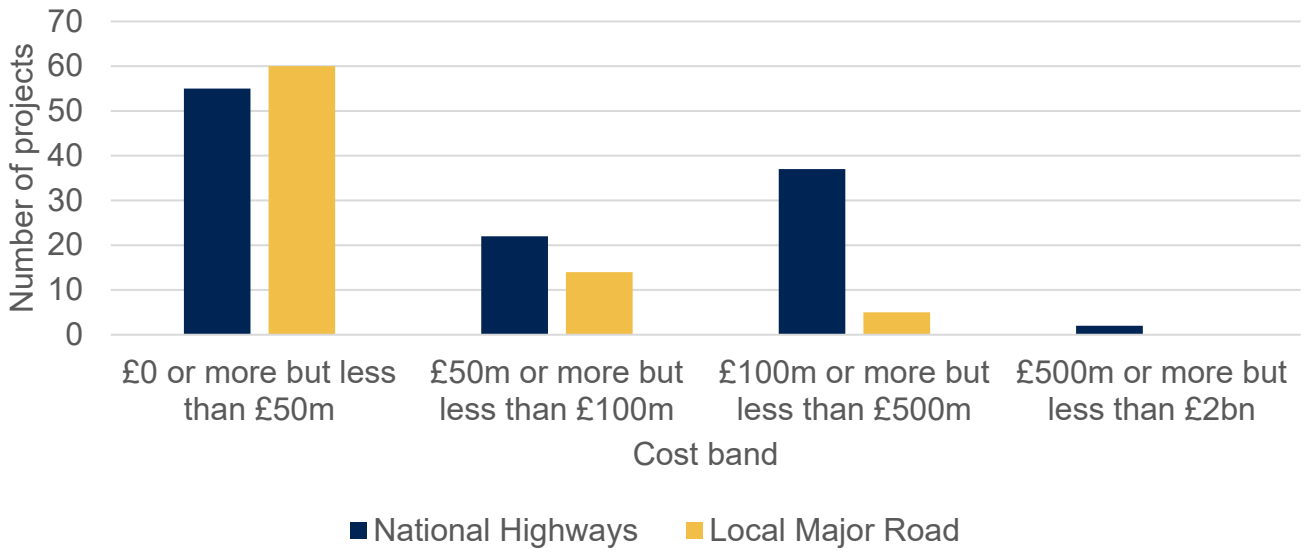
Source: DfT and National Highways scheme documents, Ipsos analysis

Cost of schemes

The figure below provides the distribution of schemes by their expected costs. National Highways schemes tended to involve more significant costs than Local Major schemes (which may be expected given the breadth of coverage of the road network represented by these schemes).

This has potentially important implications, in that the nature of the scheme approval process implies that schemes with more significant costs can also be expected to deliver more significant journey time savings. As Local Major schemes as a share of completions does not appear to be randomly distributed over time, schemes opening in later years can be expected to be associated with smaller journey times savings than those completed in earlier years. This also necessitated the analysis being completed for Local Majors and National Highways schemes separately.

Figure 5.4: Cost of schemes by scheme type

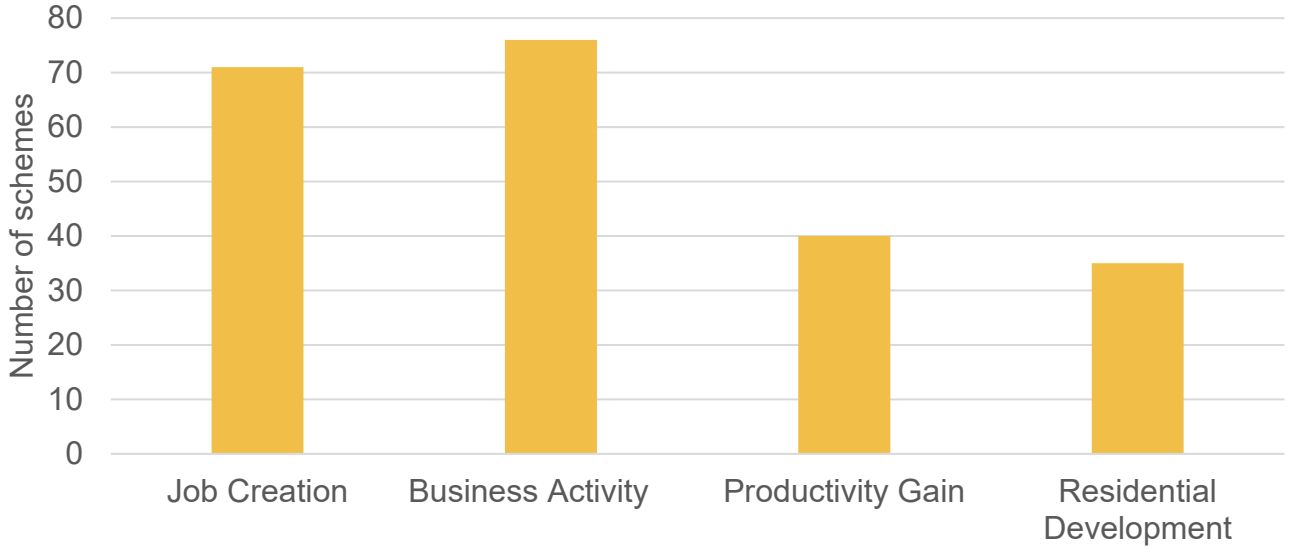


Source: DfT and National Highways scheme documents, Ipsos analysis

Scheme aims

Many of the schemes had explicit objectives to support economic growth (as illustrated in the figure below). Business cases for Local Major projects were more likely to cite these objectives than those associated with National Highways schemes (though this may partly reflect the nature of the appraisal process, where if the journey time savings are sufficiently large, there may have been less of a requirement to elaborate on the broader objectives of the scheme).

Figure 5.5: Number of schemes with explicit economic growth objectives



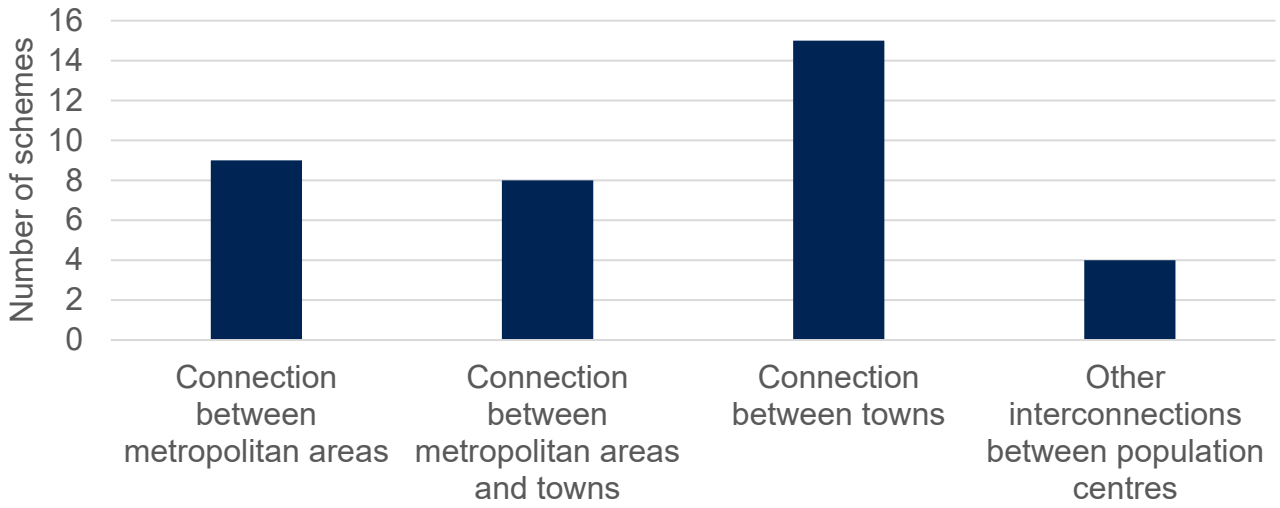
Source: Ipsos analysis of scheme documentation

Types of connections

Schemes were also classified in terms of the types of areas they connected. Improvements to interconnections between population centres accounted for 19 percent of schemes compared to 28 percent of schemes improving connections into urban areas. Bypass schemes were the most common type of improvement (41 of 194 schemes), however a total of 62 other schemes did not fall into the classifications described. These schemes were predominantly motorway or smart motorway schemes[9]:

- Of the 36 schemes directly focused on improving connections between population centres, 15 sought to improve connections between metropolitan areas (with each other or with surrounding towns), while 15 sought to improve connections between smaller towns and cities.
- A further 17 schemes aimed to improve connections into and/or out of population centres (improving general connectivity).
- 19 schemes aimed to improve connections within urban areas (including connections to ports, airports, or other transport hubs).
- A relatively large number of schemes involved junction improvements (28 schemes).

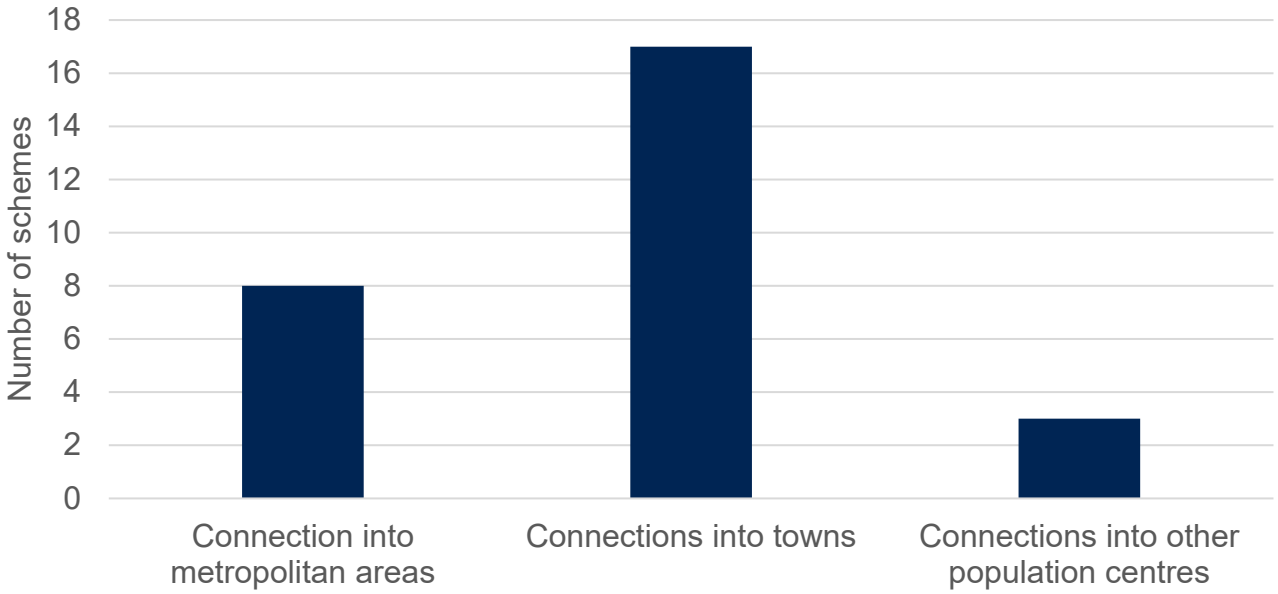
Figure 5.6: Interconnections between urban areas (new or improved links between towns and cities)



Source: DfT and National Highways scheme documents, Ipsos analysis

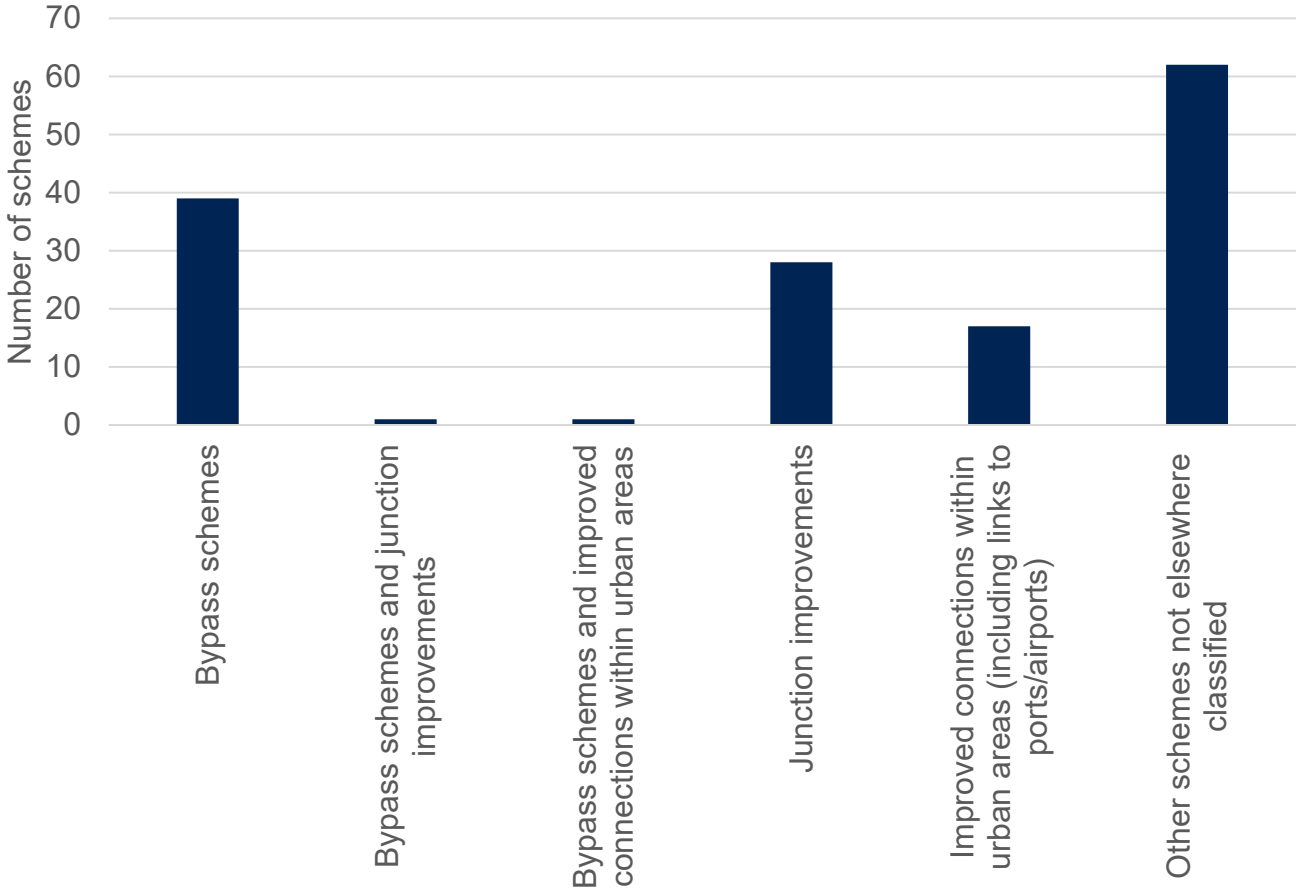
[9] For example the M1 J23a-25 Smart Motorway project - part of Tranche 2 of Highways England's Smart Motorway Programme (SMP), the A500 Etruria Widening scheme and the M6 Smart Motorway scheme.

Figure 5.7: Improved connectivity into urban areas (new or improved links into towns and cities)



Source: Ipsos analysis of scheme documentation

Figure 5.8: Other scheme types



Source: Ipsos analysis of scheme documentation

6 Methodology

This section sets out the methodological approach taken to the analysis, including the process of data assembly and the approaches taken to econometric modelling.

6.1 Data

The following section provides an overview of the data used in this analysis. These include a mixture of sources from outcome data accessed within the Secure Research Service (SRS), publicly available outcome data sources and scheme/network specific data obtained through DfT and National Highways:

6.1.1 Firm level data

Business Structure Database (BSD)

The Business Structure Database is an annual snapshot of the Interdepartmental Business Register, providing measures of employment and turnover for all firms registered for VAT and PAYE, and covers 99 percent of economic activity in the UK. The underlying data is drawn from both administrative data (VAT and PAYE returns to HMRC) and ONS' regular surveys (the Business Register Employment Survey and the Annual Business Survey). Annual cross sections are available containing mostly plant level data which was aggregated to LSOA level for the purpose of the analysis. Data was available for firms stretching back to 1997 with the latest cross section accessible for this project being 2021, allowing for a panel to be created covering this period across 33,519 LSOAs[10]. It should be noted that the data (particularly observations of turnover) is associated with reporting lags, and in some cases, measures of turnover may be two years out of date.

The BSD was also used to isolate two groups of firms of particular interest:

- Single site enterprises: Whilst employment data is available at plant level, turnover is provided at the overall enterprise level. Turnover was apportioned to local units on the basis of their share of total employment in the enterprise. This implicitly assumes that each local unit is equally productive (which may not prove to be accurate). To explore the extent to which the apportionment methodology was distortionary, firms that operate from a single site were isolated as a special group of interest. These firms were identified using the number of live units variable in the data. Single site firms accounted for the vast majority of UK based

[10] Note that the spread of this panel covered the change between 2001 and 2011 LSOAs. To avoid adding additional complexity to the analysis, only LSOAs which were not altered were in area were used. Of the 34,378 2001 LSOAs in England and Wales, 33,519 (96 percent) remained unchanged in area in the 2011 revision.

firms with such firms accounting for 98 percent of the total number of enterprises in 2021 and 84 percent of the total number of local units.

- Spatially stable firms: The local impacts of road improvements may be driven by a combination of (a) impacts on the competitiveness and growth of firms and (b) relocation of economic activity from elsewhere in the UK (which will be subject to offsetting economic losses in those areas). To provide a closer approximation of the effects of the road improvements on national economic output and efficiency, spatially stable plants (i.e. those that do change location) were also drawn out as a special group of interest. The BSD allows the identification of local units that did and did not change location over time using the Output Area tag indicating the location of the plant in each cross section. This was used to identify plants that remained stationary for at least five years following the completion of a road improvement scheme.

The BSD also enabled analysis of the following:

- **Firm level spatial structure:** As highlighted in Section 2, firms may respond to road enhancements by adjusting their spatial structure (e.g., opening new sites close to the road enhancement, closing sites further away, consolidating sites). This was explored by calculating the below variables at the enterprise level (differing from the area level analysis enabled by the above). These analyses will only provide estimates of impact on incumbent firms affected by road schemes:
  - Total number of plants operated by firms located near road improvements at the time of opening (to explore whether road enhancement schemes influenced the total number of plants operated by firms).
  - Total number of plants operated by firms located near road improvements at the time of opening, within 30km of the scheme (to explore whether road enhancements encourage firms to either open new plants to take advantage of improved connectivity or to consolidate local operations).
  - Total number of plants operated by firms located near road improvements at the time of opening, beyond 30km of the scheme (to explore how far road enhancements drive national reorganisations of operations).
- **Sectors**: Effects at the sector level were estimated by restricting samples to broad sector groups based on their SIC code. The following broad groups were derived for this purpose:
  - Primary industries (SIC section A and B)
  - Manufacturing (SIC C)
  - Utilities (SIC D and E)
  - Construction (SIC F)
-

- Transport and storage (SIC H)
- Non-tradable services (SIC G, I, L, N, O, P, Q, R, S)
- Tradable services (SIC J, K, M)

  For these analyses, only activity generated by these firms was included in the aggregation to LSOA with turnover per worker again derived by taking the resultant LSOA turnover for the relevant sector and dividing through by the LSOA employment for that sector.

Annual Business Survey (ABS)

The ABS is an annual mandatory census of large firms (with 250 employees or more) and a sample survey of small and medium sized firms. The survey is used by the ONS to generate estimates of total output (GVA)[11] in the economy and other macro-economic aggregates, but the micro-data can be used to provide observations on GVA, and GVA per worker. The data series begins in 2008 with a panel of firms created for our analysis covering the period between 2008 and 2020.

Data in the ABS is provided at the reporting unit level which can account for one or more local units. As a result, data on GVA was aggregated up to the enterprise level before being combined with the BSD data on plant level employment to apportion GVA to plants based upon their share of total enterprise employment (as per the apportionment for turnover described above in the BSD). GVA and employment indicators were aggregated up to LSOA to leave area level indicators of total GVA and employment. GVA per worker was then derived by dividing LSOA level GVA through by the derived employment variable. Where no GVA was indicated, LSOAs were given zeros for both GVA and GVA per worker leaving a dataset covering 33,519 LSOAs between 2008 and 2020.Results based upon the ABS should be viewed with caution until revised analysis can be completed.

6.1.2 Impacts on labour markets.

Annual Survey of Hours and Earnings

The Annual Survey of Hours and Earnings (ASHE) provides annual observations of the wages of workers and is based on a one percent sample of employee jobs taken from HM Revenue and Customs' (HMRC's) Pay As You Earn (PAYE) records. The sample covers approximately 300,000 workers, and the survey occurs annually. Data was available from 1997 through to 2020 at the individual level with both the locations of the workers residential location and employers' location available. A worker level panel dataset was created by appending the

[11] GVA is calculated in the ABS as income generated by a business less their intermediate consumption of goods and services used up in order to produce their output, labour costs (for example, wages and salaries) and an operating surplus (or loss).

annual cross-sections with the final dataset covering a total of just over 3m records. Hourly earnings and total hours worked were used as the outcomes of interest.

The locations of employers were used to identify a subset of workers that did not change employer for at least five years post a schemes completion. This was used to identify effects on incumbent workers to explore the extent to which wage impacts were driven by relocation of workers from other areas.

Standard Occupational Classification (SOC) codes present in the data also allowed the analysis to be restricted to certain groups of workers. The classification codes were grouped at the one-digit level and then reduced to four major groupings for analysis. These encompassed:

- **Managerial, professional and technical**: Including SOC categories 1 to 3, these occupations cover managers, directors, officials, professional occupations and associate professional and technical occupations.
- **Administrative, leisure and service occupations**: Covering SOC codes 4, 6 & 7, this category covers all service-related occupations, including administrative & secretarial occupations, caring, leisure, sales and customer service roles.
- **Skilled trades**: SOC codes 5 and 8, covering skilled trade occupations and process, plant and machine operatives. Jobs involved in the production of goods will predominantly fall under this category.
- **Elementary occupations:** Covering only SOC code 9 – elementary occupations such as farm labourers, window cleaners and security guards.

Census

The 2001, 2011 and 2021 Census data provide long-term measures of changes in the size and composition of the local population at the LSOA level. These were used to examine impacts on population and skills.

LSOA level data was obtained from each census survey from nomis on the following variables:

- **Population**: The usual resident population within each LSOA was obtained for use as the key outcome variable to assess population growth impacts.
- **Skills**: The proportion of people with an NVQ 4+[12] qualification was taken to provide a measure of the skills.

[12] NVQ 4 is equivalent to a Higher Education Certificate/BTEC with NVQ 4+ also including graduate, postgraduate and doctoral degrees.

- **Economic activity**: The proportion of working age population classified as economically active was used as the outcome measure to explore effects on economic activity.

A three period panel data was generated using the data from 2001, 2011 and 2021 for 33,519 LSOAs that did not change boundary between 2001 and 2011. To arrive at the estimated impact per scheme on these outcomes, the treatment variable was defined as the cumulative number of schemes completed within 30km (or each distance band for the analysis broken down by distance) by each census date.

Claimant count

Data on unemployment was taken from the experimental 'claimant count' series that counts the number of people claiming Jobseekers Allowance and those claiming Universal Credit that are required to seek work. This series was introduced to address the disruption caused by the Universal Credit to previous claimant count series (that counted the number of JSA claimants). Although the series has been calculated from 1986, it is only available from 2013 onwards at the LSOA level.

Annual data at the LSOA level was obtained from nomis for all years from 2013 to 2022. This was used to generate a panel dataset describing the number of claimants by year for all 33,519 LSOAs that did not change boundary between 2001 and 2011.

6.1.3 Impacts on land and property markets

Valuation Office Agency (VOA) Ratings Lists

Information on total commercial floorspace and average rateable values were taken from the 2010 and 2017 non-domestic ratings lists published by the VOA. This data provided premises level information on the floorspace and rateable value associated with commercial premises. This data is available at a site level and was aggregated to LSOA with the total amount of floorspace calculated across each LSOA and the average rateable value generated. The rateable value per metre squared is interpreted as a measure of the rental value of property, although these are the VOAs assessment of the rent the property could obtain should it be vacant and in reasonable repair, rather than observed rents.

Where no data was present on floorspace or rateable value in the VOA data it was assumed that there were no commercial units in that locality in that year and the outcomes were set to zero for these areas. This meant that the final dataset contained two periods of data covering all LSOAs that did not change boundary between 2001 and 2011. The treatment variable for this analysis was the cumulative number of schemes within 30km of the LSOA by 2010 and 2017 respectively.

HM Land Registry Price Paid Data (PPD)

The primary dataset used for the house price analysis was the transaction level data on houses sold compiled by HM Land Registry. This provides a variety of data on individual housing transactions, including:

- Postcode and address of the house sold.
- Sale price agreed.
- Date of completion.
- Some basic information on the characteristics of the property – including tenure (freehold or leasehold) and type (detached, semi-detached, terrace, or flat/maisonette).

Transactions were linked to LSOA and then linked to the treatment data defining the treatment status of the LSOA and the accessibility index. This process identified 6,247,338 transactions across 4,575,077 homes sold in LSOAs that were situated within 30km of a completed scheme between 1995 and 2022. Around 2,373,988 (38 percent) of these transactions took place before a scheme was completed. A panel dataset was then generated, configured at the transactional level.

VOA Council Tax Stock data

Data on the total number of residential properties registered for council tax was obtained from the VOA and the 'Council Tax: stock of properties' releases. This data outlines the total number of properties by council tax band in each LSOA, covering the period from 2015 to 2022. The total number of residential properties was calculated for each LSOA before it was linked to the treatment dataset defining the treatment status of the LSOA and the accessibility index. Once again this resulted in a panel dataset covering all 33,519 LSOAs that did not change boundary between 2001 and 2011.

6.2 Counterfactual approach

A credible impact evaluation requires a comparison of areas affected by road improvements to areas that were not (or areas that were less intensively affected). If those comparisons are to provide valid insights into the impact of the policy or programme, those in the comparison group should be equivalent to those affected by the intervention in all respects other than that they did not benefit from the intervention. There are several challenges involved in selecting an appropriate comparison group for an assessment of the impacts of road enhancements:

- **Reverse causality:** A central problem arises from potential biases driven by scheme placement decisions. There is a risk that the areas selected to benefit from road enhancements are chosen because firms located near the scheme are expected to grow in the future, or that past planning decisions have been made that may encourage greater levels of physical and economic development, stimulating local population and economic growth (a reverse causality problem). If so, areas that benefit from road enhancements might be expected to grow more rapidly than those areas that have not, regardless of the investment in the road network. As such, general comparisons between areas that do and do not benefit from road enhancements are likely to overstate their impacts.
- **Absence of areas not affected by road enhancements:** There is also a broader problem in that any given transport investment has the potential to improve accessibility to all areas in

the UK. While the relative importance of these improvements may be negligible for areas a long distance from the scheme, an evaluation will need to be sensitive to the issue that there are no areas that do not benefit, just areas that benefit to variable degrees.

The approach taken was to focus only upon those areas that benefited from transport investment to a greater extent (e.g. areas within a certain distance of the relevant link), using road schemes that were completed in later years as a counterfactual for those completed in earlier years (a staggered treatment or pipeline design). This assumes that the effects of road enhancement schemes should be visible amongst the group of earlier schemes first. The benefit of this approach is that areas benefiting from road schemes funded at different times may be assumed to have similar characteristics, reducing the problems driven by systematic differences between places that benefit from road infrastructure investment and those that do not.

This approach will provide an unbiased estimate of the impacts of road enhancements if there are no systematic differences between the areas benefitting from projects that were funded at different points in time. However, results could be biased if there is a link between the timing of scheme completion and the underlying characteristics of nearby areas. As an example, if transport policy changed over time to give increasing priority to facilitating economic growth, then comparisons between earlier and later schemes could also overstate the economic impacts of road enhancements.

This was partly explored by comparing the baseline characteristics (i.e., 2001 to 2003) of areas benefitting from road improvement schemes (defined as LSOAs within 30km of the enhancement) that completed in different years. The results of the analysis are illustrated in the charts below and suggest:

- There were systematic differences between the areas benefitting from road improvements before and after 2008. Later schemes tended to be targeted at areas of lower jobs density, weaker supply of highly qualified workers, lower underlying productivity (as approximated by wages), although there were no systematic differences in unemployment rates.
- The changes in the profile of areas benefitting from road improvements coincided with the increasing share of Local Major schemes in completions, indicating that these schemes may have been systematically targeted at different types of area (potentially on different growth trajectories).

Figure 6.1: Comparison of baseline (2001 to 2003) characteristics of areas near schemes completing in different years



Source: Ipsos analysis. ASHE, APS, JSA and BRES data

A statistical test of the parallel trends assumption was performed using a staggered difference-in-difference application (as described in section 5.3.1). This was completed using the base model for employment, turnover and turnover per worker and involved the estimation of any pre-treatment effects. The result of this test showed that the parallel trends assumption held in each case with joint F tests showing pre-treatment effects were not jointly significant. However, it was not possible to reject parallel prior trends completely.

6.3 Econometric approach

Two main econometric approaches were utilised to further mitigate the risk of biased findings driven by systematic differences between areas that did and did not benefit from road enhancements (or benefitted at different points in time).

6.3.1 Distance decay

To address the issue raised above, that all areas will benefit from the programme to some degree, the proximity of an area to the road infrastructure investment (or a development site to which the road provides access) was used as a proxy measure of the extent to which an area has benefitted, on the basis that areas closer to the investment are likely to benefit to a greater degree than those further away (while distant areas benefit to a negligible degree). This approach was implemented by first creating a variable that captures the strength of exposure, considering distance.

Areas near the scheme can be allocated to 'zones' of increasing distance from entry points to new or enhanced road links, or the location of new sites opened for development. Comparing the outcomes of interest before and after the road enhancements within these zones - relative to enhancements that were funded later - will yield estimates of the effects of the road infrastructure in each of the zones. These estimates will capture local displacement, multiplier and crowding out effects. If the investment causes the relocation of economic activity from zones further away to zones nearby, this will be visible in positive impacts in buffers closer to the scheme and negative impacts further away.

The general underlying econometric model takes the following form:

$$y_{it} = \alpha + \beta S_{it}^{0-30km} + \gamma X_i + \alpha^i + \alpha^t + \varepsilon_{it}$$

This equation describes the outcomes of interest (y_{it}), such as employment, in/for unit[13] i in period t as a function of the cumulative number of schemes opening within 30km of the LSOA (S_{it}^{0-30km}) by the end of period t. The parameter β gives an estimate of the marginal effect of each scheme opening on the outcome of interest with X_i a matrix of control characteristics of unit i. The outcome variables are transformed using natural logarithms, so the parameter can be interpreted approximately as the marginal percentage effect on the outcome. The models also

[13] LSOA, firm, worker or property depending on the specific outcomes and data being analysed.

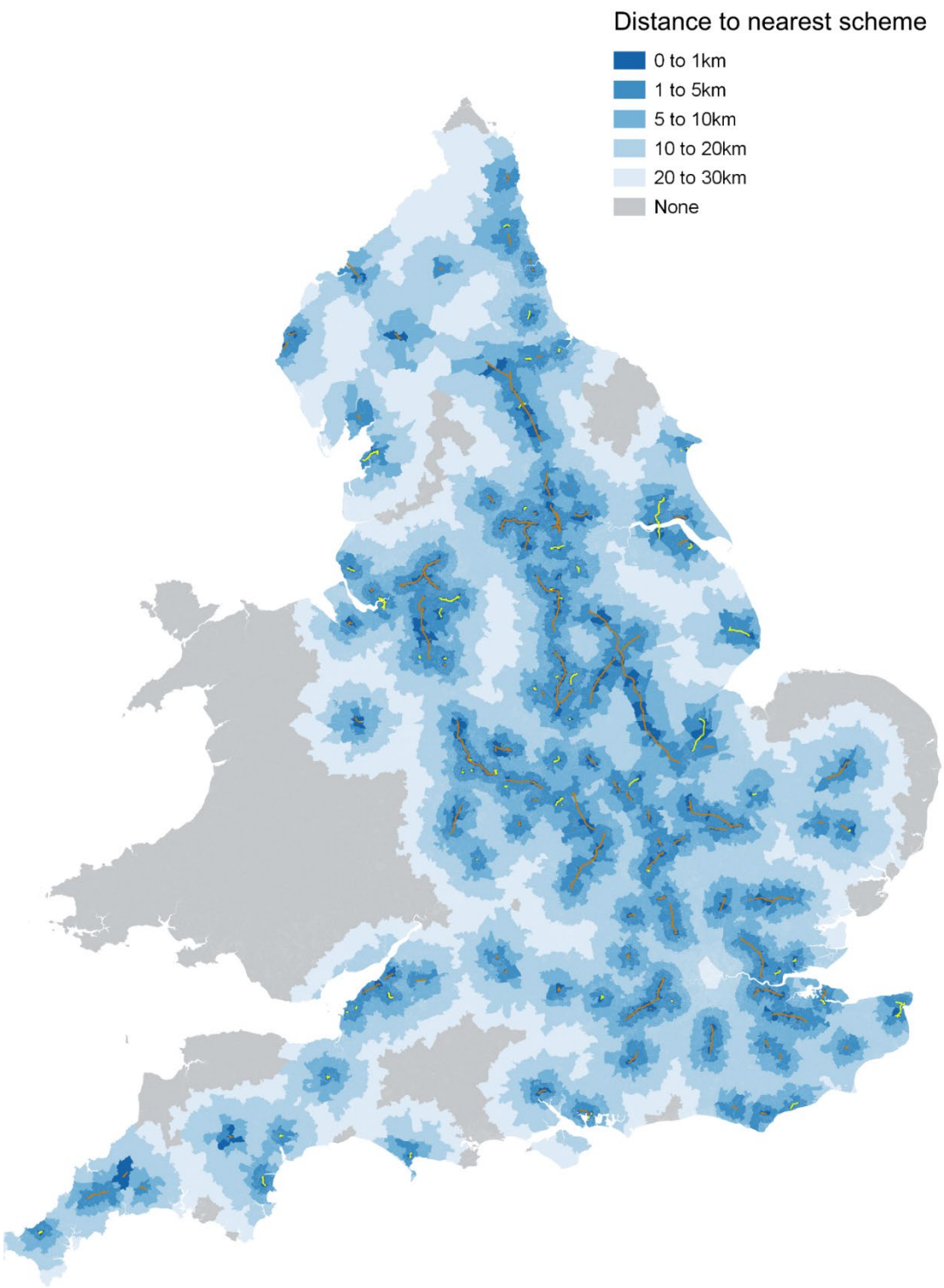
include fixed unit (α^i) and time specific effects (α^t). This accommodates any unobserved differences between units that do not change over time and any unobserved but time specific shocks affecting all units (e.g. the 2008 financial crisis).

For analysis using census and VOA ratings list data in which only differences over long periods could be explored, the model was largely unchanged with three period and two period panel models setup respectively. The definition of the treatment variable remained the same, the cumulative number of schemes opened within 30km by the relevant time period e.g. 2017 for VOA data and 2011 and 2021 for census outcomes. In the case of the VOA data, this application gives the same interpretation as a difference in difference model.

Choice of distance metric

The mapping of road enhancement schemes was used to identify LSOAs within 0 to 1km, 1 to 5km, 10 to 20km and 20 to 30km of each scheme (by calculating the straight-line distance from the population weighted centroid of the LSOA to the nearest point on the road network). This is presented in the figure below.

Figure 6.2: LSOAs by distance from the nearest road improvement scheme



Source: National Highways, DfT, OS ITN, Ipsos analysis. National Highways schemes highlighted in orange and Local Majors highlighted in yellow. Grey areas excluded from the analysis.

The above identification of LSOAs assumes that the straight-line distance is a reasonable measure of exposure. This may be misleading if the structure of the network means some LSOAs that are geographically close to the network are considerably further away when

travelling by road (implying they do not benefit from the implied intensity of exposure). This was tested in the evaluation planning stage which showed that there were substantial differences in the implied ‘exposure zones’ when using straight lines distances versus using distances by the road network. As a result, analysis was completed both with using straight line distance derived zones and those derived using the distance by the network.

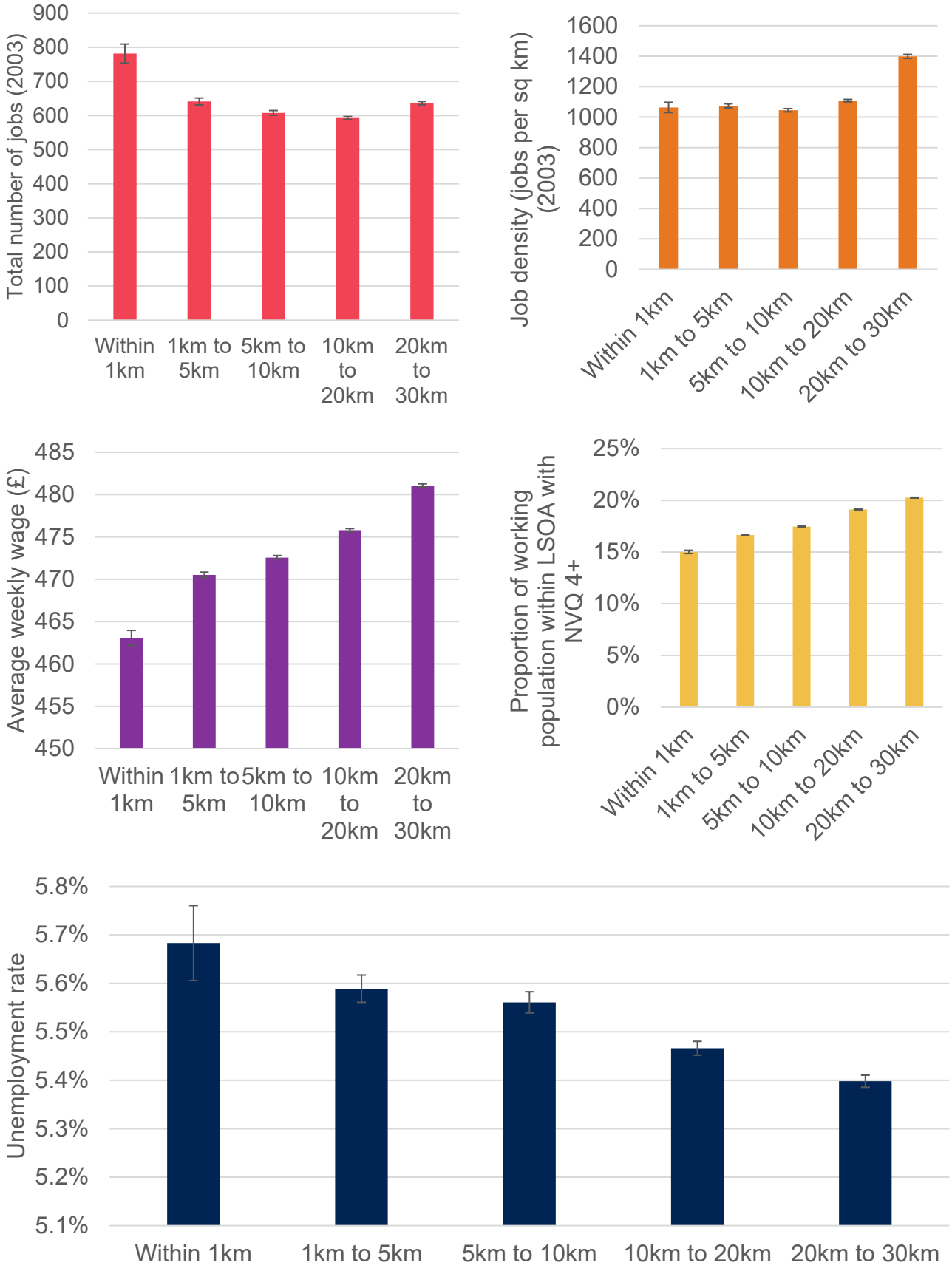
The findings presented in this report are based on results generated using distance by the network. Whilst differences in results produced by using straight line distance and distance by the network were small, the use of travel distance could be considered a more accurate reflection of the accessibility/connectivity change brought about by the scheme. For example, natural impediments such as rivers and natural parks might mean that an area reasonably close to a scheme does not benefit should there be little reasonable prospect local residents/firms can and would use it regularly if their access is blocked.

Threats to robustness

The distance decay approach also suffers from a risk of endogeneity problems, as the site locations or routes were likely to have been chosen based on their potential to accommodate expected economic growth. Areas closer to developments may have been expected to grow more rapidly than those further away, creating a risk of biased estimates of impacts. The inclusion of areas very close to the improvement (within 1km) may also introduce risk of bias driven by choices regarding the specific route of the scheme (e.g. if the route was chosen to minimise the cost of land assembly, then this may reflect low productivity at the local level). These areas may also suffer from negative physical or environmental impacts that might be caused during the completion of physical works (and could be influenced by an imperative to avoid adverse impacts on existing premises).

The following figures provide an analysis of differences in the characteristics of areas of varying distance from location schemes (with distances calculated on a ‘straight-line’ basis) to explore these issues in more depth.

Figure 6.3: Comparison of baseline characteristics by distance from completed schemes



Source: Ipsos analysis. ASHE, APS, JSA and BRES data

This suggested that areas further from road enhancement schemes were characterised by higher job density (suggestive of denser urban environments), higher wages (suggestive of higher levels of productivity), a greater share of highly educated workers in overall labour supply, and lower rates of unemployment. This reflects the spatial distribution of schemes, with National Highways schemes focused on upgrading motorways and major roads that largely run through rural areas (though improving connections between major agglomerations). If these types of area would have been expected to grow more rapidly regardless of road improvements, then basic comparisons between areas of differing distances from the scheme could produce misleading results.

To reduce the impact of the above, the following steps were taken:

- **Fixed effects estimation:** Econometric models included fixed effects that controlled for any unobserved but time invariant characteristics of areas that may have influenced overall growth trajectories. This reduces potential biases but will not account for the possibility that these features have had a time varying influence over local economic growth (a distinct possibility given the long duration of time series involved).

- **Allowance for variable trends**: Allowance for variable trends (or time specific shocks) affecting areas in different distance bands (or with different baseline characteristics) was also made by including control variables that interact a time trend (or time fixed effects) with a binary indicator of the distance band into which the LSOA falls.

- **Exclusion of areas very close to the road improvement scheme:** Results were produced with areas within 1km of schemes removed to reduce potential biases driven by the choice of route. In analysis breaking down effects by distance from the scheme, these areas (within 1km) were given their own banding.

The distance decay model described above is also known as a ‘two-way fixed effects’ model. Although this approach has been widely used in applied economic research, recent advances in econometric theory have shown that these types of models can produce (and on occasions severely) biased results in staggered designs. These risks are highest where the effects of programmes are heterogeneous (i.e. impacts vary across groups of firms) or where effects are dynamic (i.e. impacts vary over time). A variety of solutions to these problems have been proposed using an alternative staggered difference-in-difference (DiD) approach [14].

The robustness of a base set of results using the BSD and ABS was probed by applying alternative estimators that have been proposed as robust to these issues. This involved the application of an extension to difference in differences models to multi-period data proposed by Callaway and Sant’Anna (2019). This involves the application of the standard (two period)

[14] See Chaisemartin and D’Haltfoeuille (2022) Two Way Fixed Effects And Difference-in-Differences with Heterogenous Treatment Effects: A Survey.

difference-in-difference estimator for each cohort of firms and every post-treatment period (with the group of untreated areas - yet to be treated area - forming the control group for these analyses). The estimated effect of the programme is established by taking a weighted average of these treatment effects[15].

The group-specific treatment effects can be averaged to present an overall treatment effect. The expression for the group specific treatment effects is:

$$ATT(g,t) = E\left[\left(\frac{G_g}{E[G_g]} - \frac{\frac{p_g(X)C}{1-p_g(X)}}{E\left[\frac{p_g(X)C}{1-p_g(X)}\right]}\right)Y_t - Y_{g-1}\right]$$

Where the weights, p , are propensity scores, G is a binary variable that is equal to one for areas first treated in year g, and C is a binary variable equal to one for areas in the counterfactual group. The equation above gives the treatment effect at time t for the group of areas treated at time g, and it is computed by comparing changes in outcomes for group g between periods $g-1$ to that of a control group of yet to be treated areas (C).

Our chosen DiD estimator for staggered treatment effects was implemented in STATA using the user-written command ‘csdid’. Given the potential drawbacks of the two-way fixed effects models, these results are considered the most robust. However, there was as yet no implementation of this approach for multiple treatment variables, as presented in the by distance band results, nor was there an implementation for continuous treatment variables as required for the accessibility index approach described below.

The table below sets out the results of the analysis using the standard two-way fixed effects models alongside the staggered difference-in-difference approach. Estimated effects using both approaches appear to be similar with the more robust staggered difference-in-difference estimator implying slightly smaller impacts on average.[16]

[15] See Callaway and Sant’Anna (2019) Difference-in-Differences with Multiple Time Periods

[16] We did consider providing a more detailed breakdown by distance band from the scheme, but as these results are provided elsewhere in the report we have avoided over-complicating the presentation of the findings.

Table 6.1: Estimated effects of road improvements on firm performance measures – overall results

Outcome (within 30km)	Fixed LSOA effects	Fixed year effects	Estimated on-going effect per scheme	p value	Observations
Distance decay – Two-way FE					
Employment	Yes	Yes	0.0016***	0.000	678,117
Turnover	Yes	Yes	0.0012***	0.004	678,117
Turnover per worker	Yes	Yes	-0.0002	0.175	678,117
Number of local units	Yes	Yes	0.0009***	0.003	678,117
GVA	Yes	Yes	0.0022***	0.001	400,705
GVA per worker	Yes	Yes	0.0007	0.266	400,705
Distance decay – Staggered DiD					
Employment	Yes	Yes	0.0014***	0.003	678,117
Turnover	Yes	Yes	0.0010**	0.031	678,117
Turnover per worker	Yes	Yes	-0.0004	0.285	678,117
Number of local units	Yes	Yes	0.0007**	0.042	678,117
GVA	Yes	Yes	0.0018**	0.027	400,705
GVA per worker	Yes	Yes	0.0005	0.316	400,705

Source: Business Structure Database, Annual Business Survey, ONS, Ipsos analysis. '***', '**' and '*' indicate whether the estimated result is statistically significant at the 99, 95 and 90 percent level respectively.

The figures below present the estimated effects of the staggered DiD model in event study form. Whilst the results presented in the table are overall estimates, these figures break down the effects into annual components starting at T-5 years (5 years before scheme completion through to 10 years post completion (T+10)). Note that the error bars indicate 95 percent confidence intervals and in general these become larger as time goes on and fewer schemes have the requisite number of years data available post completion. Where error bars overlap the horizontal axis the effects are no longer statistically significant. Estimates of annual impacts are relative to the counterfactual at each point in time. These indicated that:

- Employment, turnover and GVA impacts are likely persistent: The estimated effects are statistically significant for up to 6 years post completion for employment and GVA impacts with impacts on turnover significant for around 5 years. A general trend is evident in so far as the impacts are largest 1 to 2 years after a scheme is completed with these gradually declining with time. Note that the effects are small in size and a high degree of variance in estimated impacts means that the confidence intervals become relatively large post 6 years. This means that there may be effects that persist longer but which cannot be identified in this analysis.

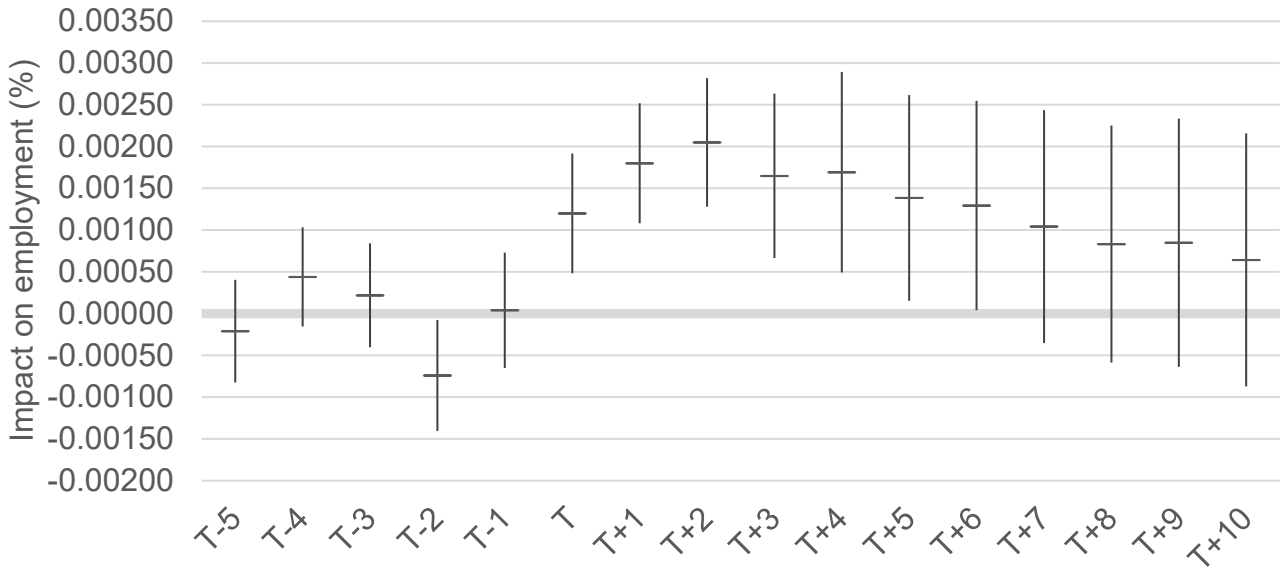
- Impacts on turnover per worker and GVA per worker maybe temporary: In contrast to the overall analysis presented in the paper below, the staggered difference-in-difference model does find some productivity impacts that are present just after a scheme is completed. However, these are no longer significant after 2 or 3 years afterwards. In the case of GVA per worker, there appears to be an increase of around 0.1 percent in the year an improvement is completed followed by 0.12 the year after and 0.08 the year after that before effects are no longer detected.

- Impacts on unemployment: Estimated effects on the claimant count are evident from one year after scheme completion until 8 years after and show a significant decrease peaking at a 0.7 percent reduction after 6 years.

- Impacts on house prices: Similarly, impacts on house prices were found to be persistent, with effects persisting for at least 10 years with little variation in magnitude. This analysis was only possible with house price data and so was not repeated for housing stock or commercial market outcomes.

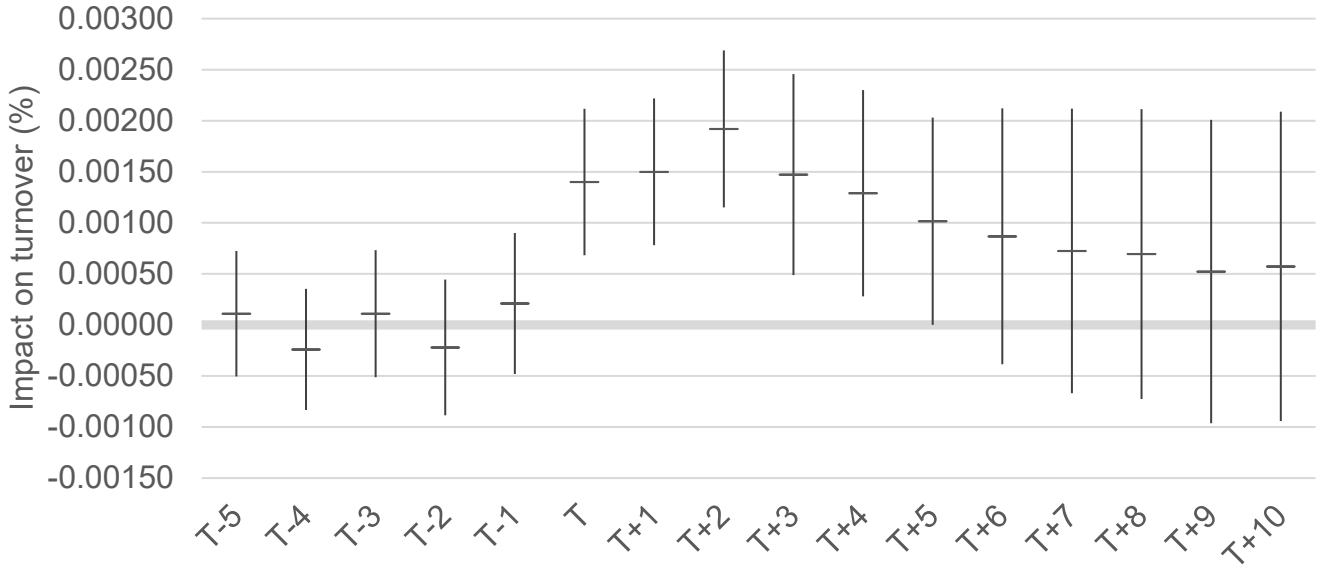
These findings appear consistent with previous research but there is limited evidence available that has explored similar outcomes over comparable timeframes.

Figure 6.4: Persistence of employment impacts



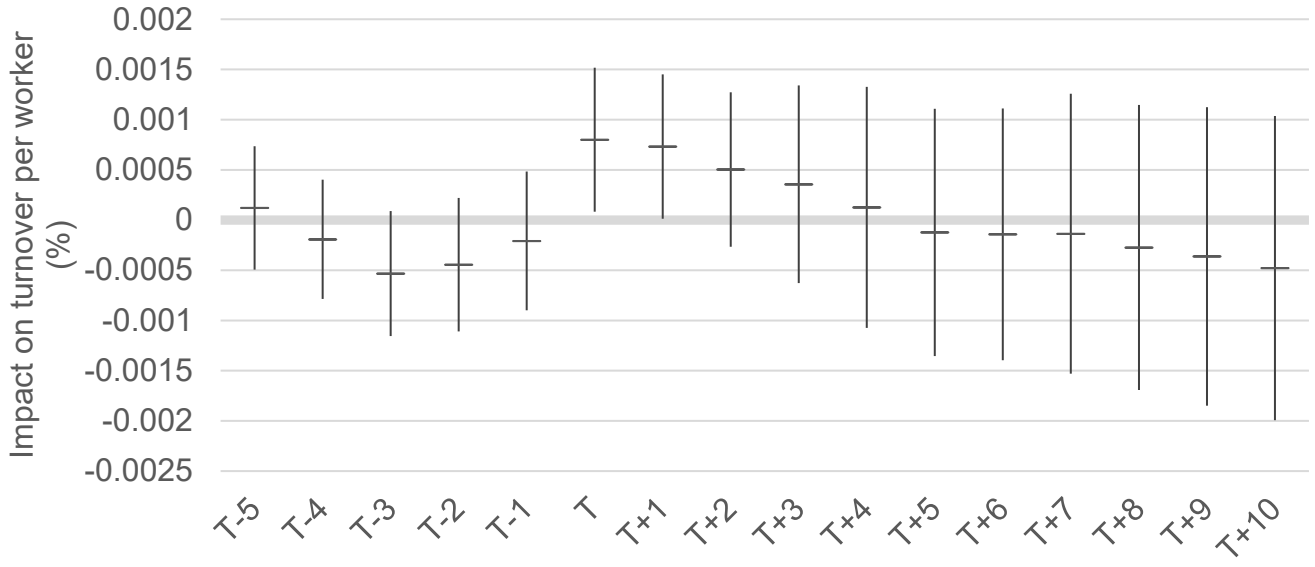
Source: Business Structure Database, Annual Business Survey, ONS, Ipsos analysis. Error bars indicate 95 percent confidence intervals.

Figure 6.5: Persistence of turnover impacts



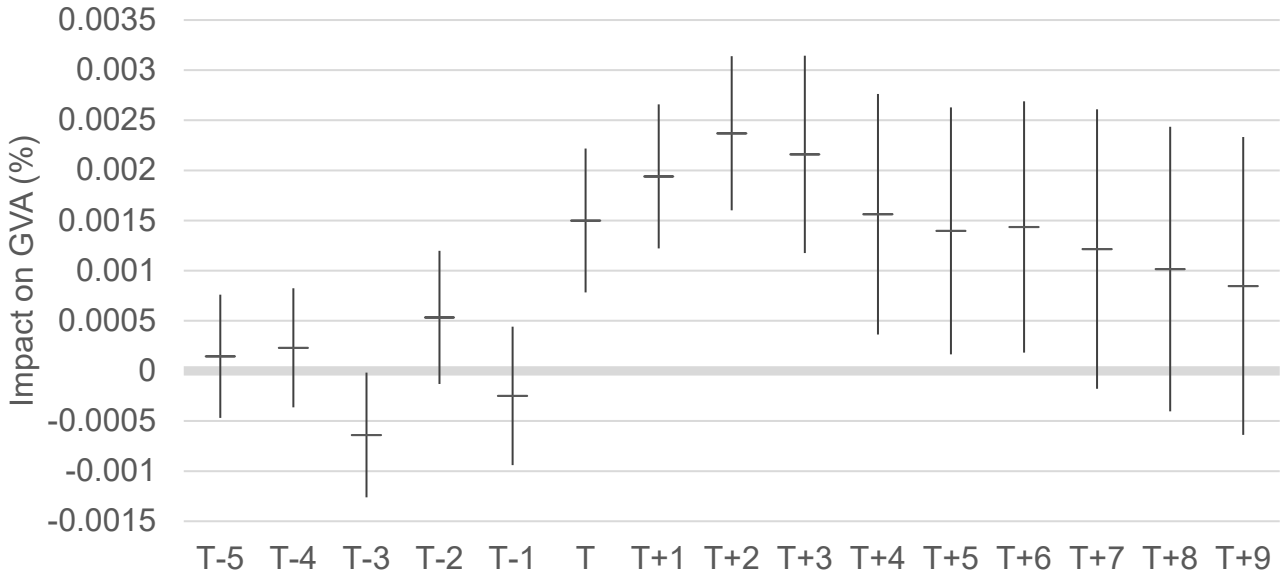
Source: Business Structure Database, Annual Business Survey, ONS, Ipsos analysis. Error bars indicate 95 percent confidence intervals.

Figure 6.6: Persistence of turnover per worker impacts



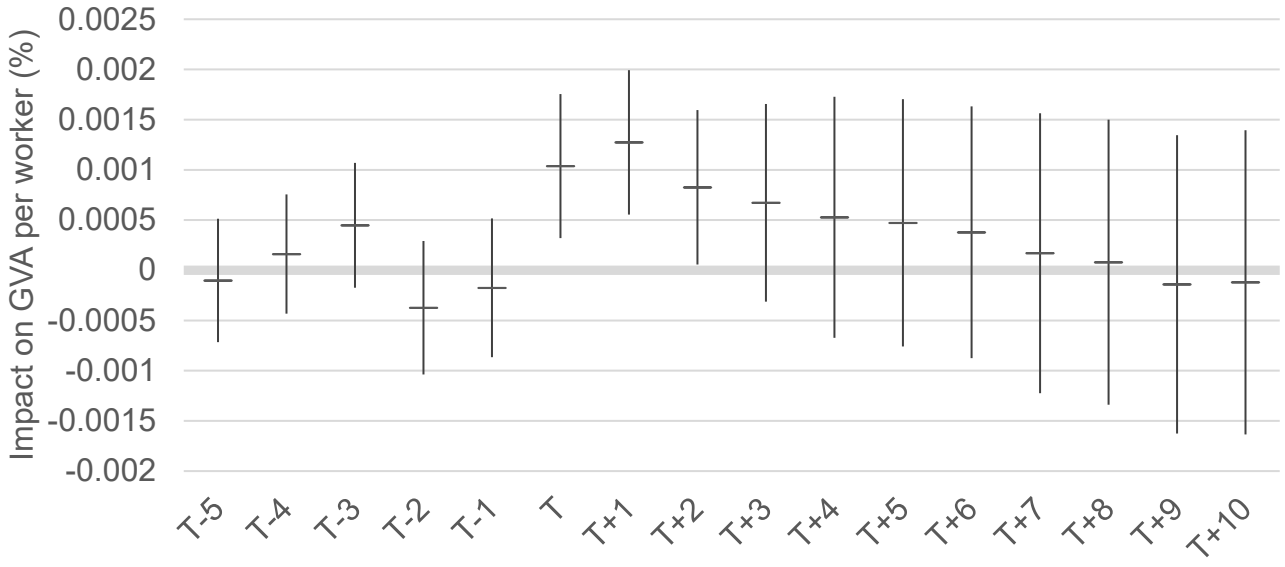
Source: Business Structure Database, Annual Business Survey, ONS, Ipsos analysis. Error bars indicate 95 percent confidence intervals.

Figure 6.7: Persistence of GVA impacts



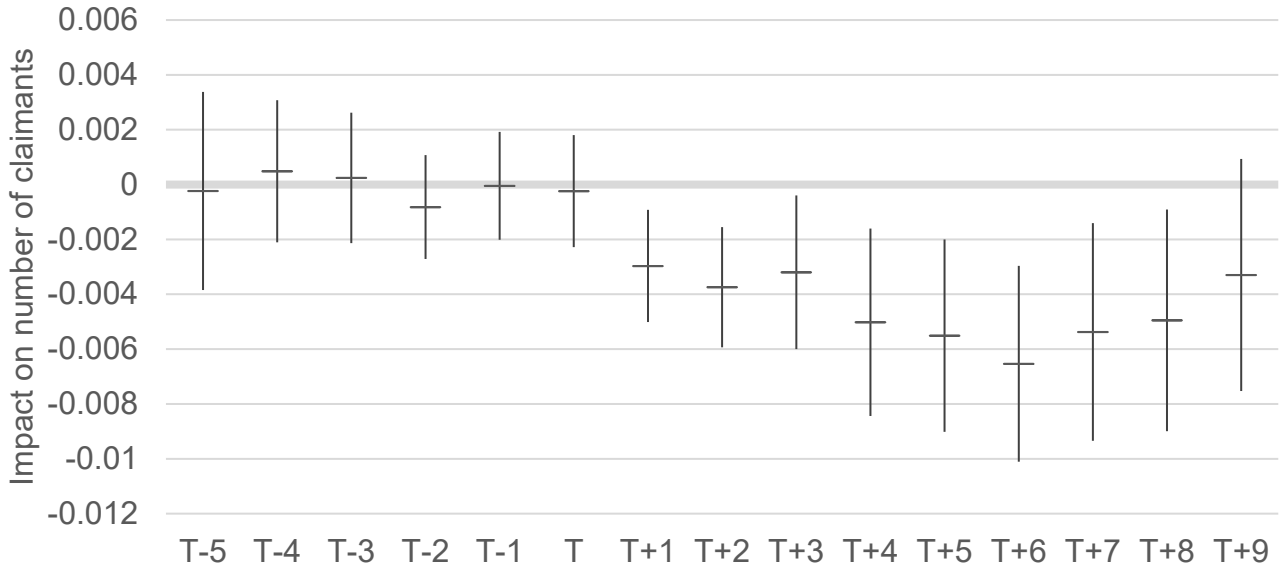
Source: Business Structure Database, Annual Business Survey, ONS, Ipsos analysis. Error bars indicate 95 percent confidence intervals.

Figure 6.8: Persistence of GVA per worker impacts



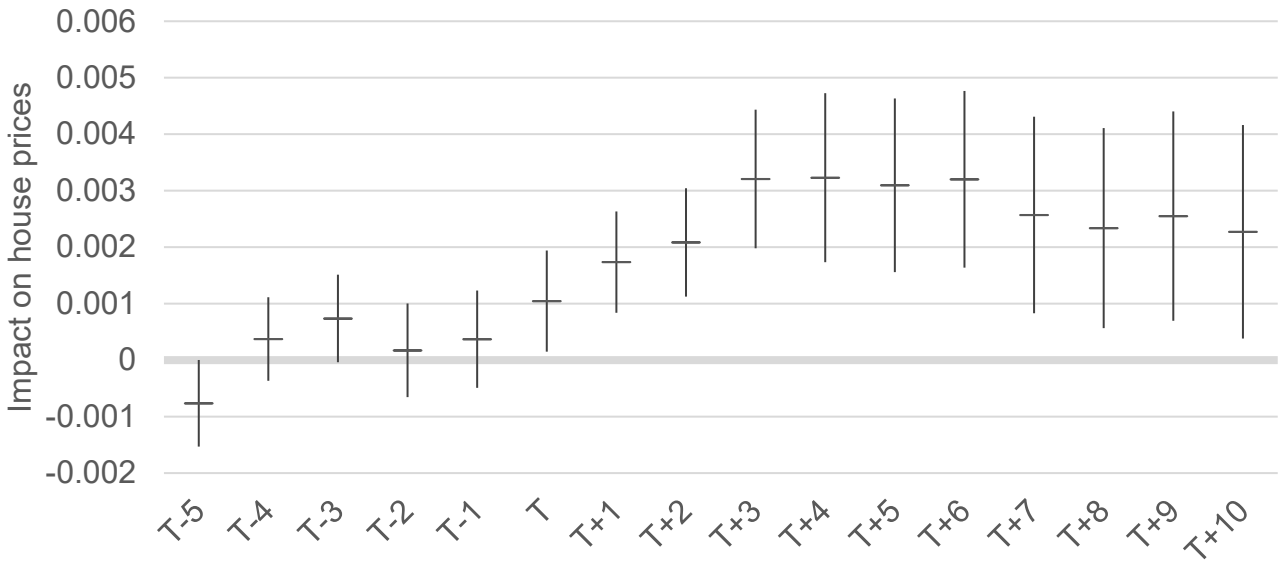
Source: Business Structure Database, Annual Business Survey, ONS, Ipsos analysis. Error bars indicate 95 percent confidence intervals.

Figure 6.9: Persistence of unemployment impacts



Source: DWP Claimant Count, Ipsos analysis. Error bars indicate 95 percent confidence intervals.

Figure 6.10: Persistence of house price impacts



Source: Land Registry Price Paid Data, Ipsos analysis. Error bars indicate 95 percent confidence intervals.

Subgroup analysis

The analysis also explored outcomes across three sets of subgroups of interests:

- Productivity: Areas were classified into productivity quartiles based on workplace-based measures of wages in the baseline year (2001), as derived from the New Earnings Survey (the predecessor to the Annual Survey of Hours and Earnings). This was used to examine how far the effects of road schemes vary across areas of differing levels of underlying productivity. Note that results combine the middle two quartiles.
- Urban density: Differences in outcomes across areas of differing levels of urban density were explored using the Defra-ONS rural/urban classification from 2001.
- Type of scheme: Variances in the impacts of different types of scheme were also explored across two dimensions (a) the funder (National Highways/Local Majors), and (b) the type of enhancement (new links vs improvement to existing links).

6.3.2 Accessibility index approach

The second approach taken to the analysis was an accessibility modelling approach. This method attempts to calculate the extent to which changes in the road network increase the accessibility of day-to-day services (employment centres in the case of this study). The method for this study draws on the methods adopted in Gibbons et al (2017) and which used an index of changing employment accessibility to estimate the impact of new road links on firm employment and productivity. The approach examines the relationship between changes in accessibility as a result of the transport improvement to changes in area and firm level outcomes following the completion of the scheme.

The index can be defined as $A_{jt} = \sum_{k \neq j} a(c_{jkt})\, l_{kt}$, i.e. for a firm in location j at time t, it is the weighted sum of employment in all destinations, k, that can be reached from origin, j by incurring some transport cost c_{jkt} along some specified route between j and k; an inverse weighting system is used such that the function $a(\cdot) = c_{jkt}\text{^} - 1$ is decreasing in the cost of reaching k from j. The index measures the amount of employment reachable from a given location per unit of travel time using the road network. Improvements to the network reduce travel times between locations and increase employment accessibility.

For this analysis, the accessibility index for each LSOA was used as the 'treatment' variable in econometric modelling following the same specification outlined in the distance decay section. The specification below follows that utilised by Gibbons et al (2017). Here, the outcome values in LSOA i at time t (y_{it}) are considered a function of the accessibility index A_{it} (rather than proximity to a scheme) for that LSOA in that year:

$$y_{it} = \alpha + \beta A_{it} + \gamma X_i + \alpha^i + \alpha^t + \varepsilon_{it}$$

Both the outcomes and accessibility index were log transformed so parameter β could be interpreted as the percentage change in the outcome from a percentage change in accessibility. Both time and LSOA fixed effects were also implemented to account for both time invariant area effects α^i and specific time shocks affecting all areas α^t.

This approach potentially suffers from a similar endogeneity issue as the distance decay approach, as the site locations or routes were likely to have been chosen based on their potential to accommodate expected economic growth. Areas closer to the developments may have been expected to grow more rapidly than those further away, creating a risk of biased estimates of impacts. To combat this, accessibility measures with the spatial distribution of employment frozen at pre-improvement level were generated, to pick up changes in accessibility driven only by changes in the capacity of the road network. This measure is correlated with actual changes in transport connectivity and uncorrelated with changes in the outcome variables so is a suitable instrument for identifying the causal effects involved.

Data

There are significant data requirements to construct the accessibility measures necessary for this type of analysis and data was obtained from the DfT, Ordnance Survey and Trafficmaster for the following purposes:

- Speed data: Generation of accessibility measures requires observations of traffic speeds on relevant road links. Annual speed data from 2011 to 2020 was obtained from the DfT and Teletrac Navman. This Trafficmaster (TM) data contained average speeds across as measured across most road links in England and Wales for the am peak in each direction. Where speeds were not observed, the average for that road classification (e.g. Motorway, A Road or B Road) was provided. In addition, a number of road links in the network file were not present in the speed data file. 2011 was treated as the base year for the analysis.

- Road network: The DfT provided road network files for 2011, 2014, 2016 and 2020 (the Ordnance Survey ITN / OS MasterMap Highways Layer). The 2011 network provided the baseline for this approach from which schemes were mapped. The base network remained frozen aside from changes made due to schemes in scope of the analysis.

- Employment count data: Changes in accessibility at an area level can be caused by changes in the road network and changes in the spatial distribution of employment. As accessibility measures are directly affected by the outcomes, this also introduces a risk of generating biased results. This was addressed by recalculating local accessibility measures with the spatial distribution of employment frozen at pre-improvement level, to pick up changes in accessibility driven only by changes in the capacity of the road network. This measure is correlated with actual changes in transport connectivity and uncorrelated with changes in the outcome variables so is a suitable instrument for identifying the causal effects involved. To implement this, employment counts for areas in the baseline year were obtained from the Business Register and Employment Survey (BRES), accessed through NOMIS.

Table 6.2: Datasets used for generating Accessibility Indices

Dataset	Description and role in study
Trafficmaster Speed Data	The DfT has also supplied observations of traffic speeds provided by Trafficmaster, which gave observed traffic speeds in both directions based on GPS signals for 2011 to 2020. This data does not provide complete coverage of road links and speeds on some links are unobserved. Where speeds were unobserved, measures were taken to impute data as described in the accessibility measure section. The data includes average speeds for the am peak in each direction. Where speeds were not observed, the average for that road classification (e.g. Motorway, A Road or B Road) was provided. In addition, a number of road links in the network file were not present in the speed data file. 2011 was treated as the base year for the accessibility analysis.
Road Network	The DfT provided road network files for 2011, 2014, 2016 and 2020 (the Ordnance Survey ITN / OS MasterMap Highways Layer). The road network was reconstructed for each year from 2011 using a manual process. The 2011 road network was used as the 'baseline' network, and restricted to Motorways, A-roads, and B-roads to reduce the complexity of calculating optimal journey times. A new network file was created for each successive year, that only included any new road links or redesigned junctions associated with the road improvement schemes completed in the relevant year. This approach was adopted to remove the influence of any parallel changes to the design of the network resulting from schemes that were not included in the portfolio of schemes being explored.
Business Register and Employment Survey (BRES)	Employment counts for LSOAs in the baseline year of 2011 index were obtained from the BRES. The BRES includes details of the number of employees working in each LSOA. This version of the BRES does not include firms that were registered for PAYE only.

Construction of accessibility measures

Accessibility measures were constructed using the following process:

- **Construction of network files:** The road network was reconstructed for each year from 2011 using a manual process. The 2011 road network was used as the 'baseline' network, and restricted to Motorways, A-roads, and B-roads to reduce the complexity of calculating optimal journey times. A new network file was created for each successive year, that only included any new road links or redesigned junctions associated with the road improvement schemes completed in the relevant year. This approach was adopted to remove the influence

of any parallel changes to the design of the network resulting from schemes that were not included in the portfolio of schemes being explored.

- **Linking LSOA centroids to the road network:** The centroid points of LSOAs were not linked to this road network. The next stage involved creating additional 'virtual' links from the centroid point of Lower Super Output Areas (LSOA) to the road network. These were generated by calculating the shortest path from the LSOA centroid point to the road network. These virtual links were short with an average length of 384m.

- **Imputation of missing speed data:** Each network file was then linked to the corresponding TM dataset using the unique 16-digit Ordnance Survey road link ID variables within each dataset. A total of 497,374 links of the 572,165 road links present in the reduced 2011 network file were initially matched. The remaining road links were present in the network file but not in the TM data. Speeds for these remaining road links were then imputed using a similar approach to those previously imputed by the DfT where Trafficmaster data was not present. The type of road link (link type and nature – e.g. roundabout, slip-road) was extracted from the network file and for each type and nature combination the most common average speed for links with observed speeds with the same characteristics was used (with a tag applied to highlight where imputation was undertaken).

- **Setting speeds in each year:** Potential difficulties arise from the possibility that journey times are endogenous. For example, if congestion alleviation leads to further employment growth, this may increase congestion and then reduce accessibility. The following approach was adopted in setting average speeds for each road link in each year:

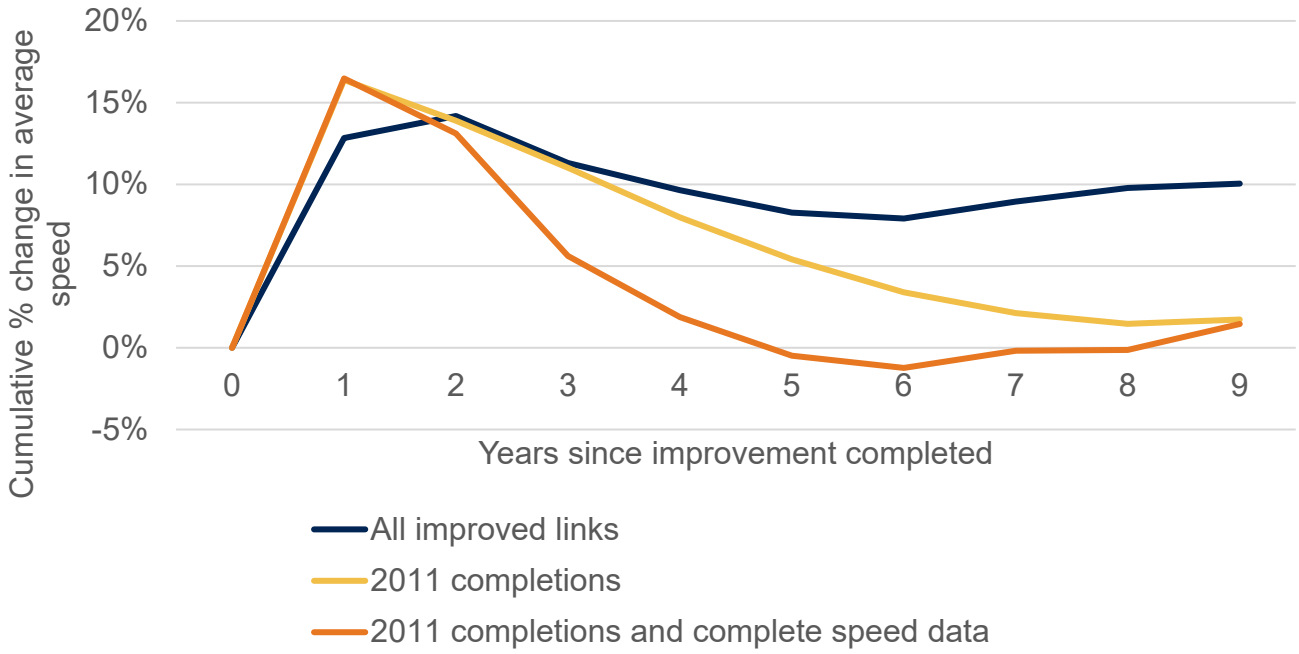
  - Unimproved road links: If the speeds on the road link were observed in TM in 2011, this was then used in all successive years (i.e. freezing journey times at 2011 levels to avoid possible distortions driven by increasing congestion arising from economic growth). If the speed was not observed in 2011 but was available for other years, the speed on the link was frozen at the value of the oldest observation. If no observations were available over the 2011 to 2020 period, the average speed in 2011 for that road type was used throughout.

  - Improved links: Pre-improvement speeds were set using a similar approach to those adopted for unimproved links. Post-improvement speeds were set based on the first post-improvement observation (and fixed at that value over time). This choice was based on an analysis of changes in average speeds on improved links that indicated that average speeds increased by around 16 percent in the first year following the improvement and fell (at the margins) in the following years (suggesting that initial gains may be eroded by growth and allowing speeds to vary could introduce endogeneity issues).

    For links with no observations of post improvement speeds, the average for that road type one year post improvement was used.

- New links: For new links, speeds were taken directly from the first available post-improvement speed in the data and fixed at that value over time. Where no speed data was available post-improvement, the average for that road type one year post improvement was used.

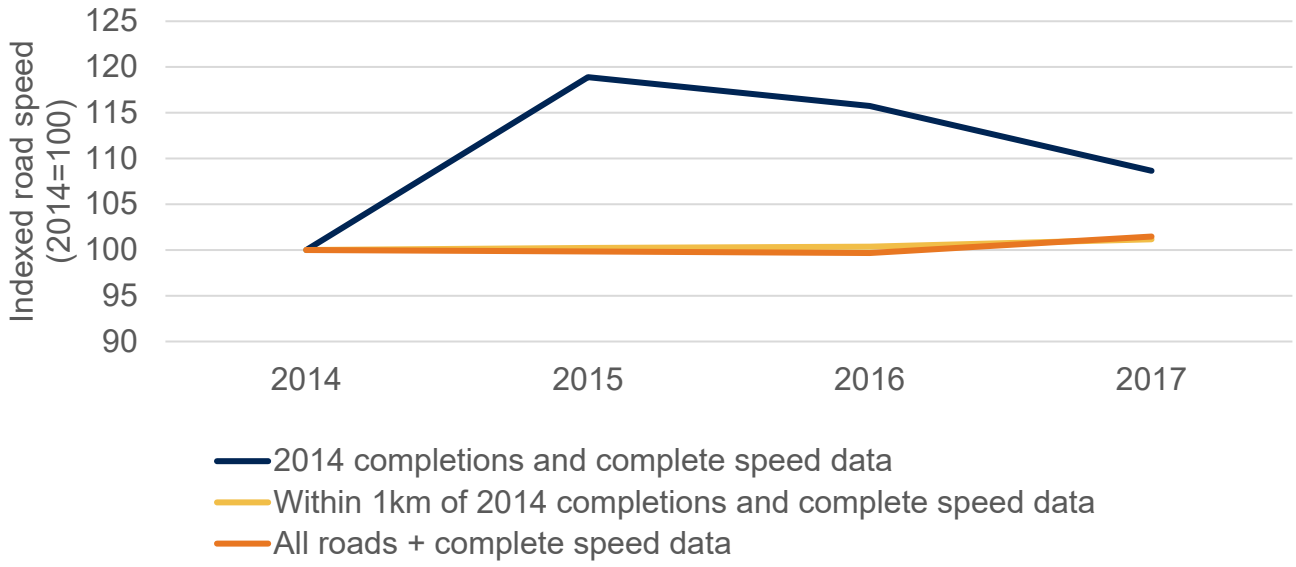
Figure 6.11: Annual change in average speeds on directly improved links



Source: Ipsos analysis of Trafficmaster and Ordnance Survey ITN data

- Spillovers onto adjacent roads: Consideration was also given to how far road improvements led to improvements in journey speeds on adjacent roads (which would not be captured using the protocol outlined above). To explore this issue, an analysis of changes in average speeds on other links within 1km of road improvements completed in 2014 was completed (using only links for which traffic speeds were observed in each year between 2014 and 2017). Note that this analysis was not repeated using the 2011 network and was undertaken when only the 2014, 2016 and 2020 networks were available. This indicated that other roads within 1km of road improvements saw no improvements in average speeds relative to speeds across the whole network. This indicates that a focus only on the new and improved links will capture the bulk of any improvements in connectivity brought about by the road improvement schemes in the sample.

Figure 6.12: Changes in road speeds on roads improved in 2014 vs those within 1km



Source: Ipsos analysis of Trafficmaster and Ordnance Survey ITN data

- **Link roads to LSOAs centroids:** Speeds on virtual links to LSOA centroids were set to 40kmph (which treats these links as unclassified roads in residential areas).
- **Calculating journey times between LSOA pairs:** Using QGIS, the QNEAT3 plugin was used to create an Origin/Destination (O/D) matrix for each year. This was setup to calculate the fastest path (time optimization) from each LSOA to every other and resulted in ten matrices with the time cost in seconds recorded for each LSOA pair. Annual origin/destination matrices that separately captured the effects of National Highways and Local Major Schemes were also produced, as well as annual origin/destination matrices to separately capture the effects of new road links and improvements to existing links.

The following algorithm was then applied to calculate the employment accessibility index for each year:

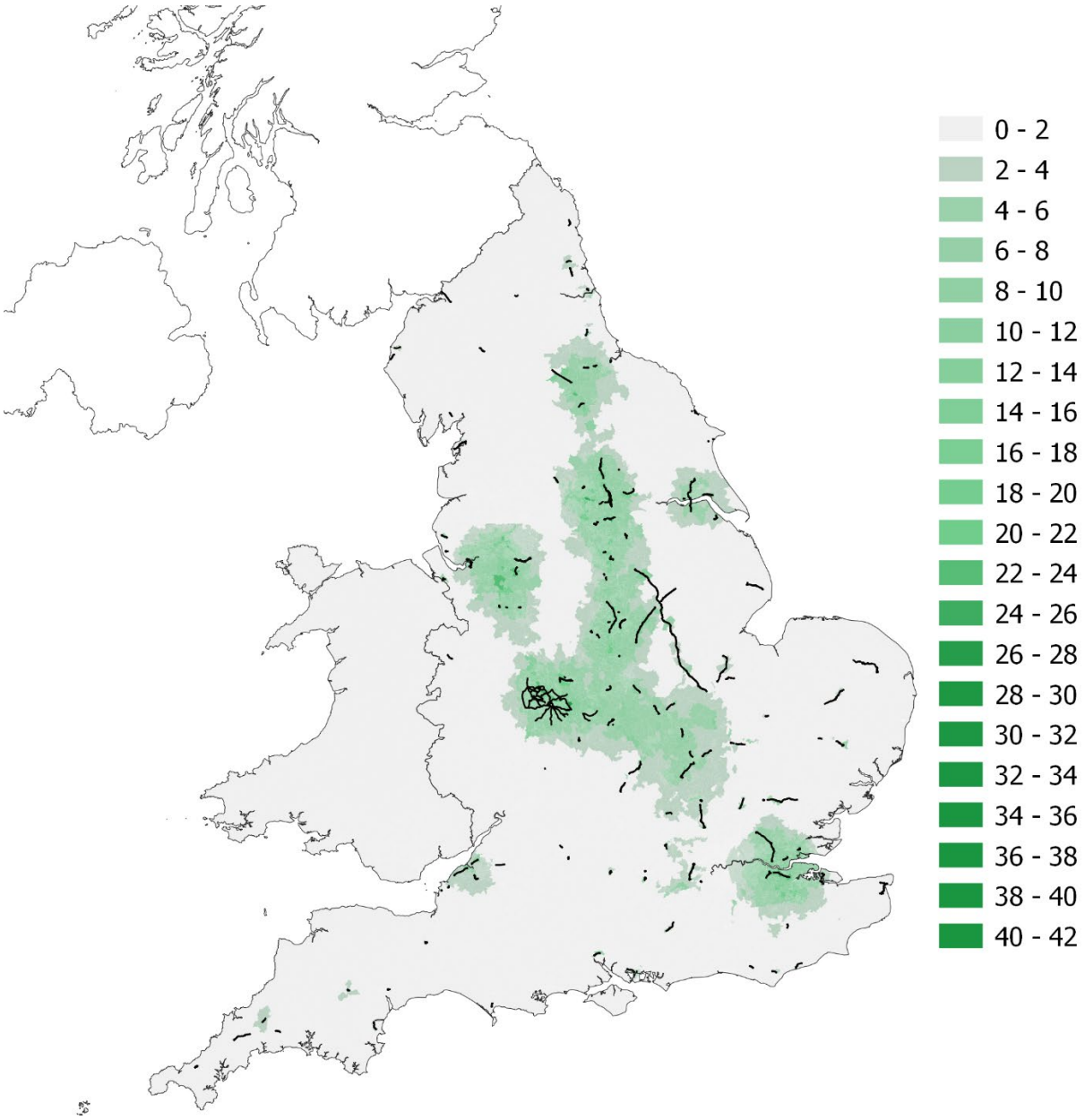
$Ajt = \Sigma k \neq j\ a(timejkt)wk0$

The accessibility index for origin LSOA j in year t is the weighted sum of economic activity at all destinations k in the baseline year. The function $(timejkt)$ was set to that used by Gibbons et al. as the inverse of travel time for origin destination pair j,k.

Changes in accessibility

The map below illustrates the cumulative change in accessibility for LSOAs mapped on to the locations of road schemes. On average, the accessibility index changed by 3.1 percent over this period with larger improvements evident where schemes are clustered.

Figure 6.13: Cumulative change in accessibility due to road improvements between 2011 and 2020



Source: Ipsos analysis, legend describes overall percentage increase in accessibility between 2011 and 2020.

In response to road scheme completion, accessibility to employment rose in areas up to 30km away by 1.03 percent[17] on average, with the change in accessibility predictably greater the closer to the scheme with areas within 1km seeing accessibility rise by just under 2 percent following scheme completion. The cumulative impact of being near to a multitude of schemes is

[17] Note that the interpretation of effects in the accessibility modelling (using logged dependant and independent variables) can be directly compared distance decay findings as the coefficients have been multiplied through by 1.03.

illustrated in the figure above and overall accessibility between 2011 and 2020 rose by 3.06 percent across all areas.

Table 6.3: Change in accessibility in areas close to schemes

Area	Average % change in accessibility following scheme completion
Within 1km	1.94
Between 1km and 5km	1.67
Between 5km and 10km	1.05
Between 10km and 20km	0.56
Between 20km and 30km	0.32
All areas within 30km	1.03

Source: Ipsos analysis

Given the average change in accessibility for areas within 30km was 1.03 percent following scheme completion, estimated effects presented throughout the remainder of this report for the distance decay and accessibility modelling approaches can be considered comparable. Had the average change for these areas been significantly different from one, a correction would need to be applied to the accessibility modelling approach results to be able to directly compare results.

7 Impacts on local firms

This focuses on the impacts of road improvements on the performance of firms located within 30km of schemes. It should be noted that these findings do not provide a full assessment of the economic impacts of road improvements, as it does not consider possible improvements to the efficiency of road users that are located far from road improvement schemes (such as national logistics operators).

7.1 Key findings

The key findings from this analysis showed that:

- Road improvement schemes are found to have positive growth impacts on local economies. The average scheme leads to an average on-going expansion in employment of 0.11 to 0.16 percent and GVA of 0.14 to 0.22. Growth impacts are concentrated within areas up to 20km from road enhancements. This finding is broadly consistent with the results of prior studies employing similar methodologies to a smaller sample of road enhancements. Effects were also persistent with those estimated on GVA and employment lasting for up to 6 years and impacts on turnover lasting around 5 years (see section 5.3).

- The local growth impacts of road enhancement schemes are primarily driven by impacts on the manufacturing and transport and storage sectors (and to a lesser degree, the construction sector). There was little evidence that road enhancement schemes stimulate significant growth of the tradable or non-tradable service sectors. This implies that any induced effects are either negligible or that additional demand for these services places upward pressure on wages or prices (leading to offsetting reductions in demand for the output of these sectors elsewhere in the local economy).

- Local growth impacts are partly driven by the spatial reorganisation of economic activity, with firms apparently opening new or relocating existing plants nearby to take advantage of improved connectivity. Road enhancement schemes lead to a net increase in the number of plants located within 30 kilometres of the improvement. This was partly driven by incumbents relocating more distant operations (i.e. beyond 30km from the enhancement) to areas closer to the enhancements - implying that road enhancements may also lead to some offsetting losses of economic activity in more distant areas. Only new road links appeared to encourage the spatial reorganisation of firms.

- There was little evidence that road enhancements lead to long term improvements in the productivity (GVA per worker) of local firms. Short term impacts were identified in modelling presented in section 5.3 but these dissipated.[18] This a potential puzzle given the apparent

[18] Note that these findings did not make us of the accessibility index as the treatment variable given limitations of the approach.

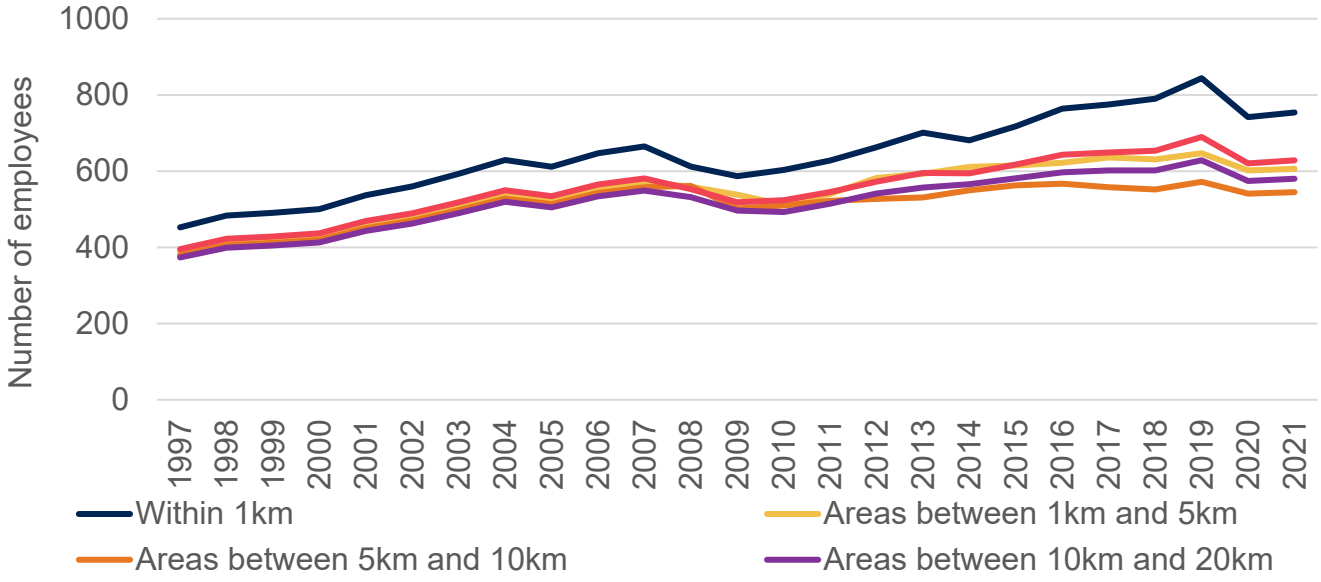
effects of road enhancements in attracting new plants to proximate locations. One possible explanation may be that road enhancements produce positive improvements in economic efficiency that are capitalised into higher land prices and rental values owing to other constraints preventing property markets from responding to price signals. It should also be noted that these findings do not capture effects on the productivity of road users whose operations may be far from road enhancements (such as national logistics operators). Other potential hypotheses are discussed in detail in section 9.2.

- Though improved road infrastructure might be expected to reduce the costs faced by manufacturers, there was no evidence that improved road networks led to increased trade volumes amongst local firms (either in terms of spending on imports or exports).
- There was some evidence that the positive growth impacts of road enhancements are concentrated in areas that already display high levels of productivity. Additionally, growth impacts principally accrue to major urban agglomerations - and to a lesser degree, rural areas - with no evidence of growth (positive or negative) impacts on suburban zones and smaller towns. This has potential policy implications in that improvements to road infrastructure appear to reinforce - rather than rebalance - existing patterns of economic development and may not be effective in stimulating growth in lagging areas.
- There were no significant differences in impacts between schemes funded by National highways and those funded by DfT and Local Authorities with the type of link a more significant influence on impacts. Only new links were associated with the spatial reorganisation of firms.

7.2 Trends in local economic performance

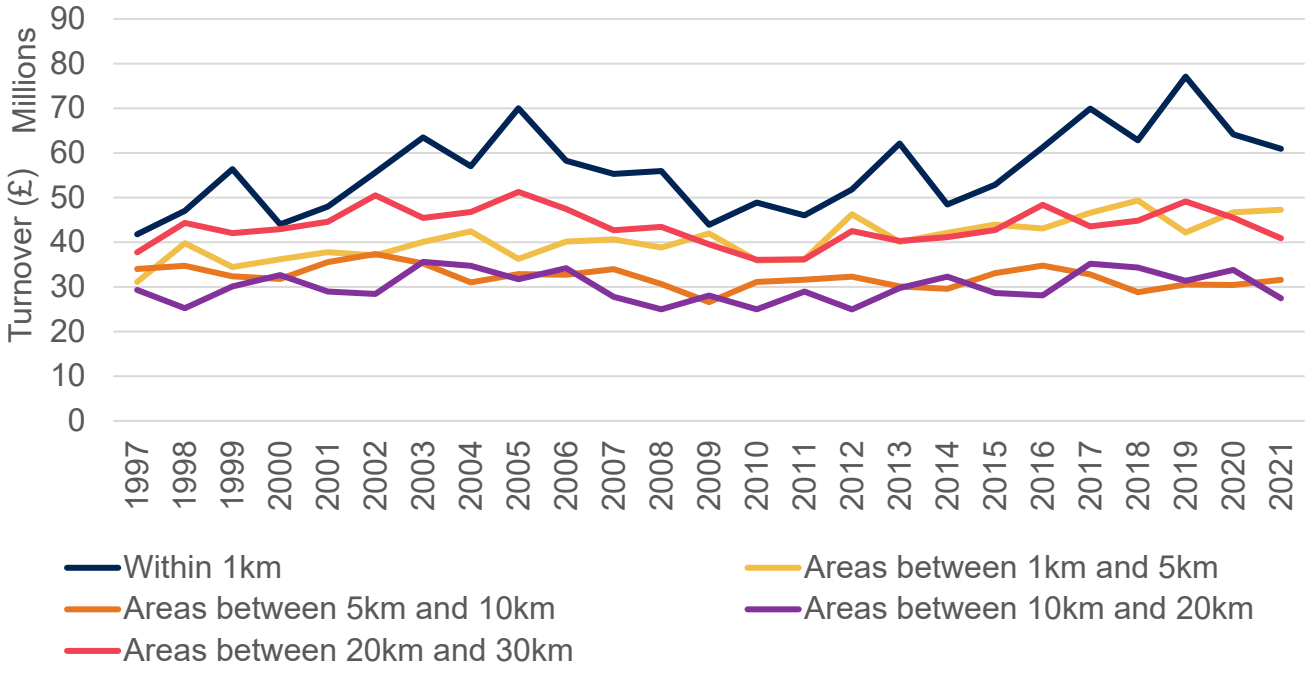
The following figure shows trends in the local economic performance of areas within 30km of the portfolio of schemes forming the focus of this study. Employment within 30km followed a general upward trend between 1997 and 2021 (a trend interrupted between 2008 and 2009 due to the global financial crisis). Real turnover and productivity levels (as approximated by turnover per worker) were broadly stable over the period.

Figure 7.1: Average employment in LSOAs within 30km of road improvement schemes, by distance from scheme between 1997 and 2021



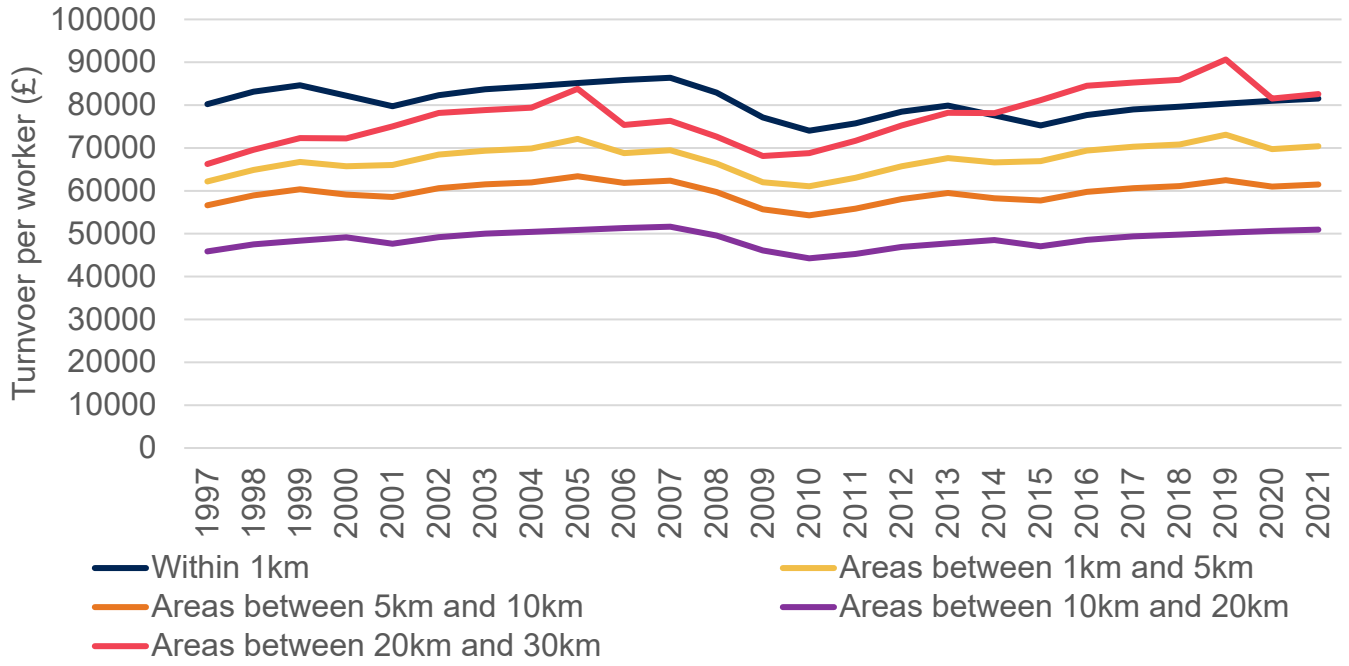
Source: Business Structure Database, ONS, Ipsos analysis.

Figure 7.2: Average turnover in LSOAs within 30km of road improvement schemes, by distance from scheme between 1997 and 2021



Source: Business Structure Database, ONS, Ipsos analysis.

Figure 7.3: Average turnover per worker in LSOAs within 30km of road improvement schemes, by distance from scheme between 1997 and 2021



Source: Business Structure Database, ONS, Ipsos analysis.

7.3 Overall impacts

The headline results of the econometric analysis are presented in the table below. The analysis showed that improvements in accessibility brought about by road improvement schemes led to:

- **Expansion in local economic activity**: The opening of road improvement schemes had a positive and on-going effect on employment, turnover and output (GVA). On average, road improvement schemes were estimated to lead to increased employment in LSOAs within 30km of the scheme by 0.11 to 0.16 percent, turnover by between 0.08 and 0.12 percent and GVA by between 0.14 and 0.22 percent. The results of the distance-decay and accessibility index approaches were broadly consistent. The estimated effects of road improvements on employment growth were smaller than estimated in prior studies using similar methods (see Gibbons (2019), which found that a one percent improvement in accessibility led to a 0.3 to 0.4 percent increase in employment)[19].

- **Plant relocations**: Road improvements were also estimated to have led to a net increase in the number of plants located within 30km of the scheme by between 0.7 and 0.9 percent. This implies that local economic growth impacts of road improvements are partly driven by the spatial reorganisation firms. The finding is larger but consistent with Gibbons (2019),

[19] Some additional analysis was also completed comparing activity generated by large and SME firms respectively. However, there were no significant differences in terms of the key outcomes.

which found that a one percent increase in accessibility led to 0.3 to 0.4 percent increase in the number of plants located in the area.

- **Productivity**: There were no statistically significant impacts identified on firm level productivity (in terms of GVA per worker or using turnover per worker as a proxy). These findings are also consistent with Gibbons (2019) – which found positive effects on gross output per worker, though not GVA per worker. The results on employment and GVA themselves however do imply some productivity growth.

Additional analysis was undertaken with a view to breaking down the inputs of firms into constituent components and exploring the extent to which these had changed since scheme completion. There were few changes overall with only the costs of goods and raw materials and energy costs increasing marginally in response to scheme completion and there was no change in where goods came from (UK or non-UK). This latter finding implies there was no import/export substitution effects from scheme completion.

Table 7.1: Estimated effects of road improvements on firm performance measures – overall results

Outcome (within 30km)	Fixed LSOA effects	Fixed year effects	Estimated on-going effect per scheme	p value	Observations
Distance decay					
Employment	Yes	Yes	0.0016***	0.000	678,117
Turnover	Yes	Yes	0.0012***	0.004	678,117
Turnover per worker	Yes	Yes	-0.0002	0.175	678,117
Number of local units	Yes	Yes	0.0009***	0.003	678,117
GVA	Yes	Yes	0.0020***	0.004	654,633
GVA per worker	Yes	Yes	0.0004	0.318	400,705
Capital investment	Yes	Yes	0.0010	0.162	400,705
Accessibility index					
Employment	Yes	Yes	0.0011***	0.004	678,117
Turnover	Yes	Yes	0.0008*	0.053	678,117
Turnover per worker	Yes	Yes	-0.0004	0.328	678,117
Number of local units	Yes	Yes	0.0006*	0.061	678,117
GVA	Yes	Yes	0.0016*	0.055	654,633
GVA per worker	Yes	Yes	0.0005	0.361	654,633
Capital investment	Yes	Yes	0.0006	0.299	654,633

Source: Business Structure Database, Annual Business Survey, ONS, Ipsos analysis. '***', '**' and '*' indicate whether the estimated result is statistically significant at the 99, 95 and 90 percent level respectively.

7.4 Spatial distribution of impacts

Results were then produced with effects broken down by distance band from the schemes[20] to explore the spatial distribution of the firm level impacts of road improvement schemes. The results indicated that:

- **Spatial concentration**: The growth impacts of road improvement schemes appear to be concentrated within 10 kilometres of the road improvement – with employment increasing by 0.10 to 0.31 percent in these areas. Plant relocations or openings appeared to be specifically concentrated within an area of 1km to 5km of the road improvement scheme (which would appear to be consistent with firms re-organising their operations to take advantage of improved connectivity).
- **Local displacement and crowding out**: There was no evidence of offsetting displacement or crowding out effects at the local level – road improvement schemes did not lead to any reductions in economic activity in zones beyond 10km and up to 30km from the improvement.

[20] Note that these include areas within 1km in their own separate banding unlike the overall results which have these areas excluded (see econometric approach for more information).

Table 7.2: Estimated effects of road improvements on firm performance measures by distance from the road improvement

Distance from scheme	Estimated impact per scheme: Employment	Turnover	Turnover per worker	Number of local units	GVA	GVA per worker
Distance decay						
Within 1km	0.0031*	0.0019*	-0.0015	0.0009	-0.0012	-0.0010
1km to 5km	0.0024**	0.0017*	-0.0014*	0.0008*	0.0033*	0.0020
5km to 10km	0.0015**	0.0008*	-0.0006	0.0002	0.0020*	0.0003
10km to 20km	-0.0003	-0.0001	0.0001	0.0002	-0.0003	-0.0002
20km to 30km	0.0001*	0.0001	-0.0001	0.0001*	0.0001	0.0001
Accessibility index						
Within 1km	0.0028*	0.0017*	-0.0013	0.0006	-0.0007	-0.0010
1km to 5km	0.0022**	0.0015	-0.0012	0.0008*	0.0024*	-0.0023
5km to 10km	0.0010*	0.0005*	-0.0004	0.0001	0.0013*	0.0002
10km to 20km	0.0001	0.0000	0.0000	-0.0001	0.0003	0.0002
20km to 30km	0.0001*	0.0001	-0.0001	0.0001*	0.0001	0.0001

Source: Business Structure Database, Annual Business Survey, ONS, Ipsos analysis. '***', '**' and '*' indicate whether the estimated result is statistically significant at the 99, 95 and 90 percent level respectively. All models presented include time fixed effects for each band and LSOA level fixed effects

7.4.2 Spatially stable firms

The following table provides the estimated impacts of road improvements on the subset of firms that did not change location for five years following completion of the scheme (to explore how far local growth impacts were driven by the relocation of firms or via stimulating the growth of incumbents). Comparisons with the findings set out above indicate that:

- Road improvement schemes have on-going growth impacts on incumbents that are of a similar magnitude to their effects on the local economy. This potentially indicates that the role of firm relocations in driving local economic growth in response to improvements in road connectivity may be relatively small, and that much of the advantage is captured by firms that were already present in the area.

- This finding is inconsistent with Gibbons (2019) which found that the local economic growth impacts of improved road connectivity was largely driven by relocations and the opening of new plants within 20km of road improvements completed between 1998 and 2007.

Table 7.3: Estimated effects of road improvements on firm performance measures by distance from road improvement schemes – spatially stable firms

Distance from scheme	Estimated impact per scheme				
	Employment	Turnover	Turnover per worker	GVA	GVA per worker
Distance decay					
Within 1km	0.0028*	0.0015	-0.0012	0.0011	-0.0015
1km to 5km	0.0022**	0.0014*	-0.0011	0.0024*	0.0001
5km to 10km	0.0014**	0.0006*	-0.0005	0.0013*	0.0002
10km to 20km	-0.0003	-0.0001	0.0001	0.0001	0.0001
20km to 30km	0.0001*	0.0001	-0.0001	0.0000	0.0000
Accessibility index					
Within 1km	0.0027	0.0014*	-0.0011	0.0010	-0.0014
1km to 5km	0.0018**	0.0012*	-0.0009	0.0019*	0.0001
5km to 10km	0.0008**	0.0004	-0.0003	0.0007*	0.0001
10km to 20km	-0.0002	-0.0001	0.0001	0.0001	0.0001
20km to 30km	0.0001*	0.0001	-0.0001	0.0000	0.0000

Source: Business Structure Database, Annual Business Survey, ONS, Ipsos analysis. '***', '**' and '*' indicate whether the estimated result is statistically significant at the 99, 95 and 90 percent level respectively. All models presented include time fixed effects for each band and LSOA level fixed effects

7.4.3 Single site firms

The analysis was also undertaken with firms only operating from a single site included, in order to examine how far the process of apportioning turnover (observed at the level of the enterprise) to local units affected results. These indicated that completed road schemes led to increases in turnover and GVA of between 0.07 and 0.15 percent and 0.05 and 0.15 percent respectively. The pattern of results is broadly similar (though weaker) than those obtained using all firms, giving confidence that the effects on turnover represent impacts on the growth of local firms (rather than being an artefact of the apportionment process).

Table 7.4: Estimated effects of road improvements on firm performance measures by distance from road improvement schemes – single site firms

	Estimated impact per scheme					
Distance from scheme	Employment	Turnover	Turnover per worker	Number of local units	GVA	GVA per worker
Distance decay						
Within 1km	0.0025	0.0014*	-0.0014	0.0003	0.0008	-0.0012
1km to 5km	0.0019*	0.0015*	-0.0003	0.0001	0.0015*	0.0001
5km to 10km	0.0012*	0.0007*	-0.0006	0.0002	0.0008*	0.0002
10km to 20km	-0.0002	-0.0001	0.0001	0.0002	0.0001	0.0001
20km to 30km	0.0001*	0.0001	0.0000	0.0001	0.0000	0.0000
Accessibility index						
Within 1km	0.0024	0.0013*	-0.0013	0.0000	0.0008	-0.0011
1km to 5km	0.0015*	0.0012*	-0.0002	0.0000	0.0012*	0.0001
5km to 10km	0.0007*	0.0004	-0.0004	0.0001	0.0005*	0.0001
10km to 20km	-0.0001	-0.0001	0.0001	0.0001	0.0001	0.0001
20km to 30km	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000

Source: Business Structure Database, Annual Business Survey, ONS, Ipsos analysis. '***', '**' and '*' indicate whether the estimated result is statistically significant at the 99, 95 and 90

percent level respectively. All models presented include time fixed effects for each band and LSOA level fixed effects.

7.5 Impacts by scheme type and area characteristics

Tables 7.5 to 7.7 present the results analysing the effects by baseline productivity, rural/urban nature of the area, type of schemes and industry sector using the accessibility index as the treatment variable. These tables show:

- **Effects are greater in more productive areas:** The highest productivity areas appear to benefit the most from road improvement schemes. Road improvement schemes were estimated to lead to a 0.13 to 0.15 expansion in employment areas with high levels of productivity, with only weak evidence of impacts on local growth in areas with medium or low levels of productivity. Positive effects on the number of local plants were also concentrated in high productivity areas (indicating that firms only relocate plants to high productivity areas in response to improvements in connectivity). This does raise some potential policy questions, as road improvements appear to reinforce patterns of economic agglomeration rather than support spatial rebalancing.

- **Agglomeration and disagglomeration**: The results also indicate that improvements in road connectivity simultaneously drive agglomeration and disagglomeration of economic activity. The impacts of road improvement schemes were strongest in major urban areas and in rural villages, with only weak effects (if any) on suburban zones and towns. This result also highlights the role of road improvement schemes in reinforcing existing patterns of economic agglomeration.

- **New vs existing links**: There were no major differences in the growth impacts associated with new links and improvements to the capacity of existing links. However, only new links appeared to result in a spatial re-organisation of firms (possibly because only new links create the potential for new transport routes to be adopted by firms).

- **Scheme funder**: There were no differences in the impacts of DfT Local Major Schemes and National Highways funded projects (although the impacts of Local Major Schemes appeared to be associated with a higher degree of spatial concentration closer to the road improvement).

- **Sector differences**: A disaggregation of results by sector indicate that the impacts of road improvement schemes were concentrated in the manufacturing and transport and storage sector (and to a lesser degree, the construction sector). These findings might be expected given the dependence of the road network to these sectors in maintaining the efficiency of supply chains and distribution networks. The results indicated that any effects of improved road connectivity on the tradable and non-tradable services sector were limited. This indicates that any induced effects arising from road improvement schemes are likely to be negligible.

Table 7.5: Estimated effects of road improvements on firm performance measures – results by area/scheme characteristics (distance decay)

Distance from scheme	Estimated impact per scheme					
	Employment	Turnover	Turnover per worker	Number of local units	GVA	GVA per worker
Productivity						
High	0.0015***	0.0014**	0.0001	0.0017**	0.0017***	0.0003
Medium	0.0008*	0.0009*	0.0002	0.0008	0.0011*	0.0002
Low	0.0002*	0.0001	-0.0001	0.0006	0.0006	-0.0001
Urban/Rural						
Urban	0.0016***	0.0014**	-0.0002	0.0011**	0.0023***	0.0007
Town/fringe	0.0007**	0.0006*	0.0001	0.0005	0.0013*	0.0004
Village	0.0014**	0.0010**	-0.0003	0.0009*	0.0017**	0.0003
Type of link						
New link	0.0017**	0.0013**	-0.0003	0.0015**	0.0020**	0.0005
Existing link	0.0015**	0.0012*	-0.0002	0.0006	0.0021**	0.0007
Scheme funder						
National Highways	0.0014**	0.0011*	-0.0002	0.0009*	0.0022**	0.0009
Local Major	0.0017**	0.0013*	-0.0003	0.0008*	0.0020**	0.0008

Source: Business Structure Database, Annual Business Survey, ONS, Ipsos analysis. '***', '**' and '*' indicate whether the estimated result is statistically significant at the 99, 95 and 90 percent level respectively. All models presented include time fixed effects for each band and LSOA level fixed effects

Table 7.6: Estimated effects of road improvements on firm performance measures – results by area/scheme characteristics (accessibility index)

Distance from scheme	Estimated impact per scheme					
	Employment	Turnover	Turnover per worker	Number of local units	GVA	GVA per worker
Productivity						
High	0.0013***	0.0013*	0.0001	0.0016**	0.0016**	0.0003
Medium	0.0007*	0.0008*	0.0002	0.0007	0.0010*	0.0002
Low	0.0002	0.0001	-0.0001	0.0006	0.0006	-0.0001
Urban/Rural						
Urban	0.0014**	0.0013**	-0.0002	0.0010*	0.0022**	0.0006
Town/fringe	0.0006*	0.0005	0.0001	0.0005	0.0010*	0.0004
Village	0.0012**	0.0009*	-0.0003	0.0008*	0.0015**	0.0003
Type of link						
New link	0.0014*	0.0012*	-0.0003	0.0012*	0.0017**	0.0004
Existing link	0.0013*	0.0010*	-0.0002	0.0005	0.0018**	0.0006
Scheme funder						
National Highways	0.0012*	0.0012*	-0.0002	0.0008*	0.0019**	0.0008
Local Major	0.0014*	0.0011*	-0.0003	0.0005	0.0017**	0.0007

Source: Business Structure Database, Annual Business Survey, ONS, Ipsos analysis. '***', '**' and '*' indicate whether the estimated result is statistically significant at the 99, 95 and 90 percent level respectively. All models presented include time fixed effects for each band and LSOA level fixed effects

Table 7.7: Estimated effects of road improvements on firm performance measures – by sector

Distance from scheme	Estimated impact per scheme					
	Employment	Turnover	Turnover per worker	Number of local units	GVA	GVA per worker
Distance decay						
Primary	0.0002	0.0002	-0.0001	0.0003	-0.0001	-0.0003
Manufacturing	0.0015***	0.0013**	-0.0003	0.0012**	0.0021***	-0.0008
Utilities	0.0001	0.0003	0.0002	0.0006	0.0000	-0.0001
Construction	0.0010*	0.0009*	-0.0001	0.0010*	0.0015**	-0.0002
Transport & storage	0.0013**	0.0011**	-0.0001	0.0011*	0.0013**	-0.0009
Non-tradeable services	0.0008*	0.0005	-0.0004	0.0009*	0.0009*	-0.0008
Tradeable services	0.0009*	0.0005	-0.0004	0.0010*	0.0007	-0.0007
Accessibility index						
Primary	0.0002	0.0002	-0.0001	0.0003	-0.0001	-0.0003
Manufacturing	0.0013**	0.0012**	-0.0003	0.0011**	0.0019***	-0.0007
Utilities	0.0001	0.0003	0.0002	0.0005	0.0000	-0.0001
Construction	0.0009*	0.0008*	-0.0001	0.0009*	0.0014**	-0.0002
Transport & storage	0.0012**	0.0010**	-0.0001	0.0010*	0.0012**	-0.0008

Non-tradeable services	0.0007	0.0004	-0.0003	0.0007	0.0007	-0.0007
Tradeable services	0.0008*	0.0005	-0.0004	0.0009*	0.0007	-0.0007

Source: Business Structure Database, Annual Business Survey, ONS, Ipsos analysis. '***', '**' and '*' indicate whether the estimated result is statistically significant at the 99, 95 and 90 percent level respectively. All models presented include time fixed effects for each band and LSOA level fixed effects

7.6 Impacts on firm structure

The spatial structure of enterprises impacted by road improvements was explored using three outcome variables derived as described in section 5.1.1. These results describe the impacts of road improvement schemes on the number of local and distant plants operated by those enterprises operating plants in areas within 30km of road improvements schemes at the point they were completed. These indicate that road improvement schemes:

- Have no statistically significant impacts on the number of firms operated in total.
- Encourage firms to increase the number of plants operating from within 30km of the road improvement by 0.08 percent, which was offset by a 0.06 reduction in the number of plants operating more than 30km from the road improvement. This implies that some of the local growth impacts of road improvement schemes are offset by reductions in economic activity elsewhere.

Table 7.8: Estimated effects of road improvements on firm spatial structure

Distance from scheme	Estimated impact per scheme
Number of firms operated in total	0.0001
Number of firms operated within 30km	0.0008**
Number of firms operated beyond 30km of schemes	-0.0006*

Source: Business Structure Database, ONS, Ipsos analysis. '***', '**' and '*' indicate whether the estimated result is statistically significant at the 99, 95 and 90 percent level respectively.

7.7 Effects on imports/exports

Firm level data in the ABS also allowed for the analysis of the amounts paid to, and received from, companies outside of the UK by UK based firms. These were used as a proxy for import and export activity respectively. No statistically significant effects were found, as presented in the table below. This suggests that the road improvement schemes did not increase local firm competitiveness in international markets and implies that any output effects estimated earlier are at the expense of firms located outside of the 30km radius of completed schemes.

Table 7.9: Estimated effects of road improvements on import/export measures – overall results

Distance from scheme	Estimated impact per scheme	
	Amounts payable to companies outside of the UK (import)	Amounts received from companies outside of the UK (export)
Distance decay		
Within 1km	0.0008	0.0006
1km to 5km	0.0005	0.0008
5km to 10km	0.0002	0.0004
10km to 20km	-0.0001	0.0002
20km to 30km	0.0000	0.0000
Accessibility index		
Within 1km	0.0009	0.0005
1km to 5km	0.0006	0.0006
5km to 10km	0.0002	0.0005
10km to 20km	-0.0001	0.0002
20km to 30km	0.0000	0.0000

Source: Annual Business Survey, ONS, Ipsos analysis. '***', '**' and '*' indicate whether the estimated result is statistically significant at the 99, 95 and 90 percent level respectively. All models presented include time fixed effects for each band and LSOA level fixed effects

8 Impacts on labour markets

This section reports the results of the analysis assessing a range of potential impacts on the local labour markets as a result of completed road schemes. This analysis makes use of ONS SRS data in the Annual Population Survey (APS), Annual Survey of Hours and Earning (ASHE), census data from 2001, 2011 and 2021 and claimant count data from DWP.

8.1 Key findings

The key findings from these analyses showed that:

- Improvements to road connectivity were found to have positive effects on local labour markets. It was estimated that road improvement schemes lead to an average increase in the hourly earnings of workers employed by firms located within 30km of 0.17 to 0.22 percent. It also appears that additional labour demand induced by road improvement schemes supports reductions in unemployment, with the number of unemployed claimants falling by 0.5 to 0.6 percent on average in response to improvements in road connectivity. Estimates of impact on the number of claimants using a staggered difference-in-difference approach (see section 5.3) indicated that these effects are persistent and last for at least 8 years post a scheme's completion.

- Wage gains for workers employed by firms prior to the completion of road improvement schemes were smaller than found across all workers employed by firms within 30km. This indicates that the overall wage effect may have been driven by incoming workers filling new vacancies associated with higher wages.

- This was consistent with other findings of the study. Road improvement schemes appeared to encourage the relocation of residents, with the resident population of areas within 30km of schemes increasing by 0.29 to 0.32 percent in response to improvements in road connectivity. This was accompanied by an intensification of the supply of higher-level skills – with the share of residents with NVQ level 4 qualifications or higher increasing by 0.09 to 0.15 percentage points as a consequence of improvements to the road network.

- Impacts on both wages and unemployment were concentrated in areas within 5 to 10 kilometres of road improvement schemes. This aligns with the spatial pattern of the local economic growth impacts of road improvement schemes. As average labour productivity (GVA per worker) did not increase in response to improved road connectivity, it is possible that additional demand for labour may be placing upward pressure on equilibrium wages in the presence of supply constraints.

- There was little evidence that road improvement schemes led to increases in labour supply via economic activity rates or by encouraging workers to increase their working hours. Given that many jobs created were in the manufacturing and transport and storage sectors, there may be a mismatch between the preferences of economically inactive residents and the requirements of the roles. It should also be noted that economic activity rates have been

rising to historically high levels over the period in question, potentially limiting scope for substantial increases.

- The findings also provided additional evidence that road improvement schemes reinforced existing patterns of economic agglomeration. The wage and population growth impacts of road improvement schemes were concentrated in high productivity areas. However, the effects of road improvement schemes in reducing unemployment tended to be higher in areas characterised by medium and low levels of productivity, suggesting that labour supply constraints may be less acute in these types of area.

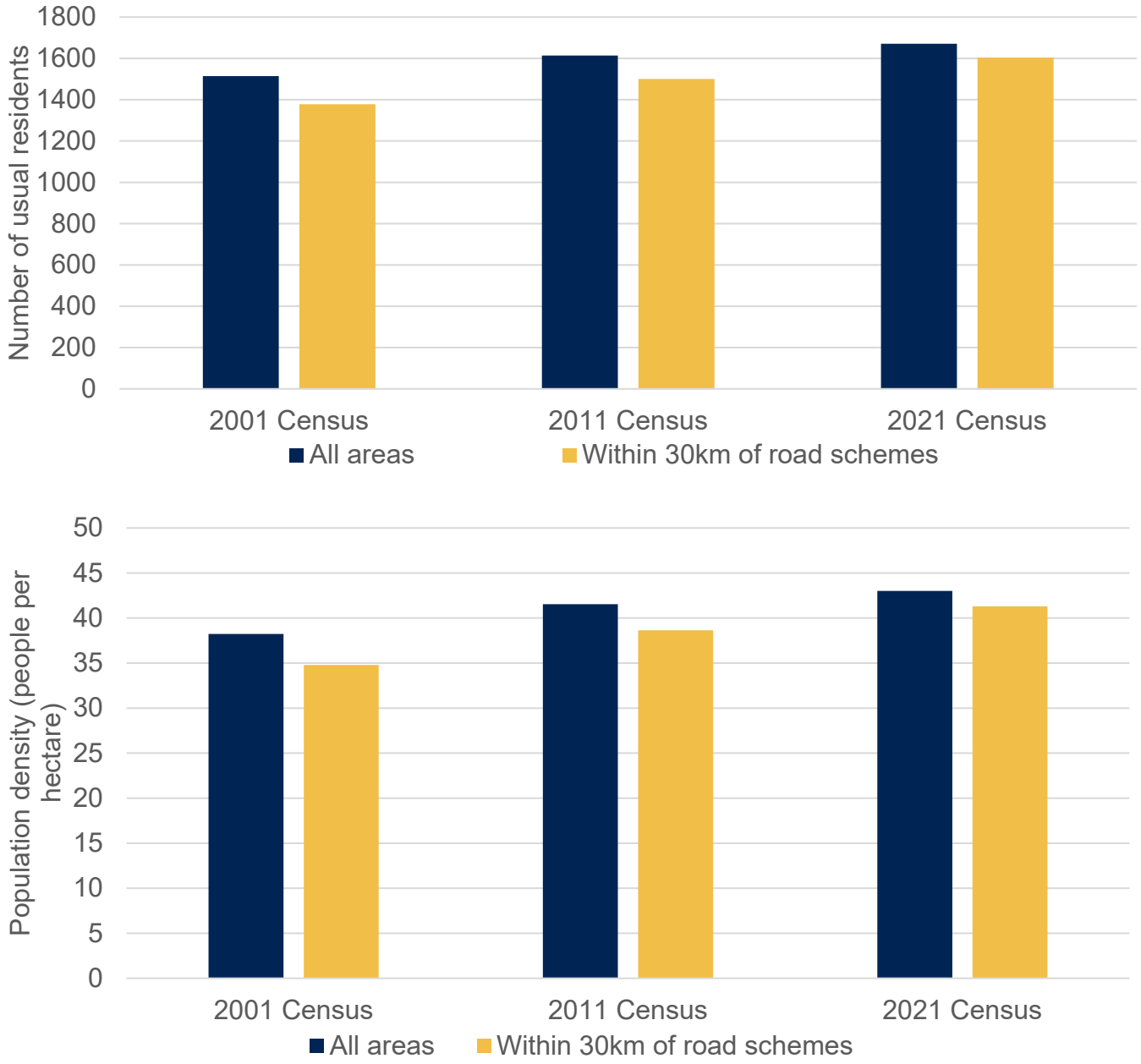
- Impacts were found to be broadly similar across scheme types with National highways and Local Major schemes associated with increased population, skill share, wages and decreased number of claimants. Overall effect sizes for wage, population growth and skills were slightly larger for National Highways than for Local Major schemes.

8.2 Population growth and skills supply

Counts of the usual resident population were obtained from the 2001, 2011 and 2021 Census. These were reported against 2001 and 2011 LSOAs respectively, and the analysis focused only on those LSOAs that did not change boundary to avoid complications introduced by a small number of complex changes in boundaries. The area in hectares for each LSOA was also obtained from Standard Area Measurement data to generate a population density variable.

For all areas there was a stepwise increase in population from 2001 to 2021, the largest of which was shown from 2001 to 2011, where population grew by 6.5 percent, compared to 3.6 percent from 2011 to 2021. Areas within a 30km radius also showed the same trend though on a greater magnitude, growing by 8.9 and 6.9 percent respectively. Population density also showed a similar trend for all areas and those within 30km of road schemes.

Figure 8.1: Comparison of population growth and population density of areas within 30km of road schemes to all areas over 2001, 2011 and 2021 census years

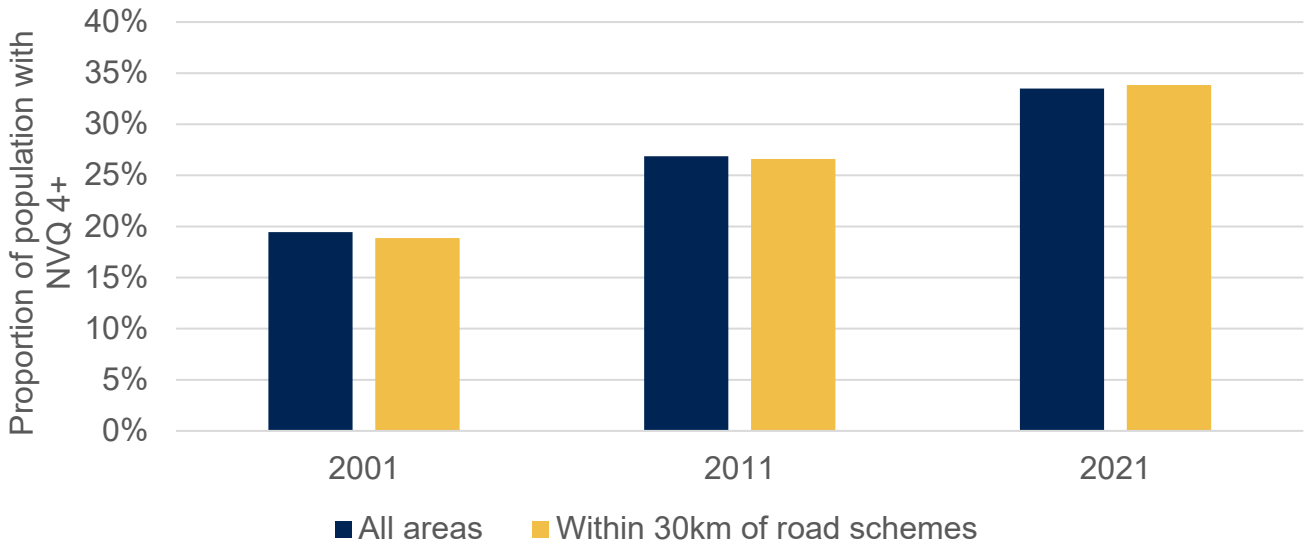


Source: ONS Census data 2001, 2011 & 2021, Ipsos analysis.

Data on the skill shares of local populations was also obtained from census data, with the proportion of resident population with NVQ 4 or higher as their highest qualification available for 2001, 2011 and 2021.

The 2001 census data showed that the percentage of those with an NVQ4+ level qualification was higher across all areas (0.7 percent) compared with those that were within 30km of the implemented road schemes. Growth by 2011 across those within a 30km radius meant that the percentage across both areas became almost level, with all areas being only 0.2 percent higher. By 2021, following further growth the population within a 30km radius of the schemes had on average 0.3 percent more people with NVQ4+ qualifications than those across all areas.

Figure 8.2: Comparison of population with NVQ 4+ in areas within 30km of road schemes to all areas over 2001, 2011 and 2021 census years

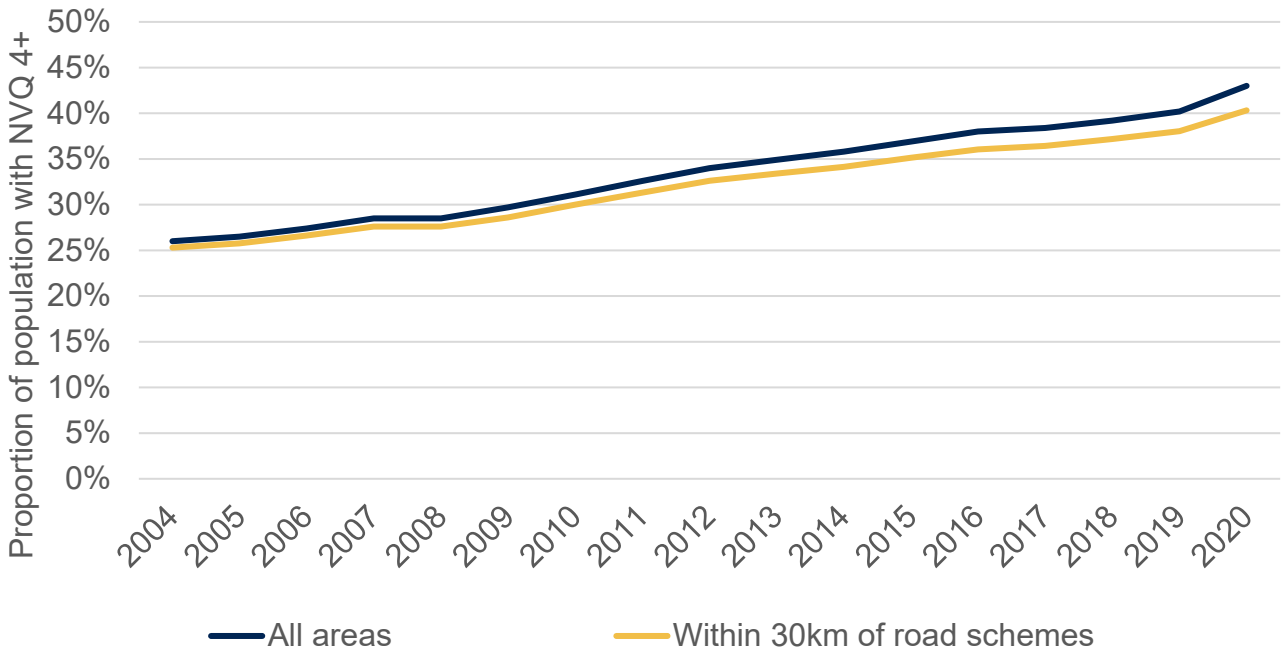


Source: ONS Census data 2001, 2011 & 2021, Ipsos analysis.

Information on skills was also available in the APS data, the figure below describes the change in the proportion of residents with NVQ 4 or higher as their highest qualification since 2004, comparing all areas to those areas within 30km of road schemes.

When looking to APS data, it shows not only that all areas and those within 30km of road schemes have a higher percentage of individuals with NVQ4+ compared with census data, it also shows that the growth of those with NVQ4+ across all areas is increasing at a faster rate than those within 30km of road schemes. In contrast to census data, the APS data also shows all areas to have a higher percentage of those with NVQ4+ than those within a 30km radius by 2021. Both measures are used in the analysis for completeness, however census data could be considered more accurate in so far as coverage is much greater than the sample based APS.

Figure 8.3: Comparison of population with NVQ 4+ in areas within 30km of road schemes to all areas between 2004 and 2020 in the APS



Source: ONS APS, Ipsos analysis.

8.3 Effects on population growth and labour supply

The results indicated that:

- Population growth: Road improvement scheme led to a 0.29 to 0.32 percent increase in the size of the resident population within 30km of schemes, indicating that improved road connectivity encourages the agglomeration of population.
- Sorting effects: There was also some evidence of population sorting, with road improvement schemes leading to 0.09 to 0.21 percentage point increase in the share of the resident population with NVQ level 4 qualifications and above. This indicates that road improvement schemes can help to improve the quality of local labour supply.

Table 8.1: Estimated effects of road improvements on population and skills – overall results

Outcome (within 30km)	Fixed LSOA effects	Fixed year effects	Estimated on-going effect per scheme	P value	Observations
Distance decay – Two-way FE					
Population	Yes	Yes	0.0032***	0.002	86,416
NVQ 4+	Yes	Yes	0.0021**	0.016	86,416
NVQ 4+ (APS)	Yes	Yes	0.0015**	0.042	553,741
Accessibility index					
Population	Yes	Yes	0.0029***	0.004	86,416
NVQ 4+	Yes	Yes	0.0015**	0.023	86,416
NVQ 4+ (APS)	Yes	Yes	0.0009*	0.061	553,741

Source: ONS APS, ONS Census data, Ipsos analysis. '*', '**', and '***' indicates whether the estimated coefficient was significant at the 90, 95, and 99 percent level of confidence respectively.

8.3.2 Spatial distribution of impacts

Analyses exploring the spatial distribution of these impacts (set out in Table 7.2) indicate that they tend to be concentrated in areas very close to the road improvement scheme (within 1km) and at longer distances (20km to 30km from the scheme). Given the findings below that road improvements do not lead to net increases in the building stock, this would imply an increased densification of population.

Table 8.2: Estimated effects of road improvements on population growth and skills – banded results

Distance from scheme	Estimated impact per scheme		
	Population	NVQ 4+	NVQ 4+ (APS)
Distance decay			
Within 1km	0.0083***	0.0024***	0.0015
1km to 5km	0.0016*	0.0010*	0.0012*
5km to 10km	-0.0004	0.0006	0.0005
10km to 20km	0.0003	0.0002	0.0003
20km to 30km	0.0027***	0.0014**	0.0016*
Accessibility index			
Within 1km	0.0071***	0.0017***	0.0009
1km to 5km	0.0012	0.0010*	0.0010
5km to 10km	-0.0005	0.0005	0.0003
10km to 20km	0.0003	0.0001	0.0003
20km to 30km	0.0022***	0.0012*	0.0013*

Source: ONS APS, ONS Census data, Ipsos analysis. '*', '**', and '***' indicates whether the estimated coefficient was significant at the 90, 95, and 99 percent level of confidence respectively.

8.3.3 Effects by scheme type and area characteristics

The impacts of road improvement schemes on population growth and skills supply aligned with the patterns reported in relation to impacts on firms. Impacts on both measures were concentrated in areas with higher levels of productivity, in urban areas and villages, and new road links appeared to have a stronger effect on the spatial reorganisation of the population than improvements to the capacity of existing links.

Impacts were found to be broadly similar across scheme types with National highways and Local Major schemes leading to increases in the size of local populations and level of skills. Overall effects sizes were slightly larger for National Highways and, in the APS analysis, effects on skills were not observed for Local Major schemes.

Table 8.3: Estimated effects of road improvements on population growth and skills – results by area/scheme characteristics

	Estimated impact per scheme					
	Population		NVQ 4+		NVQ 4+ (APS)	
	Distance decay	Accessibility index	Distance decay	Accessibility index	Distance decay	Accessibility index
Baseline productivity						
High	0.0087***	0.0075**	0.0026**	0.0021**	0.0018*	0.0014*
Medium	0.0041**	0.0032*	0.0018*	0.0014	0.0015	0.0011
Low	0.0022*	0.0020	0.0015	0.0014	0.0011	0.0012
Rural/Urban						
Urban	0.0077**	0.0054**	0.0027**	0.0019*	0.0023*	0.0015*
Town/fringe	0.0024*	0.0016	0.0019	0.0014	0.0014	0.0006
Village	0.0091**	0.0068**	0.0024*	0.0015	0.0018*	0.0014*
Type of link						
New link	0.0051**	0.0038**	0.0023*	0.0017*	0.0018*	0.0010
Existing link	0.0026*	0.0023*	0.0017*	0.0014	0.0015*	0.0009
Scheme funder						
National Highways	0.0026*	0.0031**	0.0024*	0.0016	0.0017*	0.0008
Local Major	0.0031**	0.0025*	0.0019*	0.0015	0.0013	0.0011

Source: ONS APS, ONS Census data, Ipsos analysis. '*', '**', and '***' indicates whether the estimated coefficient was significant at the 90, 95, and 99 percent level of confidence respectively.

8.4 Wage effects

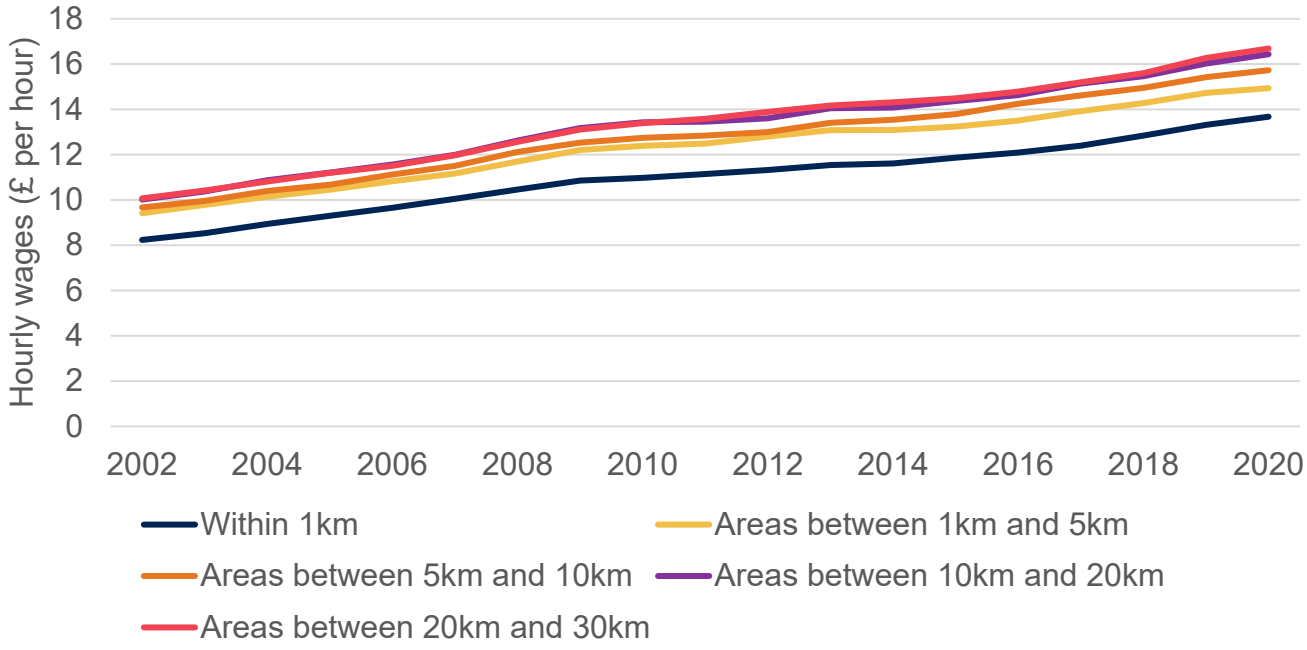
To explore the effects of road improvements on workers' wages and working hours, records of wages and hours of employees working in businesses operating within 30km of road schemes were identified in the Annual Survey of Hours and Earnings (ASHE) dataset compiled by the ONS and accessed through the SRS. The ASHE data was available since 2002 including the

workers employer's location which was used for the analysis presented below[21] (i.e. impacts are reported on the basis of the location of the employer).

Analysis of the trends across these outcomes over the specified distanced bands showed very similar trends across each of the groups of areas within 30km of completed schemes between 2002 and 2020. Hourly wages rose steadily over the period from an average of £9.48 to £15.49 in 2023 prices. Areas within 1km of road schemes persistently had lower average hourly wages implying that these areas may have been less productive.

No significant differences were visible in the hours worked data with total hours worked across all areas consistently between 36 and 38 hours. This remained steady throughout the period.

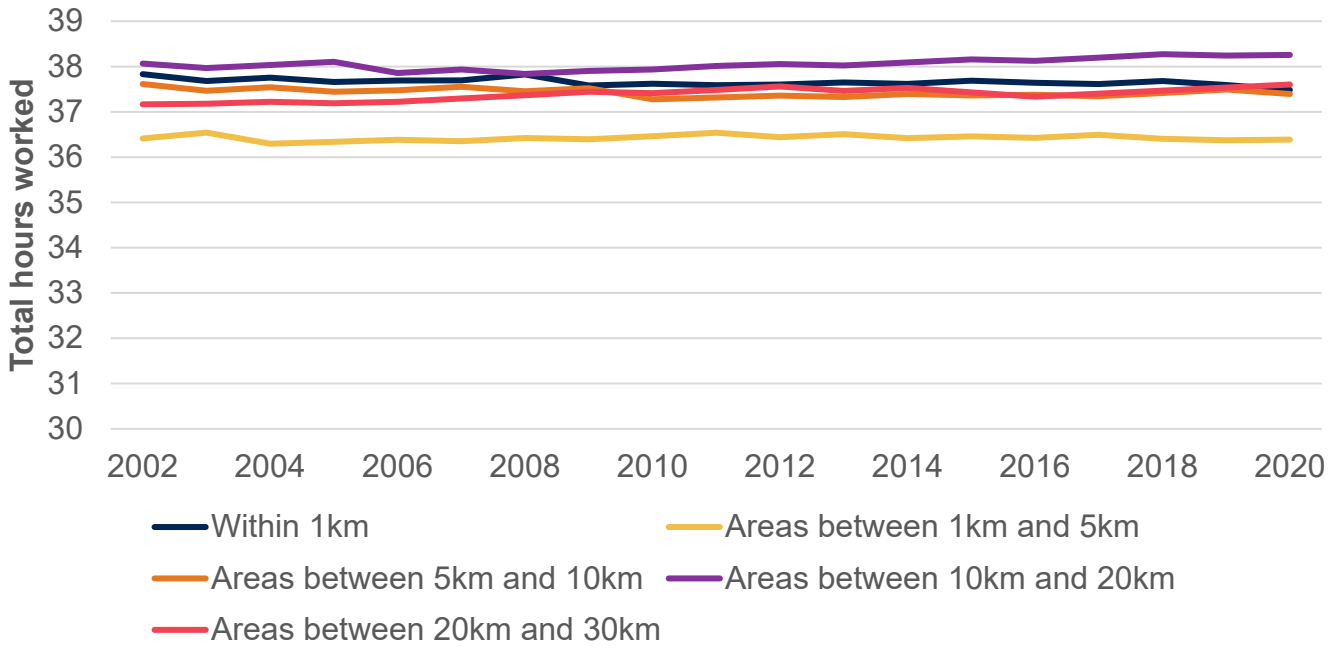
Figure 8.4: Hourly wages by distance from scheme between 2002 and 2020 (2023 prices)



Source: Annual Survey of Hours and Earnings, ONS, Ipsos analysis.

[21] Analysis using the workers location of residence was also completed. These results were qualitatively similar and therefore are not presented.

Figure 8.5: Working hours by distance from scheme between 2002 and 2020 (2023 prices)



Source: Annual Survey of Hours and Earnings, ONS, Ipsos analysis.

8.4.2 Overall results

The overall results of the econometric impact analysis are presented in the table below. The analysis showed that schemes that were completed had led to:

- Increased wages: Hourly wages of workers employed by firms located within 30km of road improvements increased by an average of 0.17 to 0.22 percent following the completion of a scheme. This result is also consistent with Gibbons (2019) which found a statistically significant positive impact of 0.25 percent. Given that overall firm level productivity does not increase in response to improvements in road connectivity, it is likely that these effects are driven by a combination of sorting effects (i.e. more highly skilled workers relocating to areas benefitting from road improvement schemes, as observed above) and supply side constraints (where additional demand for labour leads to increases in equilibrium wages).
- Hours worked: The was no evidence of impacts on labour supply as measured by the number of hours worked.

Table 8.4: Estimated effects of road improvements on wages and hours worked – overall results

Outcome (within 30km)	Fixed worker effects	Fixed year effects	Estimated on-going effect per scheme	P value	Observations
Distance decay – Two-way FE					
Hourly wages	Yes	Yes	0.0022***	0.004	3,028,277
Hours worked	Yes	Yes	0.0001	0.485	3,028,277
Accessibility index					
Hourly wages	Yes	Yes	0.0017***	0.007	3,028,277
Hours worked	Yes	Yes	0.0001	0.573	3,028,277

Source: Annual Survey of Hours and Earnings, ONS, Ipsos analysis. '***', '**' and '*' indicate whether the estimated result is statistically significant at the 99, 95 and 90 percent level respectively.

8.4.3 Spatial distribution of wage impacts

Positive effects on wages in response to road improvements were largely concentrated amongst employers located within 5km of the new or enhanced links. The spatial distribution of impacts on hourly wages also closely mirrored the spatial pattern of local growth impacts.

Table 8.5: Estimated effects of road improvements on wages and hours worked by distance (of the employer) from the road improvement

Distance from scheme	Estimated impact per scheme	
	Wages	Hours worked
Distance decay		
Within 1km	0.0028**	0.0010
1km to 5km	0.0023*	0.0007
5km to 10km	0.0014	0.0004
10km to 20km	0.0010	0.0005
20km to 30km	0.0009*	0.0003
Accessibility index		
Within 1km	0.0025**	0.0014
1km to 5km	0.0018*	0.0004
5km to 10km	0.0010	0.0006
10km to 20km	0.0006	0.0003
20km to 30km	0.0005	0.0001

Source: Annual Survey of Hours and Earnings, ONS, Ipsos analysis. '***', '**' and '*' indicate whether the estimated result is statistically significant at the 99, 95 and 90 percent level respectively.

8.4.4 Spatially stable workers

As highlighted above, impacts on average wages could be driven by 'sorting effects' where new – more highly paid – workers take the vacancies resulting from improvements to road connectivity, or via increases to the wages of incumbent workers (for example, if underlying labour productivity rises). To explore this further, further analysis was conducted restricting the sample to the pool of workers restricted to those that remained in the same job for 5 years post scheme completion to identify effects on incumbent workers.

The findings (set out in Table 7.6) that incumbent workers see wage gains of between 0.09 percent to 0.12 percent. These effects are substantially smaller in magnitude than those observed for all workers employed by firms located in proximity to road improvement schemes, indicating that potentially most wage gains are driven by the relocation of more highly skilled workers. Additionally, as there was no evidence of improvements in firm level productivity, it is also possible that wage gains amongst incumbents is a product of local labour supply constraints rather than underlying productivity gains.

Table 8.6: Estimated effects of road improvements on wages and hours worked – spatially stable workers

Distance from scheme	Estimated impact per scheme	
	Wages	Hours worked
Distance decay		
Within 1km	0.0012**	0.0013
1km to 5km	0.0010*	0.0009
5km to 10km	0.0010	0.0006
10km to 20km	0.0008	0.0002
20km to 30km	0.0007	0.0001
Accessibility index		
Within 1km	0.0009**	0.0011
1km to 5km	0.0007	0.0006
5km to 10km	0.0004	0.0004
10km to 20km	0.0006	0.0001
20km to 30km	0.0005	0.0001

Source: Annual Survey of Hours and Earnings, ONS, Ipsos analysis. '***', '**' and '*' indicate whether the estimated result is statistically significant at the 99, 95 and 90 percent level respectively.

8.4.5 Effects by occupation

An additional set of models were implemented to explore how the effects of road schemes varied across occupational groups. A series of models were implemented using combined groupings of 1-digit Standard Occupational Classification (SOC) codes. Table 7.7 below outlines the results of these analyses which show that road scheme completions principally benefitted workers in higher skill occupations (managerial, professional, and technical occupations, skilled trades, and administrative, leisure and service occupations). No effects were identified for those in the lowest skilled elementary occupations.

Table 8.7: Estimated effects of road improvements on wages and hours worked – analysis by occupation group

Occupation group	Fixed effects	Time fixed effects	Estimated impact per scheme	
			Hourly wages	Hours worked
Distance decay				
Managerial, professional and technical	Yes	Yes	0.0021**	0.0004
Skilled trades	Yes	Yes	0.0035**	0.0003
Administrative, leisure and service occupations	Yes	Yes	0.0015**	0.0006
Elementary occupations	Yes	Yes	0.0007	0.0001
Accessibility index				
Managerial, professional and technical	Yes	Yes	0.0019**	0.0004
Skilled trades	Yes	Yes	0.0029**	0.0004
Administrative, leisure and service occupations	Yes	Yes	0.0014*	0.0003
Elementary occupations	Yes	Yes	0.0008	0.0001

Source: Annual Survey of Hours and Earnings, ONS, Ipsos analysis. '***', '**' and '*' indicate whether the estimated result is statistically significant at the 99, 95 and 90 percent level respectively.

8.4.6 Effects by scheme type and area characteristics

Finally, the results showed a similar distribution of effects as other types of impact considered. Wage gains were principally concentrated in high productivity areas, although workers employed in all types of urban density saw some benefit from road improvement schemes.

Table 8.8: Estimated effects of road improvements on wages and hours worked – results by area/scheme characteristics

	Estimated impact per scheme			
	Hourly wages		Hours worked	
	Distance decay	Accessibility index	Distance decay	Accessibility index
Baseline productivity				
High	0.0033***	0.0027***	0.0009	0.0007
Medium	0.0016	0.0014	0.0010	0.0009
Low	0.0018	0.0017	0.0007	0.0006
Rural/Urban				
Urban	0.0028**	0.0027**	0.0006	0.0007
Town/fringe	0.0016**	0.0014*	0.0009	0.0006
Village	0.0021**	0.0019*	0.0005	0.0004
Type of link				
New link	0.0028**	0.0025**	0.0006	0.0005
Existing link	0.0018**	0.0016*	0.0004	0.0002
Scheme funder				
National Highways	0.0025**	0.0021**	0.0003	0.0002
Local Major	0.0020**	0.0017*	0.0005	0.0003

Source: Annual Survey of Hours and Earnings, ONS, Ipsos analysis. '***', '**' and '*' indicate whether the estimated result is statistically significant at the 99, 95 and 90 percent level respectively.

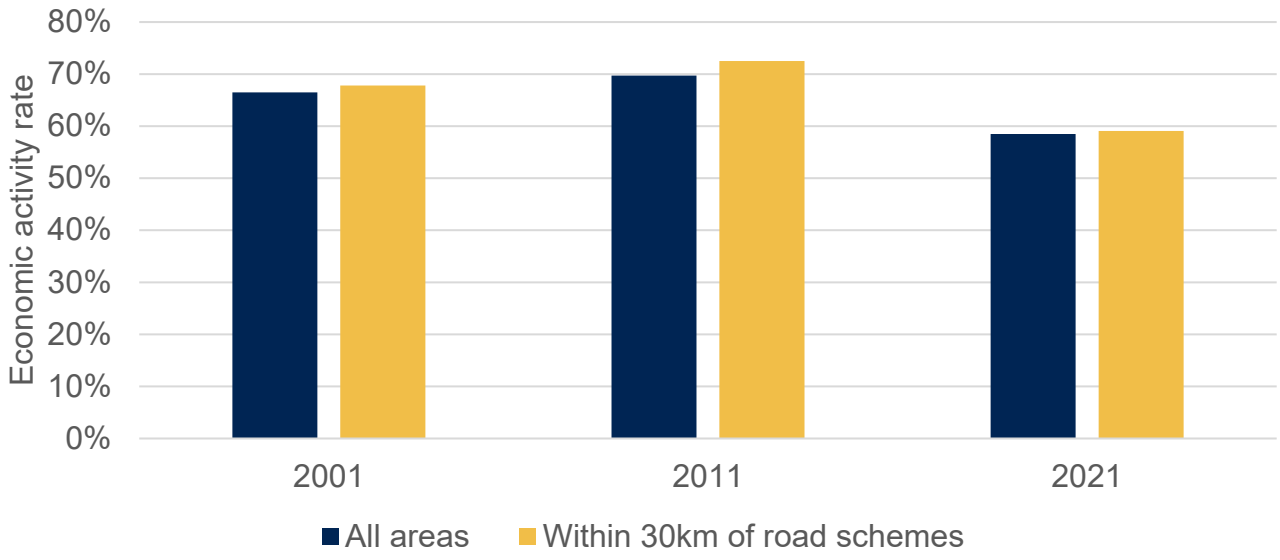
8.5 Economic activity & unemployment

Data on economic activity rates by LSOA was obtained from two sources, the ONS Census data and the Annual Population Survey (APS) in the ONS SRS. Census data was obtained for 2001, 2011 and 2021 with 2001 data reported at 2001 LSOAs. As a result, as with the earlier analysis on population growth, the analysis focused only on those LSOAs that did not change boundary to avoid complications introduced by a small number of complex changes in boundaries.

The census data showed that economic activity rates were higher on average across areas within 30km of road schemes in 2001, 2011 and 2021 compared with all areas. There is also a significant drop in economic activity in both areas from 2011 to 2021 (likely caused by the COVID-19 pandemic). This drop is more pronounced in those within 30km of road schemes

from 73 to 59 percent, meaning that by 2021 all areas and those within 30km of road schemes had near level economic activity rates at 58.4 and 59.1 percent respectively.

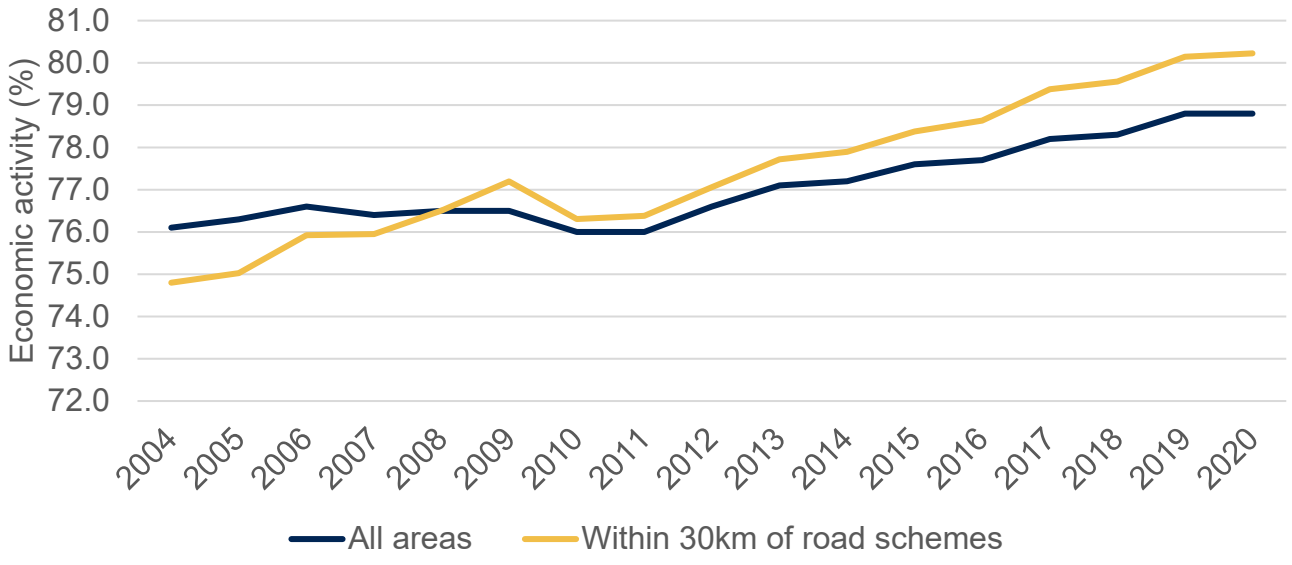
Figure 8.6: Comparison of economic activity rates in areas within 30km of road schemes to all areas over 2001, 2011 and 2021 census years



Source: ONS Census data 2001, 2011 & 2021, Ipsos analysis.

Information on economic activity was also available in the APS data, the figure below describes the change in economic activity rates between 2004 and 2020 in this dataset, comparing all areas to those areas within 30km of road schemes. Areas within 30km of road schemes were shown to have had consistently higher economic activity rates since the financial crisis. Additionally figure 5.7 shows that the growth in areas within 30km of a road scheme is higher than that of all areas, and by 2019, all areas economic activity rate is 1.4 percent lower than those closer to road schemes at 78.8 percent.

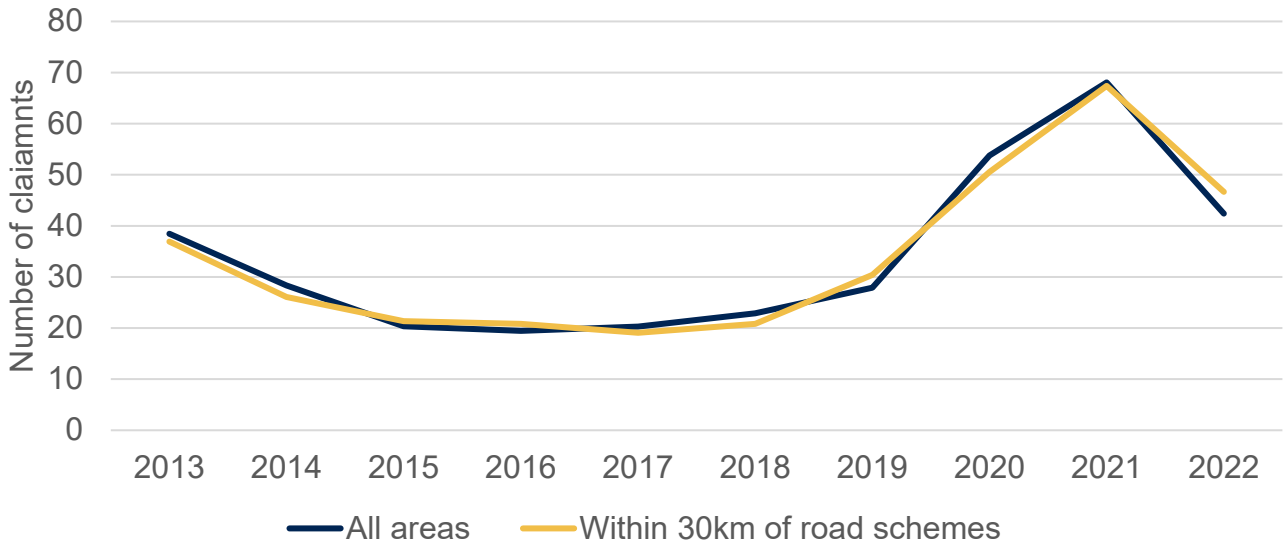
Figure 8.7: Comparison of economic activity rates in areas within 30km of road schemes to all areas between 2004 and 2020 in the APS



Source: ONS APS, Ipsos analysis.

Data on unemployment was taken from the experimental 'claimant count' series that counts the number of people claiming Jobseekers Allowance and those claiming Universal Credit that are required to seek work. Data is available from 2013 onwards at the LSOA level. Comparison of trends since 2013 between areas within 30km of road schemes and all areas showed that the average number of claimants from 2013 to 2022 has been near identical for all areas and those within 30km of road schemes. It is only in 2022, that areas within 30km of road schemes have been notably above that of all areas at 47 average claimants compared with 42 average claimants.

Figure 8.8: Comparison of average claimant counts in areas within 30km of road schemes to all areas between 2013 and 2022



Source: DWP Claimant count, Ipsos analysis.

8.5.2 Overall results

Application of the distance decay and accessibility index approaches generated the estimated effects of road scheme completions on these outcomes:

- Unemployment: Greater levels of local economic activity stimulated by road improvement schemes led to 0.5 to 0.6 percent reduction in the number of unemployed claimants within 30km of road improvement schemes.
- Economic activity rates: However, there was little evidence that road improvement schemes produced increases in labour supply by encouraging economically inactive individuals to seek employment. Given that many jobs created were in the manufacturing and transport and storage sectors, there may be a mismatch between the preferences and skills of economically inactive residents and the requirements of the positions that act as a constraint preventing the expansion of economic activity rates amongst the resident population. It should also be noted that economic activity rates have been rising to historically high levels over the period in question, limiting scope for substantial increases.

Table 8.9: Estimated effects of road improvements on economic activity rates and unemployment – overall results

Outcome (within 30km)	Fixed LSOA effects	Fixed year effects	Estimated on-going effect per scheme	P value	Observations
Distance decay – Two-way FE					
Economic activity rate (Census)	Yes	Yes	0.0006	0.217	86,416
Economic activity rate (APS)	Yes	Yes	0.0012	0.182	553,741
Claimant count	Yes	Yes	-0.0055***	0.002	325,730
Accessibility index					
Economic activity rate (Census)	Yes	Yes	0.0002	0.254	86,416
Economic activity rate (APS)	Yes	Yes	0.0007	0.164	553,741
Claimant count	Yes	Yes	-0.0052***	0.001	325,730

Source: ONS APS, DWP Claimant count, Ipsos analysis. '*', '**', and '***' indicates whether the estimated coefficient was significant at the 90, 95, and 99 percent level of confidence respectively.

8.5.3 Spatial distribution of impacts

Reductions in unemployment arising from road improvements were largely concentrated within 10km of the schemes. This aligns closely with the spatial pattern of economic growth impacts and indicates that workers typically travel short distances to employment (although smaller reductions in unemployment were observed up to 30km from the schemes).

Table 8.10: Estimated effects of road improvements on economic activity rates and unemployment – banded results

Distance from scheme	Estimated impact per scheme		
	Economic activity rate (Census)	Economic activity rate (APS)	Claimant count
Distance decay			
Within 1km	0.0010	0.0018*	-0.0175***
1km to 5km	0.0005	0.0010*	-0.0272***
5km to 10km	0.0006	0.0005	-0.0144***
10km to 20km	0.0002	0.0002	-0.0041***
20km to 30km	0.0004	0.0006	-0.0036***
Accessibility index			
Within 1km	0.0011	0.0015*	-0.0210***
1km to 5km	0.0006	0.0011*	-0.0264***
5km to 10km	0.0004	0.0004	-0.0121***
10km to 20km	0.0003	0.0001	-0.0035***
20km to 30km	0.0002	0.0005	-0.0029***

Source: ONS APS, DWP Claimant count, Ipsos analysis. '*', '**', and '***' indicates whether the estimated coefficient was significant at the 90, 95, and 99 percent level of confidence respectively.

8.5.4 Effects by scheme type and area characteristics

The findings suggested that the beneficial impacts of road improvement schemes in reducing unemployment levels were concentrated in medium and low productivity areas. These areas may be better able to accommodate increases in employment demand without placing upward pressure on local equilibrium wages. There was little other significant variation in the impacts of road improvement schemes on unemployment across other types of area.

Table 8.11: Estimated effects of road improvements on economic activity rates and unemployment – results by area/scheme characteristics

	Estimated impact per scheme					
	Economic activity rate		Economic activity rate (APS)		Claimant count	
	Distance decay	Accessibility index	Distance decay	Accessibility index	Distance decay	Accessibility index
Baseline productivity						
High	0.0008	0.0006	0.0008	0.0006	-0.0024***	-0.0022***
Medium	0.0005	0.0005	0.0005	0.0002	-0.0061***	-0.0057***
Low	0.0010*	0.0010	0.0014*	0.0012*	-0.0053***	-0.0047***
Rural/Urban						
Urban	0.0010	0.0008	0.0011	0.0009	-0.0059***	-0.0054***
Town/fringe	0.0005	0.0006	0.0008	0.0010	-0.0032***	-0.0030***
Village	0.0009	0.0007	0.0009	0.0012	-0.0052***	-0.0046***
Type of link						
New link	0.0007	0.0006	0.0011	0.0009	-0.0054***	-0.0049***
Existing link	0.0005	0.0003	0.0009	0.0008	-0.0051***	-0.0048***
Scheme funder						
National Highways	0.0009	0.0010	0.0012	0.0012	-0.0055***	-0.0050***
Local Major	0.0006	0.0005	0.0011	0.0009	-0.0057***	-0.0054***

Source: ONS APS, DWP Claimant count, Ipsos analysis. '*', '**', and '***' indicates whether the estimated coefficient was significant at the 90, 95, and 99 percent level of confidence respectively.

9 Land and property market impacts

This section reports the results of the analysis assessing the commercial and residential property impacts using the available VOA data and Land Registry house price (PPD) data.

9.1 Key findings

The findings from this strand of analysis indicated:

- Road improvement schemes increase demand for commercial floorspace in high productivity areas, leading to increases in commercial rents (as far as can be ascertained from changes in the rateable values of premises) of around 0.09 to 0.13 percent per square metre of floorspace. However, it appears that developers are unable to respond to price signals by increasing the supply of commercial and industrial floorspace in these areas. The inelastic nature of the supply of commercial and industrial floorspace may result in the productive advantages created by road improvement schemes being capitalised into rents (rather than being visible in firm level productivity gains).

- Similar patterns are also observed in housing markets. Road improvement schemes increase the value of residential properties within 30km by an average of 0.26 to 0.33 percent. Again, these impacts are concentrated in high productivity areas – which see average increases in house prices of 0.51 to 0.57 percent in response to improvements in road connectivity. However, road improvement schemes do not induce the construction of additional dwellings, again indicating that the supply of residential property may be inelastic. Increases in house prices appear to be persistent and analysis presented in section 5.3 indicated that these last over 10 years.

- The findings raise possible questions regarding the role of the planning system in constraining the potential local economic impacts of road improvement schemes and determining how the resultant productive advantages are shared between firms, workers, and landowners.

- The results of the study again highlight the role of road improvement schemes in reinforcing existing patterns of economic agglomeration. Road improvement schemes do not appear to place pressure on either commercial or residential property markets in areas characterised by medium or low productivity – either because they do not induce significant levels of additional demand or because there is more flexibility on the supply side.

- The findings of the study provide some evidence of the negative social welfare impacts associated with the construction of road improvements. Residential properties within 1km of road improvement schemes lose 9.5 percent of their value following the completion of schemes. Under some strong assumptions, this could be taken as a signal of the value of the negative externalities associated with living in proximity to new road or improved road links (e.g. as a consequence of the loss of visual amenities or higher levels of traffic, noise, or

pollution). This presents a puzzle when viewed alongside the population growth impacts which appear strongly in these areas.

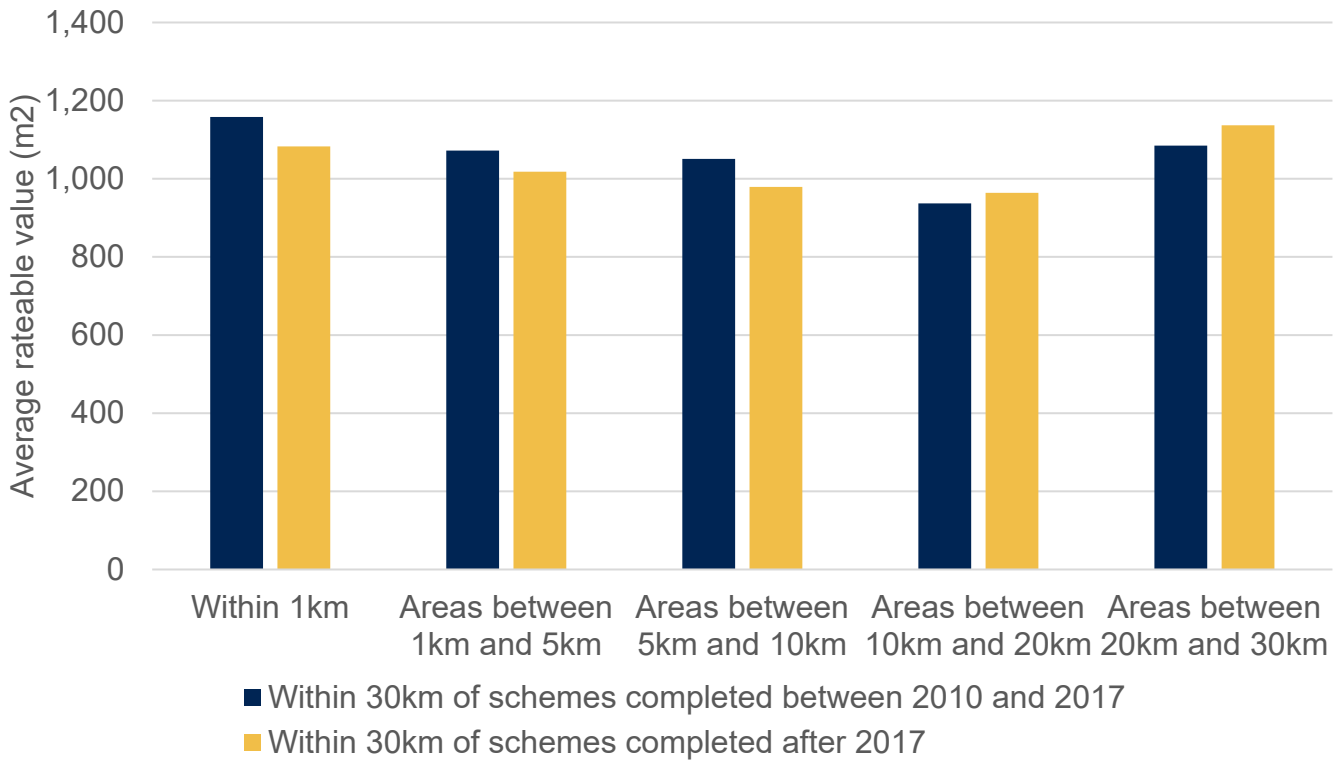
- National Highways schemes appeared to have a slightly larger effect on commercial rents compared to Local Major schemes. However, house price impacts appear to have been little affected by the scheme funder. Only Local Major schemes had significant impacts on the housing stock estimated at between 0.27 and 0.29 percent. Combined with the evidence on link type, this implies that new links in local areas had the greatest stimulating impact on development.

9.2 Commercial rental values and floorspace

Information on total commercial floorspace and average rateable values for commercial spaces were taken from the 2010 and 2017 non-domestic ratings list published by the VOA. This data provided premises level information on the floorspace and rateable value associated with the premises. The rateable value per metre squared is interpreted as a measure of the rental value of property, although these are the VOAs assessment of the rent the property could obtain should it be vacant and in reasonable repair, rather than observed rents.

The data available enabled an assessment of the change in the average rateable value per metre squared between 2010 and 2017. Analysis of the data from the VOA suggested that the average rateable value per square metre was broadly similar across areas within 30km of completed road schemes in comparison to areas within 30km of road schemes completed after 2017 (control group areas).

Figure 9.1: Comparison of average rateable value in areas within 30km of road schemes completed between 2010 and 2017



Source: VOA, Ipsos analysis.

LSOAs within 30km of schemes completed between 2010 and 2017 saw average rateable values per square metre rise from £1,056 to £1374 (30 percent) over this time, slightly more rapidly but not dissimilar to the rise observed for areas within 30km of schemes completed after 2017 (from £1,021 to £1,304, a rise of 28 percent in 2023 prices).

9.2.2 Overall results

The results of the base econometric analysis of VOA outcomes are presented below and did not suggest any impacts on commercial floorspace or rateable value within 30km of road improvement schemes. This suggests that on average, road improvement schemes did not induce commercial property development or place additional pressure on commercial rents.

Table 9.1: Estimated effects of road improvements on commercial property markets – overall results

Outcome (within 30km)	Fixed LSOA effects	Fixed year effects	Estimated on-going effect per scheme	P value	Observations
Distance decay – Two-way FE					
Floorspace (m^2)	Yes	Yes	0.0017	0.185	62,836
Rateable value per m^2	Yes	Yes	0.0004	0.273	62,836
Accessibility index					
Floorspace (m^2)	Yes	Yes	0.0010	0.210	62,836
Rateable value per m^2	Yes	Yes	0.0002	0.294	62,836

Source: VOA, Ipsos analysis. '*', '**', and '***' indicates whether the estimated coefficient was significant at the 90, 95, and 99 percent level of confidence respectively.

9.2.3 Spatial distribution of impacts

The findings are more mixed when broken down by distance from road improvement schemes although without a clear pattern of effects. The results imply that new road improvement schemes may place pressure on commercial property markets in both areas within 1km of the scheme and at 20km to 30km. This was accompanied by decreases in rents areas 10km to 20km away, however, ranging from between 0.5 and 0.6 percent. There was limited evidence that road improvement schemes led to any net changes in the supply of commercial and industrial floorspace. These findings may suggest that firms expanding employment and output

may have sought additional space and help drive rents upwards. However, the pattern is not clear, particularly where rents fall in the 10km to 20km band.

Table 9.2: Estimated effects of road improvements on commercial property markets by distance from the road improvement scheme

Distance from scheme	Estimated impact per scheme	
	Floorspace (m^2)	Rateable value per m^2
Distance decay		
Within 1km	-0.0072	0.0284*
1km to 5km	-0.0024	-0.0042
5km to 10km	-0.0026	-0.0051
10km to 20km	0.0068*	-0.0060**
20km to 30km	-0.0003	0.0078***
Accessibility index		
Within 1km	-0.0008	0.0184
1km to 5km	0.0005	0.0008
5km to 10km	-0.0010	-0.0022
10km to 20km	0.0029*	-0.0049**
20km to 30km	0.0002	0.0052***

Source: VOA, Ipsos analysis. '*', '**', and '***' indicates whether the estimated coefficient was significant at the 90, 95, and 99 percent level of confidence respectively.

9.2.4 Effects by scheme type and area characteristics

Breaking the overall results down by area and scheme characteristics showed that the overall results presented above masked some variation:

- Baseline productivity: The impacts of road improvement schemes were clearest in the most productive areas, which saw rental values rise by between 0.09 and 0.11 percent in response to improvements in road connectivity. These were not accompanied by an expansion in the supply of floorspace, indicating that developers in these areas face constraints in responding to price signals (likely related to the planning system). There were no impacts on commercial property markets in areas with medium or low levels of productivity.

- Urban and rural impacts: Urban areas also saw rental prices rise by 0.10 to 0.13 percent in response to the completion of road improvement schemes (again, without an impact on the supply of floorspace). There were some indications that road improvements did induce an expansion in the supply of commercial floorspace in villages and rural locations, allowing additional demand to be accommodated without significant pressure on rents. There were no significant effects on commercial property markets in suburban zones and towns.

- Link type: New links appear to have the most significant effects on the spatial organisation of economic activity and appear to be associated with relatively large (0.22 to 0.36 percent)

impacts on the supply of commercial floorspace. These may not be sufficient to fully accommodate additional demand, however, as commercial rents also appear to rise between 0.10 and 0.13 percent in response to improvements to road connectivity.

Table 9.3: Estimated effects of road improvements on commercial property markets – results by area/scheme characteristics

	Floorspace (m^2)		Estimated impact per scheme Rateable value per m^2	
	Distance decay	Accessibility index	Distance decay	Accessibility index
Baseline productivity				
High	0.0022	0.0016	0.0011**	0.0009**
Medium	0.0014	0.0013	0.0007	0.0008
Low	0.0006	0.0003	0.0004	0.0002
Rural/Urban				
Urban	0.0019	0.0017	0.0013**	0.0010**
Town/fringe	0.0013	0.0009	0.0005	0.0004
Village	0.0024*	0.0023*	0.0007*	0.0005
Type of link				
New link	0.0036**	0.0022*	0.0013*	0.0010*
Existing link	0.0009	0.0005	0.0010*	0.0008
Scheme funder				
National Highways	0.0022*	0.0015*	0.0004	0.0006
Local Major	0.0016*	0.0009	0.0003	0.0006

Source: VOA, Ipsos analysis. '*', '**', and '***' indicates whether the estimated coefficient was significant at the 90, 95, and 99 percent level of confidence respectively.

9.3 Residential house prices and housing stock

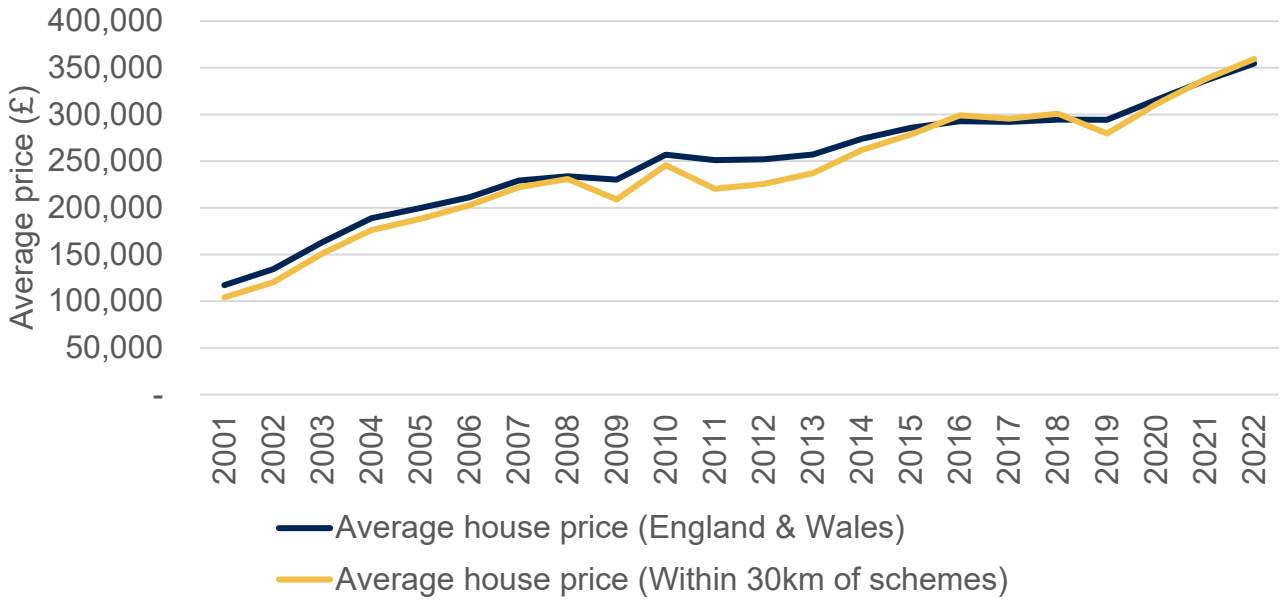
The primary dataset used for the analysis of house prices was the transaction level data on houses sold compiled by HM Land Registry. This provides a variety of data on individual housing transactions, including:

- Postcode and address of the house sold.
- Sale price agreed.
- Date of completion.

- Some basic information on the characteristics of the property – including tenure (freehold or leasehold) and type (detached, semi-detached, terrace, or flat/maisonette).

The figure below provides an overview of changes in (unweighted) average house prices between 2001 and 2022 in areas situated within 30km of completed road schemes and England and Wales overall. House prices in areas close to road schemes increased quickly over this period (rising by 246 percent over the period), somewhat mirroring national trends.

Figure 9.2: Evolution of house prices in England & Wales and areas within 30km of completed road schemes between 2001 and 2022



Source: Land Registry HPI, Ipsos analysis

On average, the prices of houses sold within 30km of completed schemes were 3.8 percent lower than those sold across England and Wales over this period (£248,863 versus £238,905). This does not account for differences in the types of houses traded, of which there were few, as illustrated in the table below.

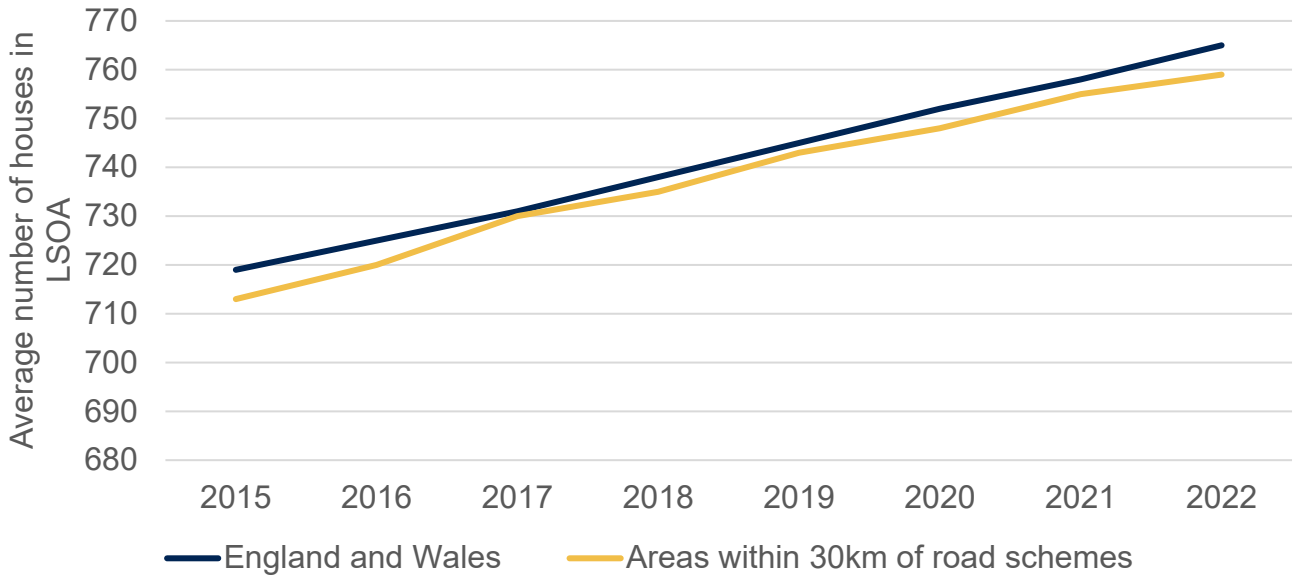
Table 9.4: Distribution of houses sold by type, scheme areas and England & Wales, 2001 to 2022 (percentage of transactions)

Type of home	Areas within 30km of schemes	England and Wales overall
Detached	24%	26%
Semi-detached	30%	23%
Terraced	23%	28%
Flat	13%	17%

Source: HM Land Registry, Ipsos analysis

VOA data on council tax lists was used for the analysis of housing stock. This data series goes back to 2015 and includes the total number of residential properties eligible for council tax by band. Analysis of the data showed that areas within 30km of road schemes contained a similar number of properties in total when compared to England and Wales overall with matching trends between 2015 and 2020 with the number of properties steadily rising.

Figure 9.3: Evolution of housing stock in England & Wales and areas within 30km of completed road schemes between 2015 and 2022



Source: VOA Council tax lists, Ipsos analysis

9.3.2 Overall results

The results of the house price analysis indicated that road improvement schemes increase the value of house prices within 30km by between 0.26 and 0.32 percent. This may reflect a variety of welfare improvements associated with improved accessibility, making it easier for people to travel to and from work, schools, shopping centres, and other amenities. This may also reflect an increased ability for residents to pay given the effects identified on wages. However, no impacts were found in terms of the total stock of the properties implying that road schemes had not induced significant development of residential housing (again, pointing to an inelastic supply side).

Table 9.5: Estimated effects of road improvements on residential property markets – overall results

Outcome (within 30km)	Fixed LSOA effects	Fixed year effects	Estimated on-going effect per scheme	P value	Observations
Distance decay – Two-way FE					
House prices	Yes	Yes	0.0032**	0.031	2,221,573
Stock of properties	Yes	Yes	0.0010	0.133	262,032
Accessibility index					
House prices	Yes	Yes	0.0026**	0.047	2,221,573
Stock of properties	Yes	Yes	0.0006	0.164	262,032

Source: HM Land Registry, VOA, Ipsos analysis. '*', '**', and '***' indicates whether the estimated coefficient was significant at the 90, 95, and 99 percent level of confidence respectively.

9.3.3 Spatial distribution of impacts

There was a significant degree of variation in impact ranging by distance from the scheme. The banded analysis showed particularly noticeable decreases in property prices in areas up to 1km away from completed schemes. The analysis suggests that these areas saw prices decline by 7 to 10 percent in response to scheme completion. There are several potential explanations for this:

- Noise and Pollution: Construction of road schemes and traffic on the improved or new link often lead to increased noise and air pollution. Living very close to such areas might be less desirable for many people because of these factors, leading to a decrease in property values.
- Changes in Landscape: Road schemes may involve significant alterations to the landscape, like cutting down trees or altering natural features. If these changes are seen as negative, they could potentially decrease the appeal of nearby properties and lower their values.
- Increased Traffic: While improved roads can enhance accessibility, they may also lead to increased traffic, especially with major thoroughfares. Living very close to busy roads might not be appealing to many people due to issues like noise, pollution, and safety concerns, which can negatively impact house prices.

However, these areas also saw the strongest effect on population growth. This presents a puzzle that may require further exploration.

In areas more distant from road improvement schemes (from 10km to 30km), increases in house prices are positive. Properties in areas 10km to 20km away increased by between 0.34 and 0.38 percent on average whilst properties in areas 20km to 30km away increased by 0.19 to 0.24 percent on average.

This highlights that road improvement schemes may have important distributional effects – involving a trade-off between significant losses in the welfare of (a smaller group of) residents living in proximity to road improvement schemes that is balanced by more marginal improvements to the welfare of larger groups of residents living more distant from schemes.

Table 9.6: Estimated effects of road improvements on residential property markets – banded results

Distance from scheme	Estimated impact per scheme	
	House prices	Stock of properties
Distance decay		
Within 1km	-0.0951*	0.0015
1km to 5km	-0.0823	0.0011
5km to 10km	0.0046	0.0005
10km to 20km	0.0038*	0.0003
20km to 30km	0.0024**	0.0008
Accessibility index		
Within 1km	-0.0714*	0.0016
1km to 5km	-0.0725	0.0009
5km to 10km	0.0038	0.0006
10km to 20km	0.0034*	0.0004
20km to 30km	0.0019**	0.0005

Source: HM Land Registry, VOA, Ipsos analysis. '*', '**', and '***' indicates whether the estimated coefficient was significant at the 90, 95, and 99 percent level of confidence respectively.

9.3.4 Effects by scheme type and area characteristics

As with some of the prior findings in this report, the characteristics of an area, such as rural/urban status, play a role as to the extent to which impacts are observed as a result of completed road schemes:

- Productivity: Impacts on house prices were strongest in high productivity areas (with the price of residential properties rising by between 0.5 and 0.6 percent in response to road improvement schemes, compared to 0.2 and 0.3 percent for medium and low productivity areas respectively). This may be unsurprising given the role of road improvement schemes in stimulating demand for residential properties in high productivity areas (as demonstrated in the preceding section).

- Rural/Urban status: Residential property markets saw similar patterns of effects across areas of different urban densities as observed in commercial property markets. The prices of residential properties in both urban areas and more rural areas rose in response to improvements in road connectivity, though there were little impacts on suburban zones and towns. As with commercial property markets, only village and rural areas saw the housing stock increase in response to additional demand.

- Type of link: New links appear to have had a larger effect on both house prices and housing stock. Existing links saw price rises by a smaller amount after a scheme was completed with no impacts on housing stock.

- Scheme funder: House price impacts appear to have been little affected by the scheme funder, however Local Major schemes did have significant impacts on the housing stock estimated at between 0.27 and 0.29 percent. Combined with the evidence on link type, this implies that new links in local areas had the greatest stimulating impact on development.

Table 9.7: Estimated effects of road improvements on residential property markets – results by area/scheme characteristics

	Estimated impact per scheme			
	House prices		Stock of properties	
	Distance decay	Accessibility index	Distance decay	Accessibility index
Baseline productivity				
High	0.0057**	0.0051**	0.0008	0.0010
Medium	0.0024*	0.0023*	0.0012	0.0007
Low	0.0028*	0.0025*	0.0009	0.0006
Rural/Urban				
Urban	0.0039*	0.0040*	0.0007	0.0009
Town/fringe	0.0021	0.0019	0.0014	0.0015
Village	0.0027*	0.0022*	0.0017*	0.0014*
Type of link				
New link	0.0049**	0.0056**	0.0025**	0.0022**
Existing link	0.0021*	0.0024*	0.0006	0.0007
Scheme funder				
National Highways	0.0032*	0.0049	0.0009	0.0012
Local Major	0.0025*	0.0037	0.0029**	0.0027**

Source: HM Land Registry, VOA, Ipsos analysis. '*', '**', and '***' indicates whether the estimated coefficient was significant at the 90, 95, and 99 percent level of confidence respectively.

10 Logic model refinement and considerations for future work

This final section sets out a detailed description of the changes made to the initial logic model through based upon the econometric work completed. Issues for consideration in future work are also included here.

10.1 Logic model

The original EPIRE logic model was primarily developed to organise the econometric work by providing a logically coherent framing for the investigation. As such, it sought to identify key aspects of the impact pathways for road enhancements in what is a highly complex set of relationships.

The case study component of this study has allowed these complex inter-relationships to be examined in greater detail, including addressing aspects of pathways to impact that do not lead themselves to econometric analysis, but that are important to understanding these types of economic impact. The purpose of this part of the report on the econometric work is to:

- Consider the econometric results explicitly in the context of the initial EPIRE logic model, in so doing helping to place these results into this analytical framework.
- Identify any major omissions in the initial logic model that relate to econometric analysis.
- Briefly discuss the interface between this econometrics-oriented framing and the broader set of considerations pertaining to how road enhancements boost local economic performance - in effect establishing a link between the econometric and case study work.

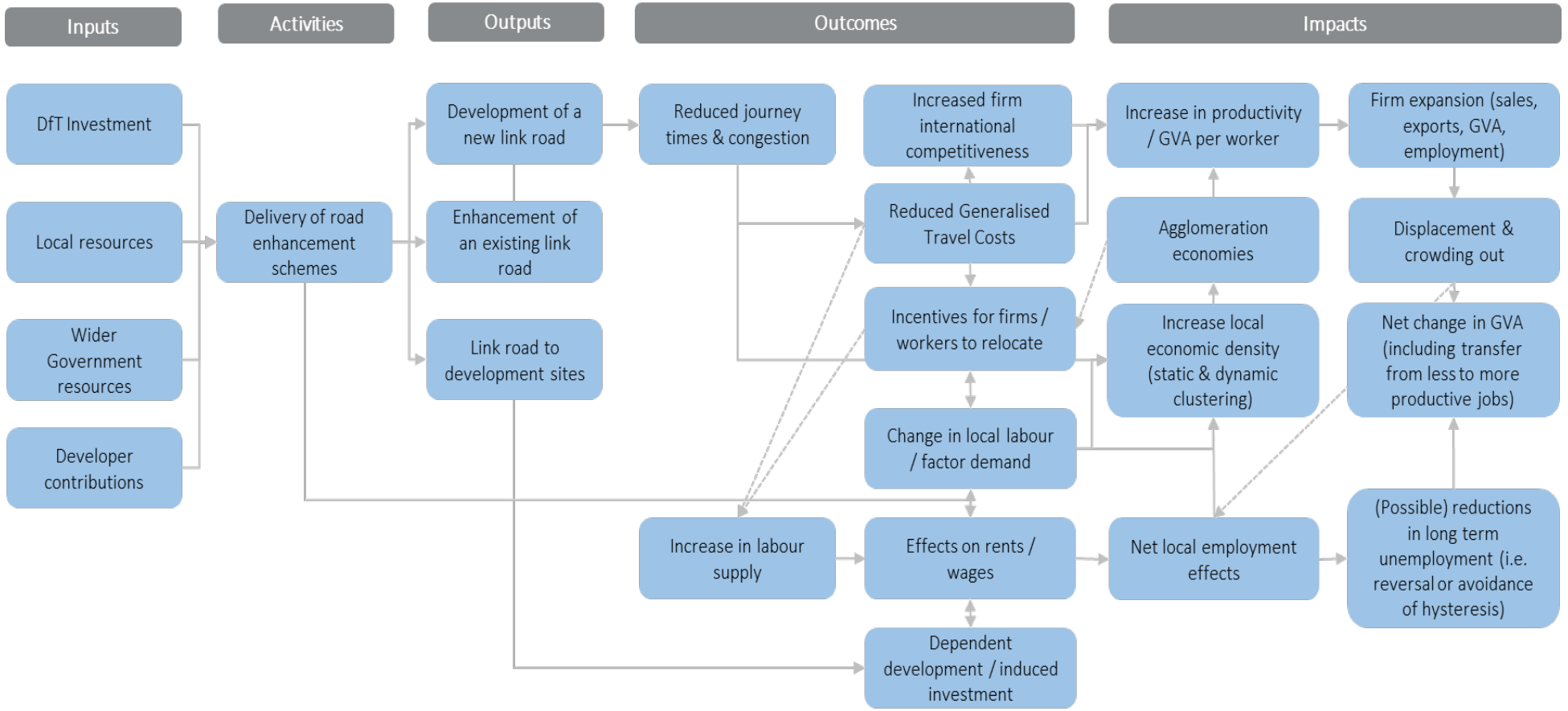
The initial logic model is provided below (see Figure 9.1) followed by an annotated version (Figure 9.2) that highlights the key findings from the econometrics in regard to the strength of causal effects identified and also draws attention to any missing causal components that emerged from the econometric work. The annotated version contains letter and numbered annotations that are discussed in more detail in the narrative that follows.

It is important to note, as caveats, that:

- the effects identified are limited to a 30 km distance from the scheme, there may be more spatially pervasive effects but these have not been examined;
- the analysis has revealed more nuanced differences in sectoral impacts that would overly complicate a general logic model (manufacturing, transport and storage sectors and to a lesser degree, the construction sector) that dominate industrial benefits, and;
- the type of scheme matters; only new road links appeared to encourage the spatial reorganisation of firms;

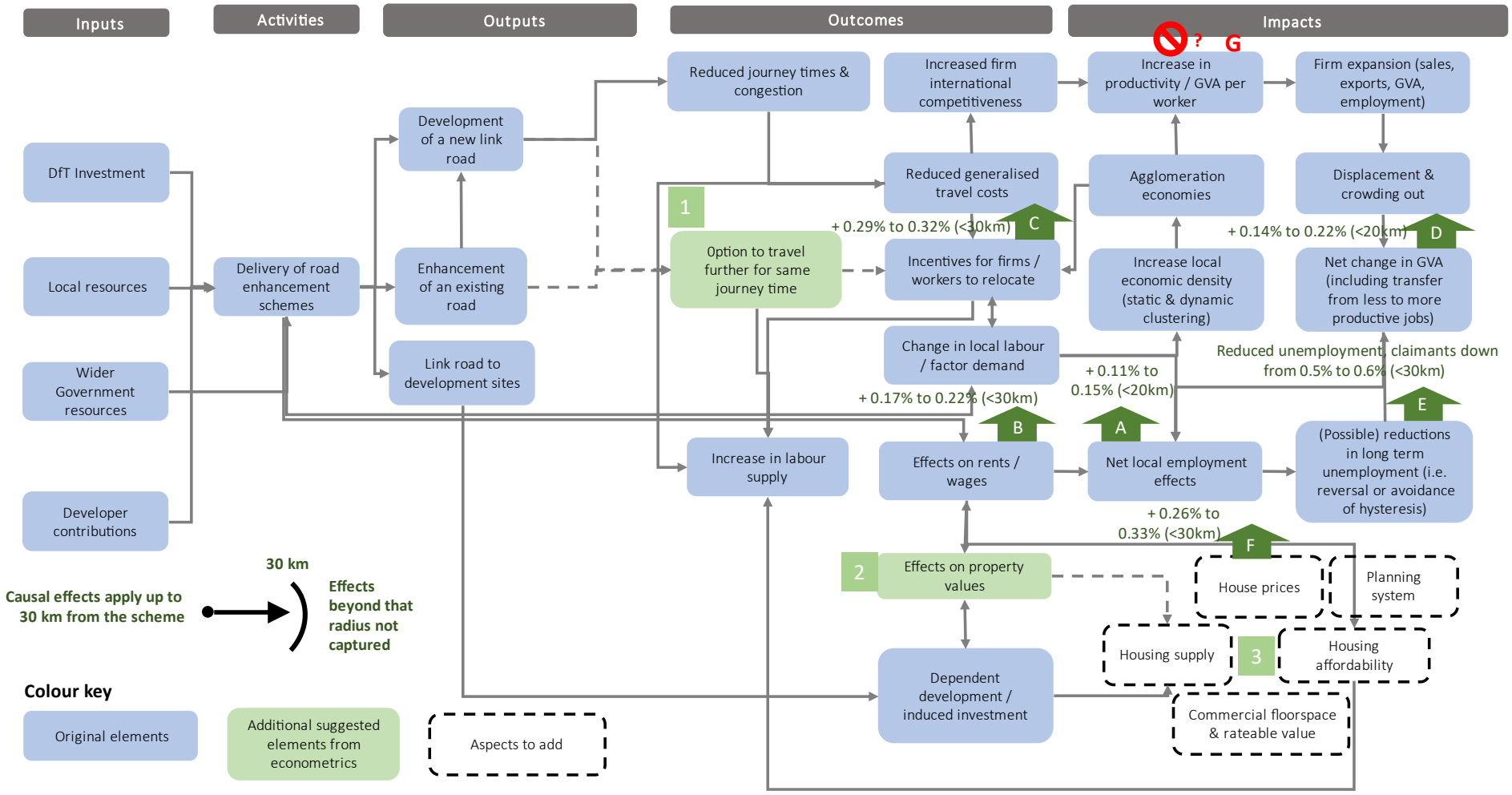
- more (labour) productive areas benefit more than less productive areas.

Figure 10.1: Initial EPIRE logic model



Source: Ipsos

Figure 10.2: Annotated EPIRE logic model highlighting key findings from the econometrics



Source: Ipsos

Key findings in the logic model context

In general, as discussed earlier, the results confirm the expected economic impacts in the key variables except for GVA per worker. Specifically (with reference to the logic model elements):

- [A] Employment increases by between 0.11% and 0.15% up to 20km from the scheme.
- [B] Wages increased by between 0.17% and 0.22%, also up to 20km from the scheme.
- [C] The relocation of residents is picked-up, with the resident population of areas within 30km of schemes increasing by 0.29% to 0.32% in response to improvements in road connectivity.
- [D] GVA increased by between 0.14% and 0.22% up to 20km from the scheme.
- [E] Small reductions in unemployment were also identified up to 20km from the scheme (claimants reduced by between 0.5% and 0.6%).
- [F] The inclusion of an examination of house price effects addressed aspects not made explicit in the initial logic model. Housing in especially important because it impacts on local labour supply (an important issue outside of major urban areas), see [2] and [3] below for a more detailed discussion of this aspect. We observed house price increases between 0.26% and 0.33% up to 30km from the scheme (plus expected close proximity house price reductions adjacent to the scheme).
- [G] No significant effects on GVA per worker were identified. As noted earlier, one possible explanation may be that road enhancements produce positive improvements in economic efficiency that are capitalised into higher land prices and rental values owing to other constraints preventing property markets from responding to price signals. It should also be noted that these findings do not capture effects on the productivity of road users whose operations may be far from road enhancements (such as national logistics operators).

New components that may need adding:

[1] The findings on urban concentration - rural dispersion effects indicate that the logic model would benefit from an explicit consideration of the implication of how road improvements can make it possible to travel further for the same journey duration, rather than only considering journey time reductions. This reflects the importance of our finding that, by implication, agglomeration-related urban advantages that concentrate benefits and amenity-based rural benefits that disperse benefits are leading to a bifurcation in spatial impacts. There is no evidence of growth impacts (positive or negative) on suburban zones and smaller towns. This means that improvements to road infrastructure appear to reinforce - rather than rebalance - existing patterns of economic development and may not be effective in stimulating growth in lagging areas.

[2 & 3] As noted above, housing provision and commercial floorspace and the rateable value of commercial floorspace play an important role in pathways to impact in this context, especially via labour supply (via housing). Consequently, it would be useful to incorporate this aspect in

the EPIRE logic model moving forwards. Key components to consider are how road enhancements affect housing supply, the effectiveness of the planning system in facilitating housing developments, effects on house prices and housing affordability (the latter influenced by local wage changes). This is likely to add a distinct and important sub-system to the EPIRE logic model. Figure 4 suggests one way of adding this element for residential housing. Commercial floorspace could be added in a similar manner in order to draw-out business activity and investment attraction aspects.

Other comments and observations

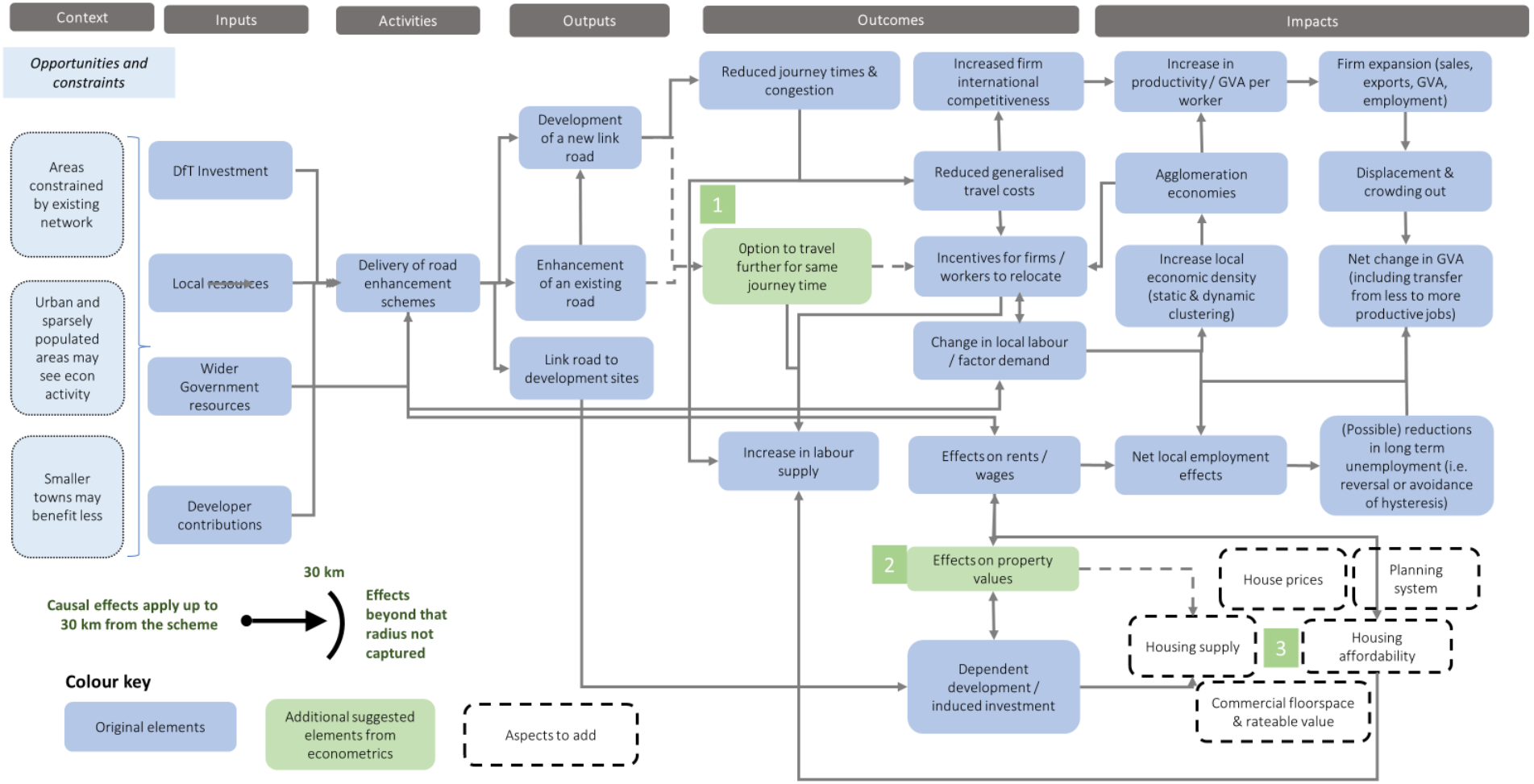
As expected, there are clear spatially dependent causal relationships. Employment and GVA effects (at up to 20km) are the most spatially concentrated whilst re-location, wages and house price effects are picked up out to 30km from the scheme. If/when the impact of road enhancements in providing the option to travel further for the same journey time are incorporated, then this opens-up a potentially important link with functional economic geographies (which are defined by the commuting radius) and, therefore, an 'intensive margin' versus 'extensive margin' dimension. Specifically, impacts within a given spatial area and an extension to the functional economic geography respectively.

Given that the analysis has revealed a range of more nuanced impacts (sector, type of scheme) logic model evolution will need to reflect these differences and will therefore need to be more complex. One practical solution would be for DfT to develop an interactive online version of the EPIRE logic model that allows the user to specify the type of scheme and sector(s) of interest and, in so doing, generating the relevant set of key expected causal impact pathways. Such an interactive logic model could be of use in informing future business cases. This would help to overcome the 'average effects for the average place' challenge (once the necessary additional data on different contextual factors and their consequences for economic performance impacts is included). Indeed, an interactive tool of this type could also be used to highlight potential barriers and impediments to benefits realisation post-investment. For instance, the market processes that can result in potential GVA per worker impacts not eventuating, [G] as discussed above. This function could help to maximise returns-on-investment by anticipating and acting to reduce such impediments in areas not currently considered by business cases.

Finally, the econometric analysis has highlighted the importance of adding the scheme context to the logic model. The results tell us that there are some key conditions that shape economic impacts: (a) the existing road network must be acting as a constraint to economic activity, (b) the effects will be strongest when the local area spans urbanised and sparsely populated places (creating the conditions for urban concentration - rural dispersion effects), this means that smaller towns tend not to experience significant economic benefits. Given that traditional good practice is to include the context and the rationale in an intervention logic model, these results point to the importance adding the Context into the logic model (the rationale is also addressed in effect by doing this when framed in this manner), see Figure 9.3. If, in the future, an interactive online version of the EPIRE logic model were to be developed, a classification reflecting different types of investment context/type of local economy could be especially useful.

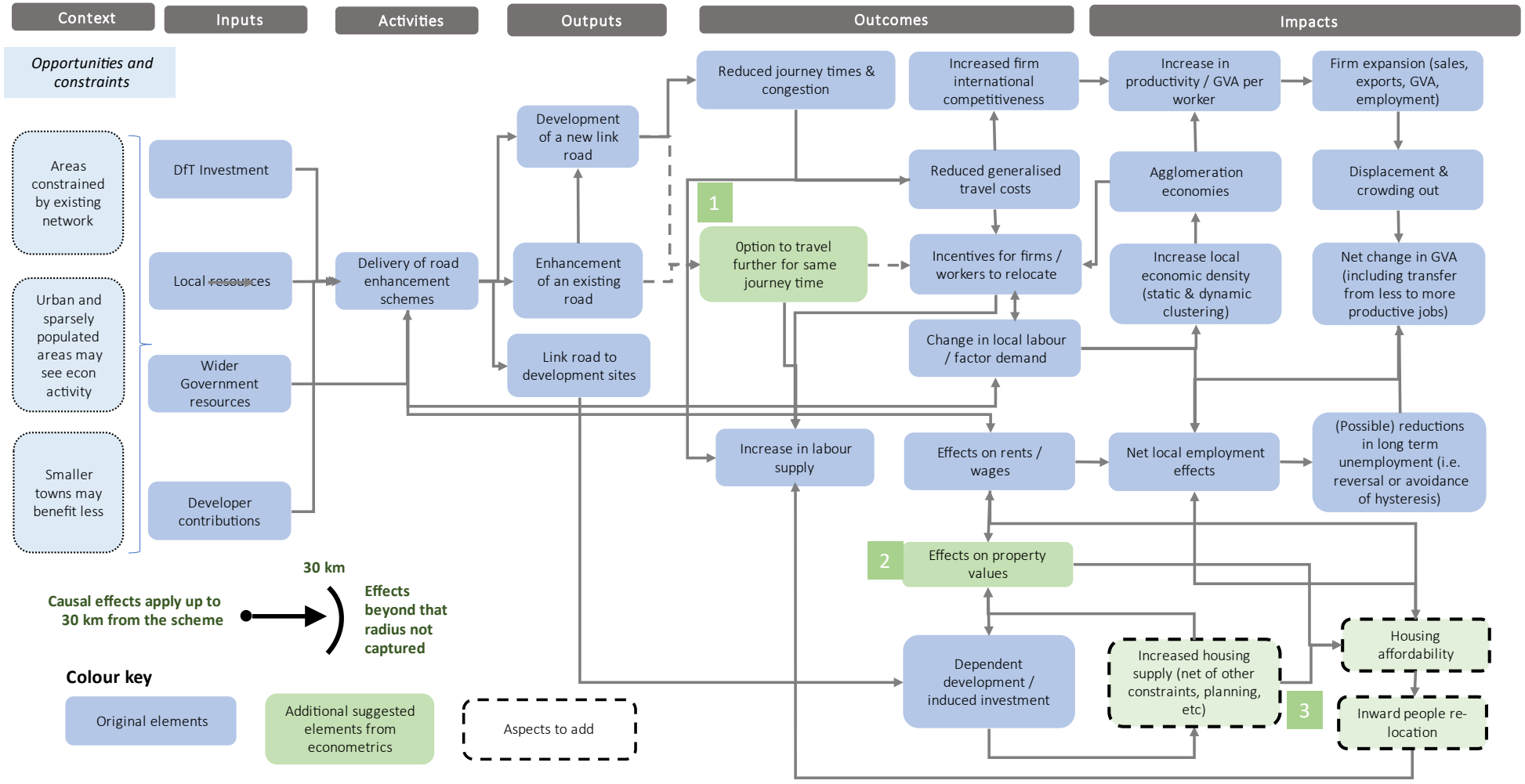
Building upon the econometric analysis, the case study workstream in this study takes a closer look at the context dimension and also considers additional aspects relating to how road connectivity impacts on innovation activities and participation in spatially extended supply chain systems. These are aspects that can have economic impacts independently from spatially localised ‘distance-decay’ effects. Given that the econometric analysis has examined ‘average affects in an average place’, a contextual analysis, and in particular, efforts to develop an analytical taxonomy for characterising different types of local economy informed by a modified logic model could help to improve future road investment business cases. This challenge is addressed in the case study discussion. Of course, it is also important to also consider potential future changes in behaviours that may lead to future impact pathways being different from the historical patterns identified in the econometric analysis. This is also addressed in the case study workstream.

Figure 10.3: Adding the Context to the logic model



Source: Ipsos

Figure 10.4: Indication of how the housing - workforce aspects can be included in the logic model



Source: Ipsos

10.2 Issues for consideration in future work

The purpose of this concluding section to the report on the econometrics is to discuss the implications of the econometric finding for future analyses at a more general level. The accompanying Lessons Learned report addresses the more specific aspects in greater detail in order to inform future econometric and case study work.

10.2.1 GVA per worker

The behaviour of GVA per worker is one key area for further exploration. This is the only aspect of the economic impacts for which we failed to find a statistically significant effect. On further examination via the events analysis using staggered DiD analysis, the indication is that there is in fact an initial increase in labour productivity, but that this subsides over the first seven years after scheme opening. As a result, the overall impact on GVA per worker over the entire timeline we examined is not statistically significant.

Whilst GVA and employment also exhibit a similar time-profile of diminishing effects, they both end-up (at least over the ten-year period post scheme opening covered by the analysis) at higher levels than prior to scheme opening. Consequently, the behaviour of GVA per worker constitutes a potential puzzle. When considering this finding, it is useful to bear in mind the fact that road investment business cases typically use a 60-year appraisal period (the assumed asset lifespan). This leaves ample scope for road enhancements to generate longer-term labour productivity impacts that the EPIRE econometrics have been able to capture.

Given this long-term context, one potential explanation, which can be framed as a hypothesis (see below), is that the initial post-opening stimulus to GVA per worker sets in train second order effects associated with knock-on impacts on local service sector businesses with lower labour productivity. This means that this beneficial economic impact ‘dilutes’ aggregate GVA per worker performance – but reflects economic benefits that include reducing unemployment (especially in lower skilled occupations). This hypothesis is informed by experiences gained from local economic development strategy and delivery work, which highlights the importance of a local economic ‘ecosystems’ associated with small independent services businesses.

- Hypothesis: the local economic stimulus created by road enhancements drives a ‘broadening-out’ of the local mix of businesses as a second-order effect. Local economies are ecosystems in which there is a symbiotic relationship between dynamic high-productivity firms (especially manufacturing) and the low productivity businesses that make for a pleasant and attractive place to live and work: cafes, restaurants, hairdressers, grocers and a range of local shops. For this latter business segment, their retail offer is based on the fact that they are traditional labour-intensive services and therefore low productivity. Indeed, their business model is based on not using modern technologies (if available), so their competitiveness pivots on deliberately using older vintages of technology (e.g. employing a barista not a self-service machine). This creates more vibrant and resilient local economic ecosystems with strong employment multipliers able to decrease unemployment because the employment opportunities tend not to be highly skilled in the sense of requiring extensive training and education. So, this implies that after an initial GVA/worker boost that metric will settle down to

a new equilibrium as the average ratio starts to reflect these second-order business diversity effects.

Crucially, the existence of this local ‘cosmopolitan’ low productive business segment can be a key inward investment attractor. For example, a high-tech global firm will avoid setting up a facility of there isn’t this type of vibrant cosmopolitan local economy. This means that there is the potential for third-order effects of a longer-term nature (such as attracting a high-tech R&D facility).

Consequently, the overall chain of causality is long-term, dependent on the second-order effects associated with ‘trickle down’ to local services businesses, and the manifestation of third-order effects will be contingent on a range of enabling ‘strategic fit’ considerations such the quality of natural environment, planning system, housing availability etc that the third order effects require.

The validity of this hypothesis can be tested by a closer examination of the SIC breakdown of GVA, employment and GVA per worker, and also (if possible) occupational shifts. Note: the potential third order effects are likely to manifest themselves over a longer timeline that ten years post opening, however the data used to test the second order effects in the hypothesis may also be able to identify and benefits of this type (but will only be possible for older schemes).

The following table brings together a set of hypotheses with the potential to explain the productivity puzzle. It would be useful for DfT to consider this set of hypotheses as a draft list and add any missing hypotheses in order to provide a comprehensive list for use in future work of various types.

Table 10.1: Potential hypotheses to explain the productivity puzzle

Unlocking latent demand via reduced congestion that attracts further traffic results in dissipation of the initial GVA/worker increase due to positive local growth impacts	**Hypotheses:** An initial boost to GVA/worker associated with the road enhancements results in positive knock-on effects as additional latent demand is stimulated via reduced congestion that boosts local economic performance **Comments:** This hypothesis indicates that there may be broader and more positive effects as second-order consequences which induce traffic beyond aspects modelled in current investment appraisals
Improvements in economic efficiency are capitalised as higher land prices and rental values due to constraints to property supply responses	**Hypotheses:** Road enhancements produce positive improvements in economic efficiency that are capitalised into higher land prices and rental values owing to other constraints preventing property markets from responding to price signals **Comments:** As regards the GVA/worker productivity puzzle specifically this hypothesis relies on more complex indirect relationships between overall business Total Factor Productivity and labour productivity.

Inward relocations bring down the average GVA/worker value	**Hypotheses:** Incoming firms previously had lower productivity and are moving to areas which enable them to increase their own productivity. However, those new levels of productivity, on average, are not higher than the average for the area they are moving into. **Comments:** Relies on there being a sufficient number of inward re-location firms to influence the average GVA/worker value (an effect only associated in the results with new road links).
Inward relocations are unable to boost the average GVA/worker value	**Hypotheses:** Incoming firms simply do not account for a sufficient share of the local economy to shift the average. **Comments:** If all of the productivity gains are disappearing in the form of higher rents, why would incoming firms go to the expense and risk of relocating?
The average GVA/worker value boost generates beneficial second order effects that 'round out' local economies but reduce average GVA/worker	**Hypotheses:** GVA/worker declines after an initial boost as it is 'diluted' by a broadened lower labour productivity segment as the local economy experiences 'trickle down' effects to local firms. **Comments:** Under this scenario the long-term economic impact of road enhancements will be in more 'rounded' and resilient local economies more able to attract future inward investment and business inward re-location due to a more cosmopolitan business ecosystem.
Tightening of labour market leads to hiring of less productive workers	**Hypotheses:** As labour markets tighten in the years after scheme completion, firms are forced to hire less productive workers and so gains in productivity are eroded. **Comments:** Requires there to be an insufficient number of productive workers in areas surrounding schemes. Is supported by relatively low unemployment rates over recent years.
Employing new workers to meet demand reduces average GDP per worker in the local economy	**Hypotheses:** Businesses need to employ new workers to respond to increased demand, but labour supply characteristics mean that this requires less productive workers to be hired at the margin. **Comments:** This hypothesis requires GVA increases to be sustained alongside GVA per worker performance.

10.2.2 Supply chain connectivity.

The results for firm location changes suggest that (as expected) road enhancements lead to employment, turnover and GVA increases associated with exploiting improved road connectivity. This effect is particularly strong for manufacturing, transport and storage businesses. As the main focus of the econometric work has been on distance-decay and accessibility aspects, we have not been able to capture the economic impacts associated with improved extended supply chain connectivity. Supply chain connectivity impacts take place because better 'close proximity' roads allow businesses for which extended (non-local) supply chains are important to benefit from access to the strategic road network, and any inter-modal transport benefits. Whilst road investment business cases do pay attention to these more systemically driven benefits this is not currently matched by evaluation studies (including EPIRE 1.0). It would therefore be useful for follow-up work, to consider this supply chain connectivity

dimension. Indeed, the case study work carried out in this study has examined the supply chain aspect and has demonstrated that it is possible to either collect such data (via survey work) or, potentially, access new datasets that trace business-to-business (B2B)supply chains via financial payments tracing.[22] The use of such data would go a long way towards addressing this limitation, in so doing enriching future evaluations.

10.2.3 Housing, property and labour supply

Given the importance of housing and labour supply effects, and also commercial floorspace availability, as highlighted section 9 above on implications for the logic model, it would be useful for future econometric work to have a stronger focus on these aspects. This may require spending on commercially provided data sources that were not used in EPIRE 1.0. A strengthened analysis of these aspects would be of particular relevance to non-urban economies, and heavily rural economies in particular – where labour supply constraints can inhibit growth.

10.2.4 Regionalisation and sub-group analyses

EPIRE 1.0 focussed on the average effects for the average type of scheme for an average type of local economy. This 'vanilla' approach was a sensible first step given the complexity of the issues being considered (as evident in this report). The utility of these historical analyses in informing future business cases would, however, be improved if future econometric studies applied some segmentation to the different types of local economy in which road investments will be made in regard to industry structure, workforce characteristic, geographical characteristics and location in the strategic road network. This segmentation would help to close the feedback loop between *ex post* evaluation and *ex ante* appraisal, helping to improve predictive accuracy in business cases.

Making progress on this aspect will require the development of a suitable taxonomy for categorising different types of road investment context optimised for future econometric analyses. The work done in EPIRE 1.0 on more complex logic models, can inform this taxonomic work. The key success factor here will be to base the segmentation on available data sources that can be used in the econometrics.

It might also be useful to explore the use of a regionalised growth accounting framework that de-composes measured changes in GVA into its constituent change drivers using a familiar growth accounting identity framing (including total factor productivity) and related interactive effects between these growth drivers. It would be particularly useful if any such regionalised growth accounting framework explicitly addressed the spatial dimension as this will allow the

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[22] These new datasets use data from commercial providers on BACS and CHAPS payments to trace supply chains. The ONS is currently working on experimental data on inter-regional trade using such data. See< Industry-to-industry payment flows, UK - Office for National Statistics (ons.gov.uk)

ways in which road enhancements can increase the size of functional economic areas/geographies via workforce commute time reductions. This spatial aspect could allow future analyses to distinguish between intensive and extensive margin impacts (impacts in a fixed initial functional economic area and the additional impacts from an extended functional economic area). This spatial aspect could be particularly useful in cases where road enhancements result in functional economic areas expanding to overlap with each other, thus amplifying economic impacts.

In theory, the combination of a taxonomy-based segmentation and the use of a regional growth accounting framework could make a major contribution closing the feedback loop between *ex post* evaluation and *ex ante* appraisal. It would provide a useful comparative framework for improving predictive accuracy in future business cases. It is hard to achieve this improvement in predictive accuracy using average effects for the average type of scheme for an average type of local economy.

10.2.5 Structural changes

It is now widely recognised that the COVID-19 pandemic has helped to drive changes in transport use, or perhaps bring forward in time changes in transport use likely to have happened anyway. An increased uptake of home and hybrid working take advantage of modern information and communication technologies (ICT) capabilities leading to changes in commuting patterns is a stand-out factor here.

Given that EPIRE 1.0 has analysed pre-pandemic era data, it is inevitable that such structural changes may limit the utility of these historical findings for use in closing the feedback loop between *ex post* evaluation and *ex ante* appraisal. It would therefore be useful to consider the nature and extent of potential structural changes of this type. The Ipsos team have developed an initial framework for consulting local authorities on these matters, and a workshop with local authority officers to discuss this challenge is being arranged by the Business Board Network (the successor to the LEP Network). The results from that consultation, conducted on a pro-bono basis outside of the EPIRE project will be fed back to DfT.

It is plausible that our ability to understand the potential implications of these structural changes for future business cases will be assisted if more a segmented taxonomy-based econometric analysis were conducted in a few years' time including data for the first few years of the post-pandemic era (thus allowing a comparison to be made between pre and post pandemic patterns).

10.2.6 Weak signals analysis for noisy timeline events

Looking to the future regarding further analysis of event timelines, a key technical challenge is that quasi-experimental methods and econometric analyses faces the challenge of noisy data that limits statistical significance. Given the potential importance of event timelines to future analyses (evident in the preceding discussion of a potential explanation of the labour productivity puzzle) it would be useful to assess other statistical analysis methods that could be used, (such as Bayesian updating as used in machine learning, intelligence analysis, clinical

research and signal detection analyses (including the analyses of small number events in particle physics)[23]. These types of method are used when decisions need to be made in response to threats (in particular) where acting early can avoid or limit damage/costs. The need to act quickly to address threats means that it will be too late to wait for statistically significant results (by which time the damage may have occurred). Consequently, such methods may be worth exploring as solutions to analysing noisy event studies data.

[23] Such as early work on neutrino detection (where very few observations were available) for details of intelligence applications see the *Handbook of Bayesian Analysis for Intelligence for the CIA* – available at: https://www.cia.gov/readingroom/docs/CIA-RDP86B00269R001100080001-0.pdf. Bayesian applications in healthcare evaluation (often a source of more generally used evaluation methods) are covered in detail in David Spiegelhalter, (2003) *Bayesian Approaches to Clinical Trials and Health-care Evaluation* (Statistics in Practice. Wiley-Blackwell. A well-regarded introduction to Bayesian approaches is: Jaynes, E.T. (1984) *Bayesian Methods: General Background: An Introductory Tutorial*. Paper presented at the Fourth Annual Workshop on Bayesian/Maximum Entropy, Methods, Calgary, August 1984. For applications of Bayesian signal detection methods, widely used in clinical research, see Swets, J.A., Dawes, R.M., Monahan, J. (2000*)* Psychological Science Can Improve Diagnostic Decisions. *Psychological Science in the Public Interest*: A Journal of the American. Psychological Society.

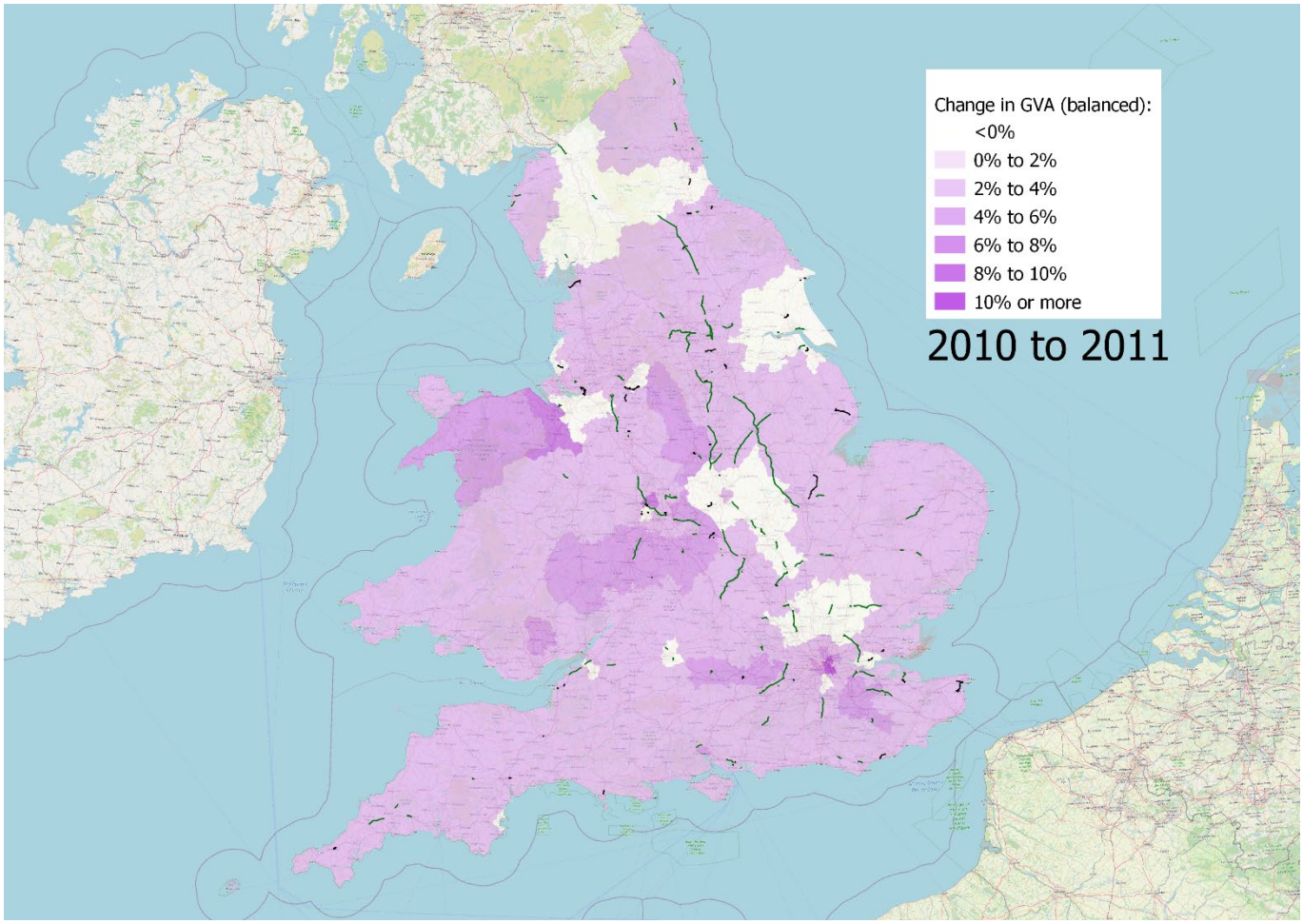
Annex A: Additional mapping work

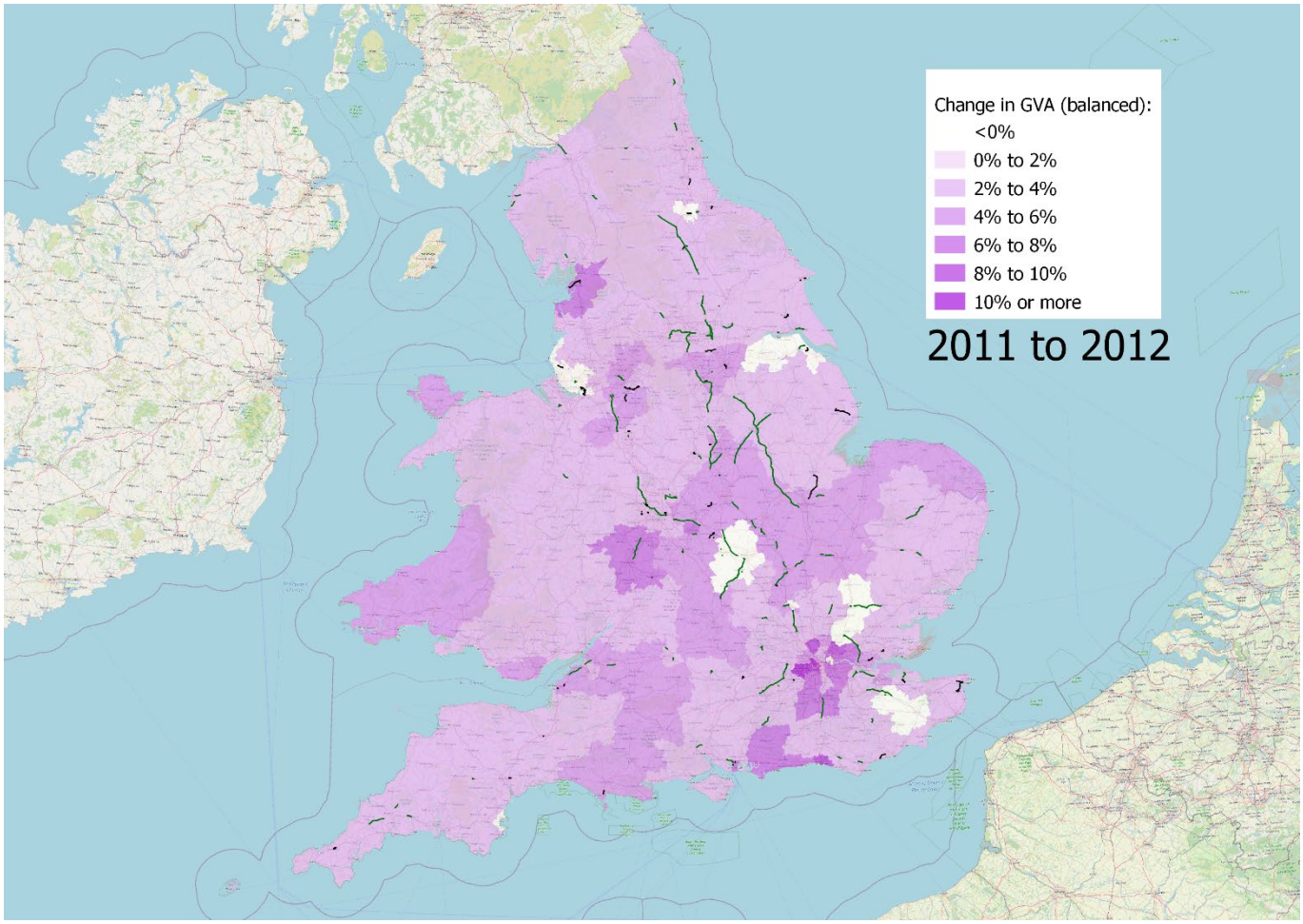
This annex presents some of the additional mapping work completed as part of the evaluation. These informed thinking behind the case study research and aided synthesis of findings but were not critical to the econometric exercise and are presented here for context.

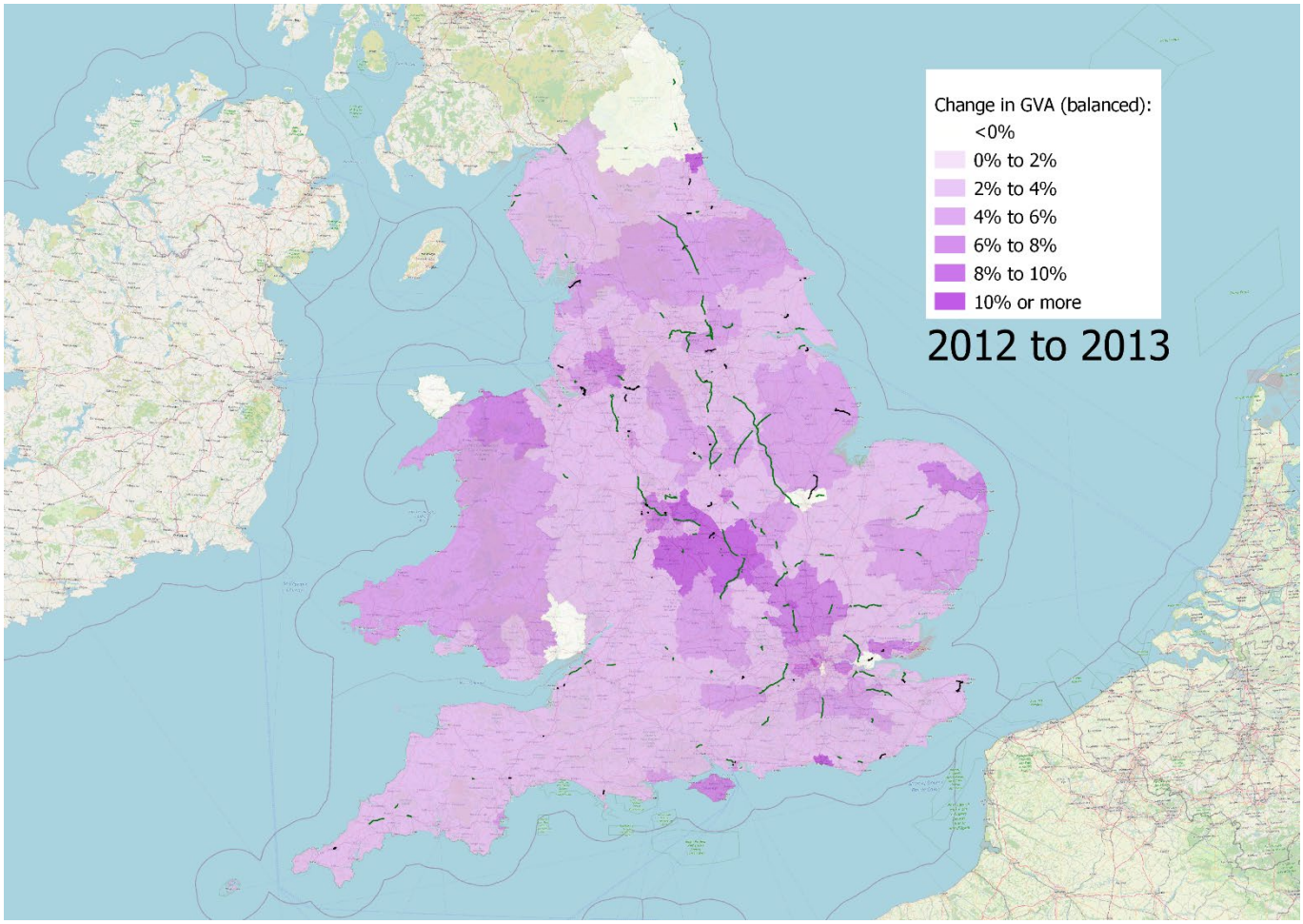
The maps below illustrate changes in key variables across England and Wales between 2010 and 2019 with the road schemes within scope plotted on the map. Simple descriptive analysis of trends did not identify clear patterns at this level of aggregation.

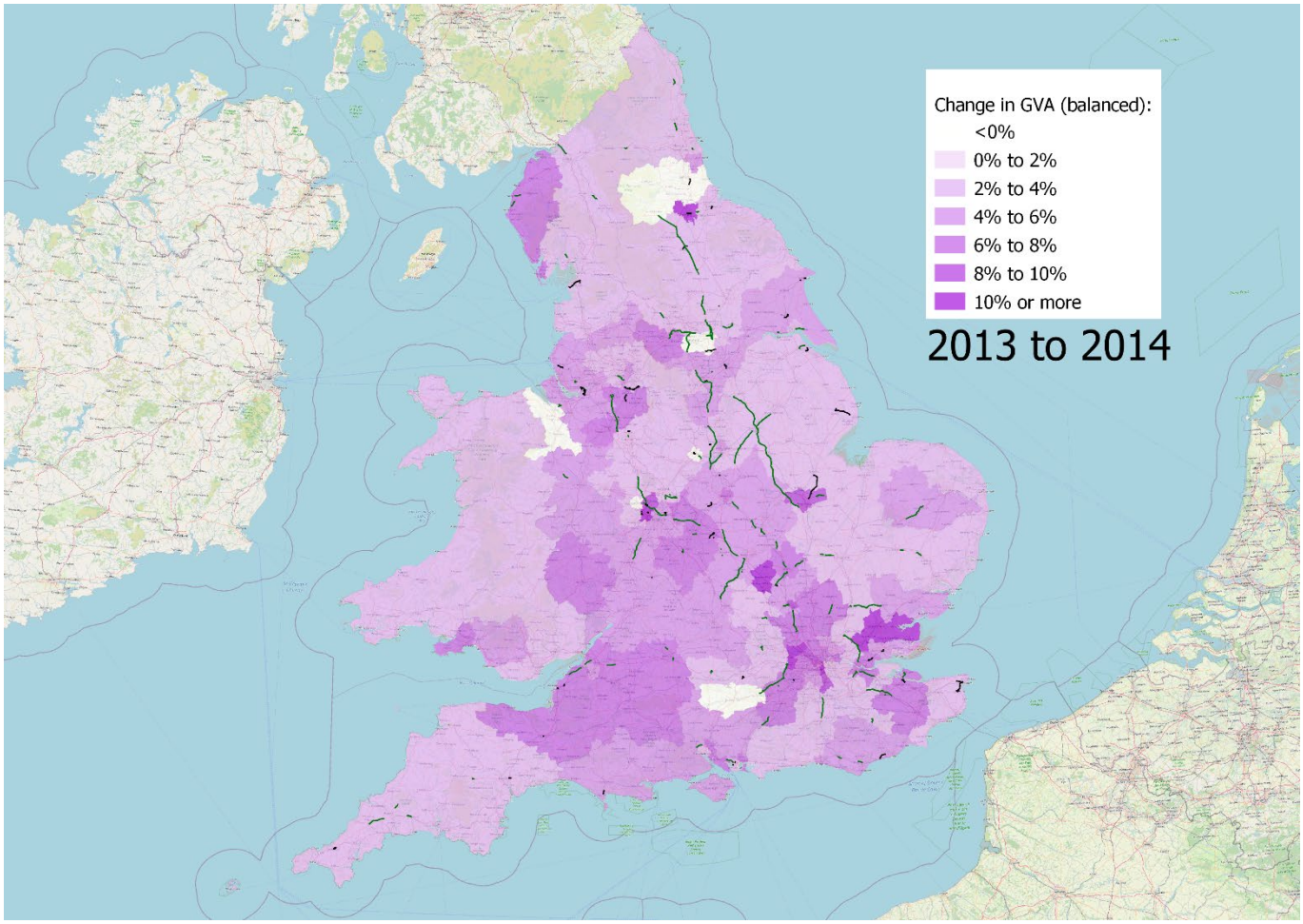
10.3 Changes in GVA

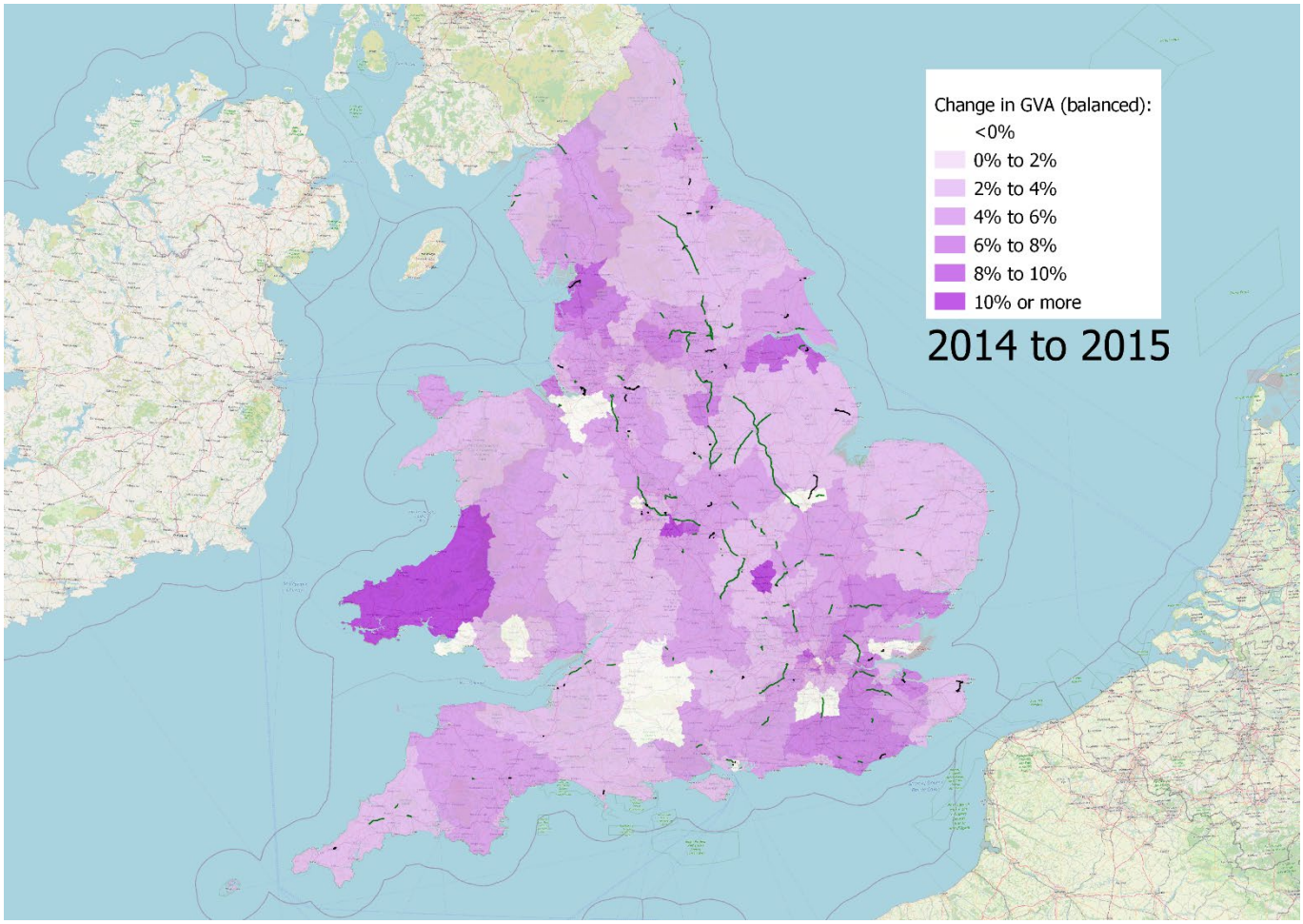
Figure 10.5: Changes in GVA (2010 to 2019)

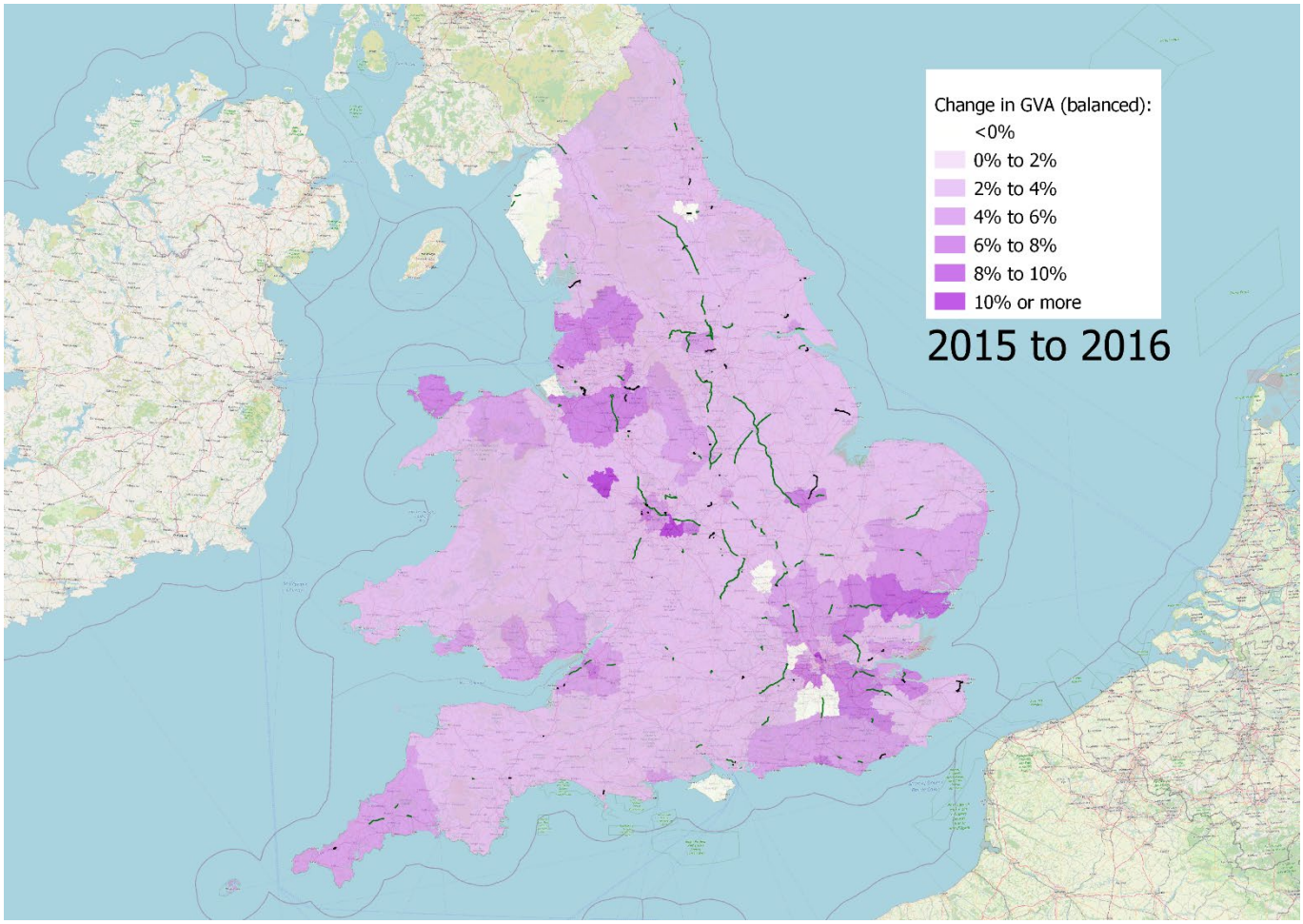


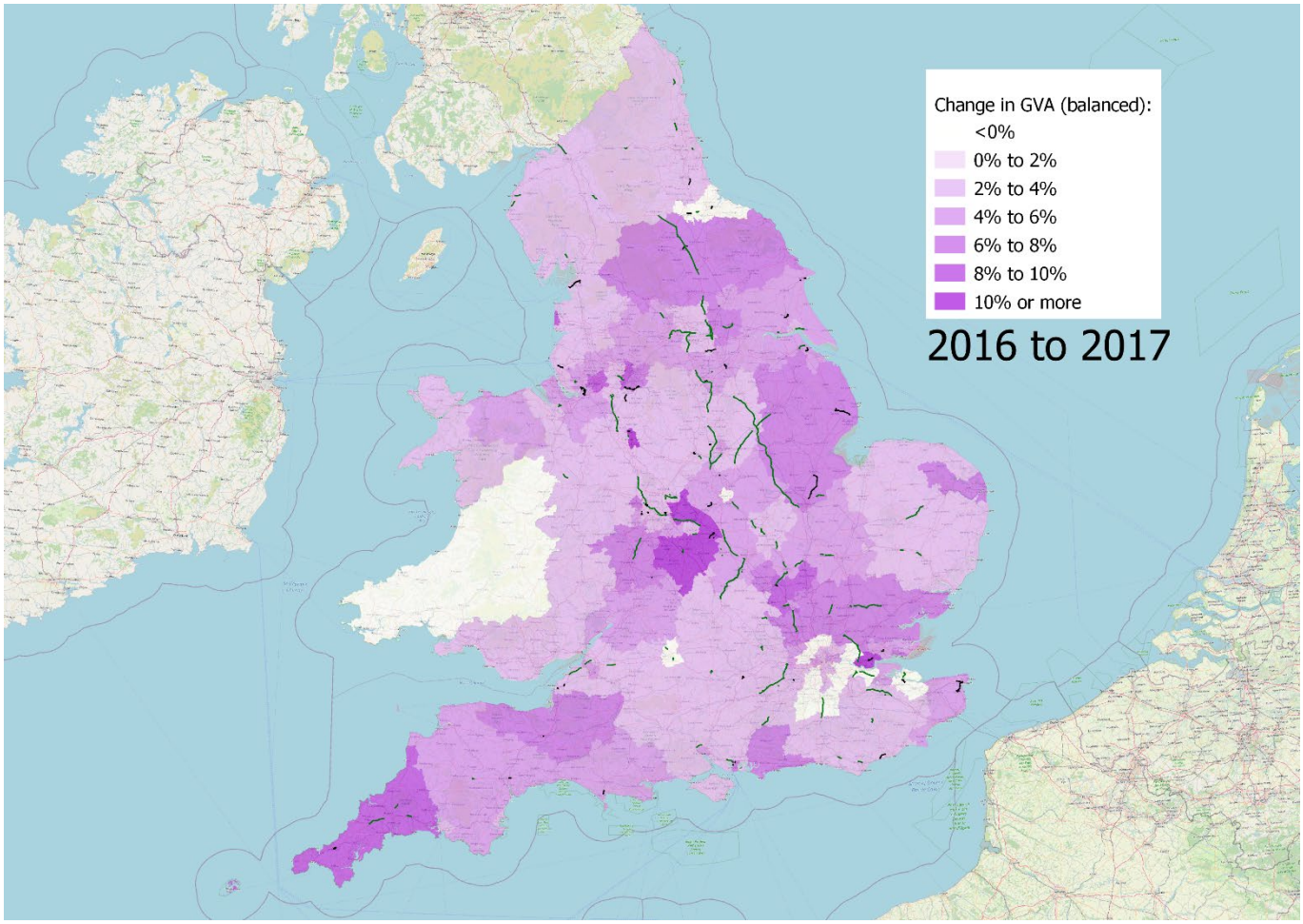

Change in GVA (balanced):
<0%
0% to 2%
2% to 4%
4% to 6%
6% to 8%
8% to 10%
10% or more
2011 to 2012

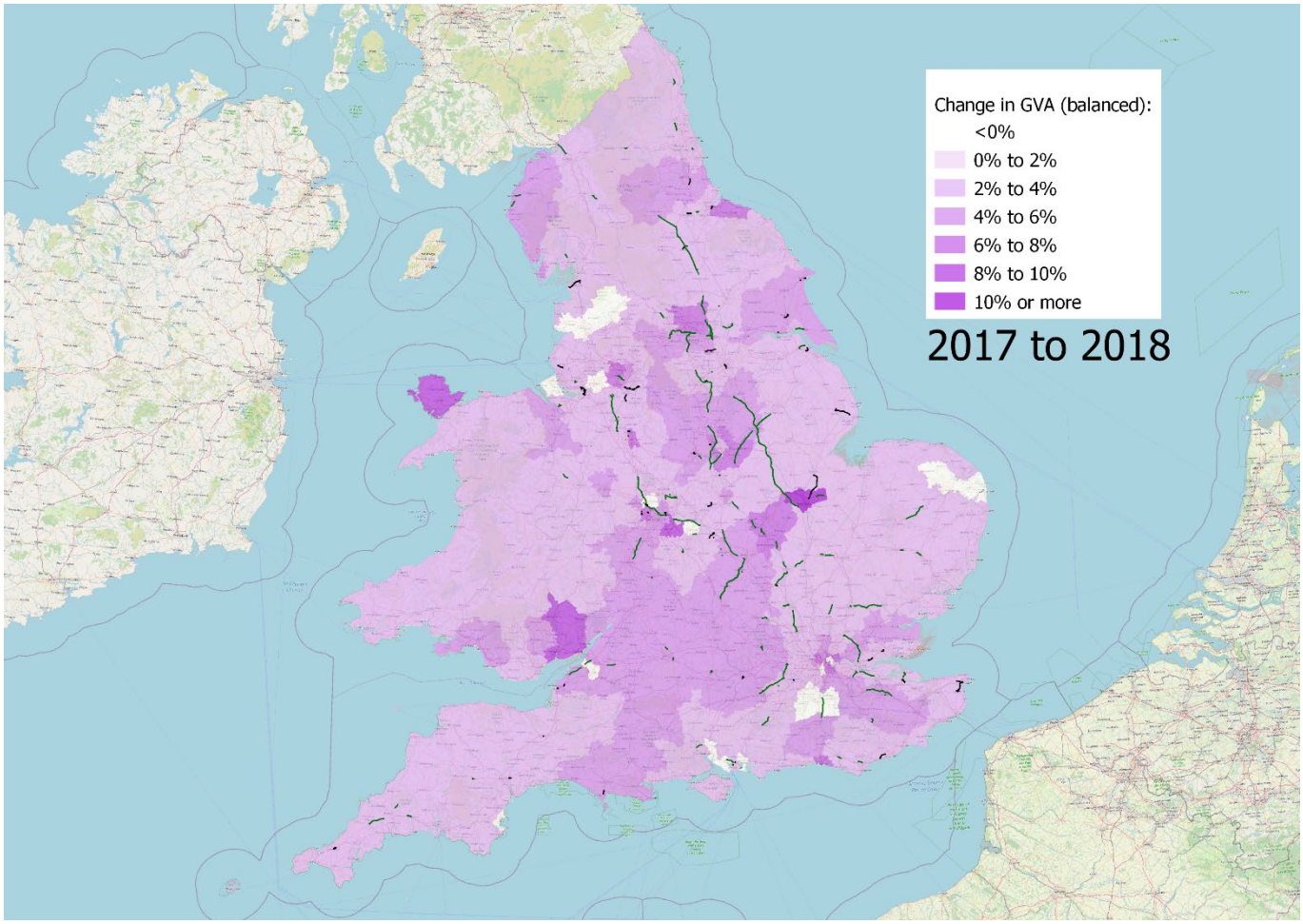

Change in GVA (balanced):
<0%
0% to 2%
2% to 4%
4% to 6%
6% to 8%
8% to 10%
10% or more
2012 to 2013

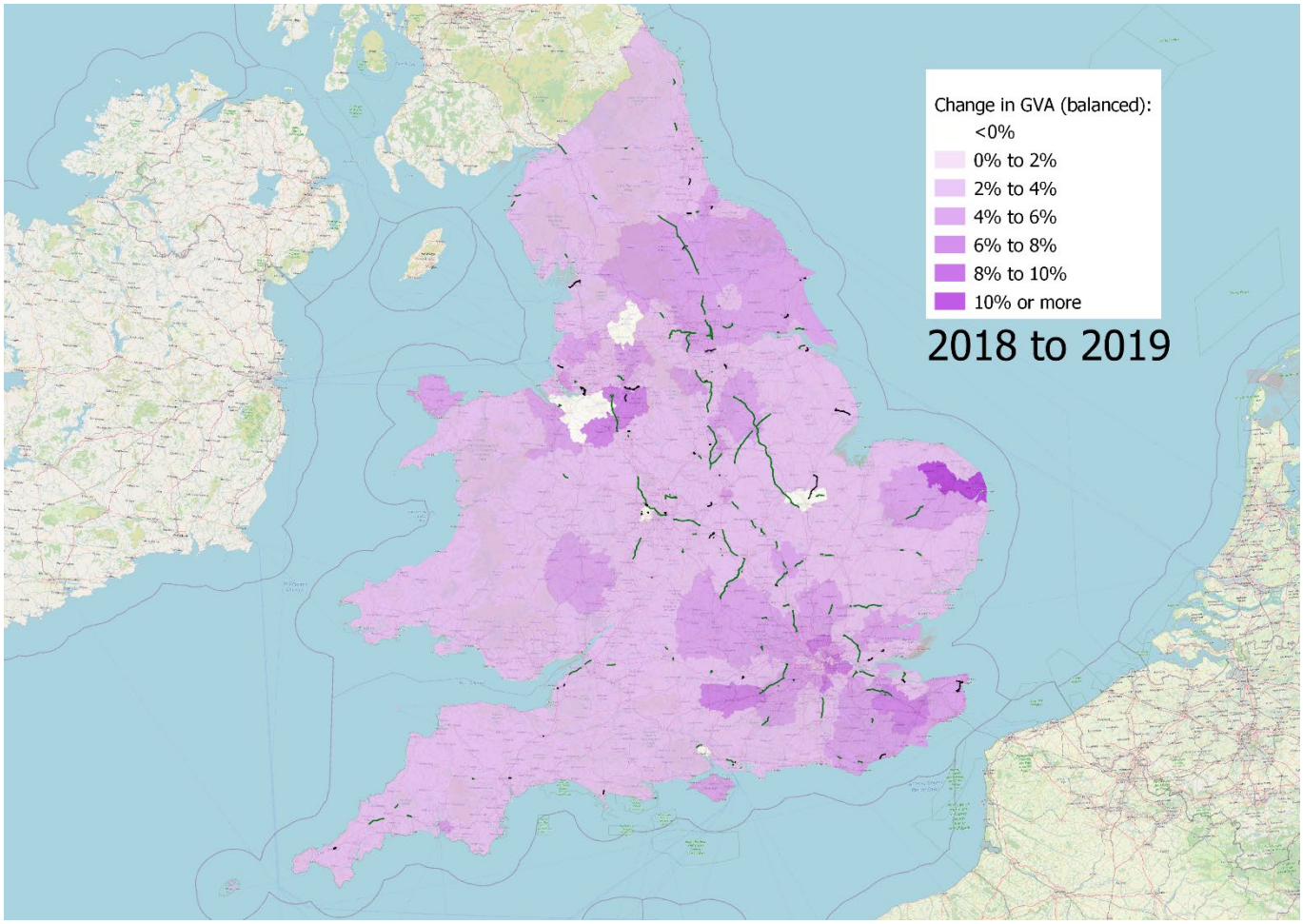

Change in GVA (balanced):
<0%
0% to 2%
2% to 4%
4% to 6%
6% to 8%
8% to 10%
10% or more
2013 to 2014


Change in GVA (balanced):
<0%
0% to 2%
2% to 4%
4% to 6%
6% to 8%
8% to 10%
10% or more
2014 to 2015


Change in GVA (balanced):
<0%
0% to 2%
2% to 4%
4% to 6%
6% to 8%
8% to 10%
10% or more
2015 to 2016

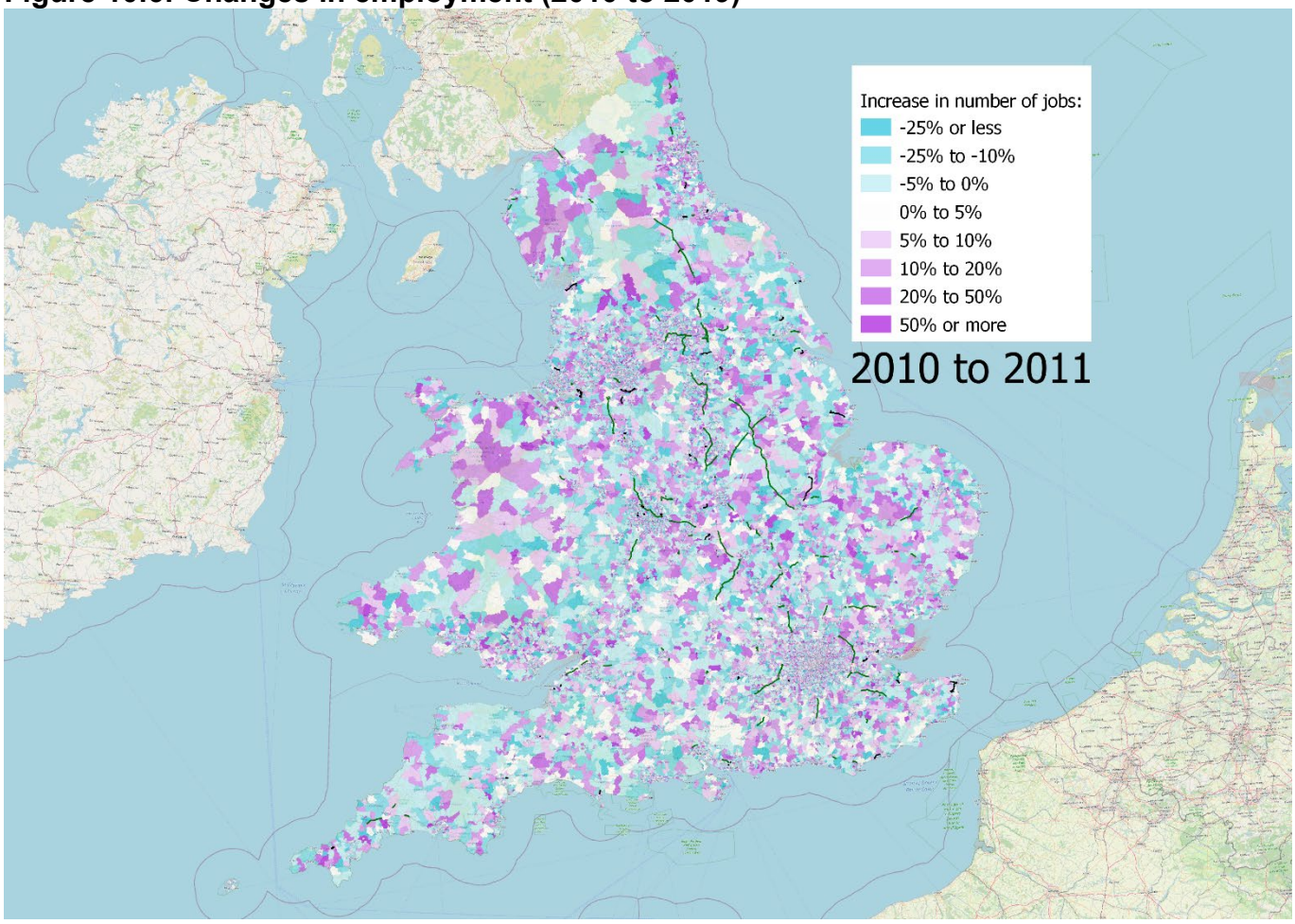

Change in GVA (balanced):
<0%
0% to 2%
2% to 4%
4% to 6%
6% to 8%
8% to 10%
10% or more
2016 to 2017

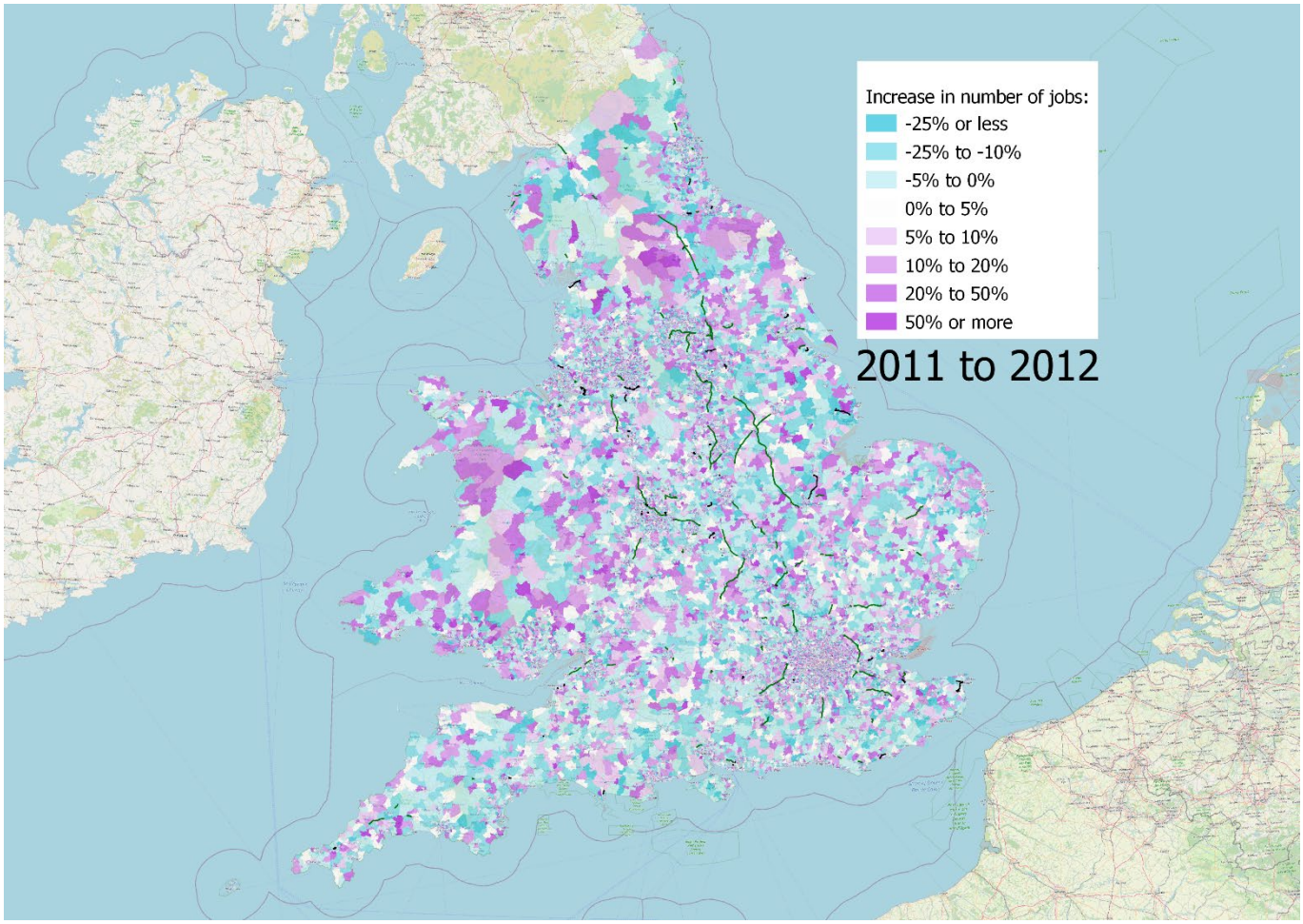

Change in GVA (balanced):
<0%
0% to 2%
2% to 4%
4% to 6%
6% to 8%
8% to 10%
10% or more
2017 to 2018

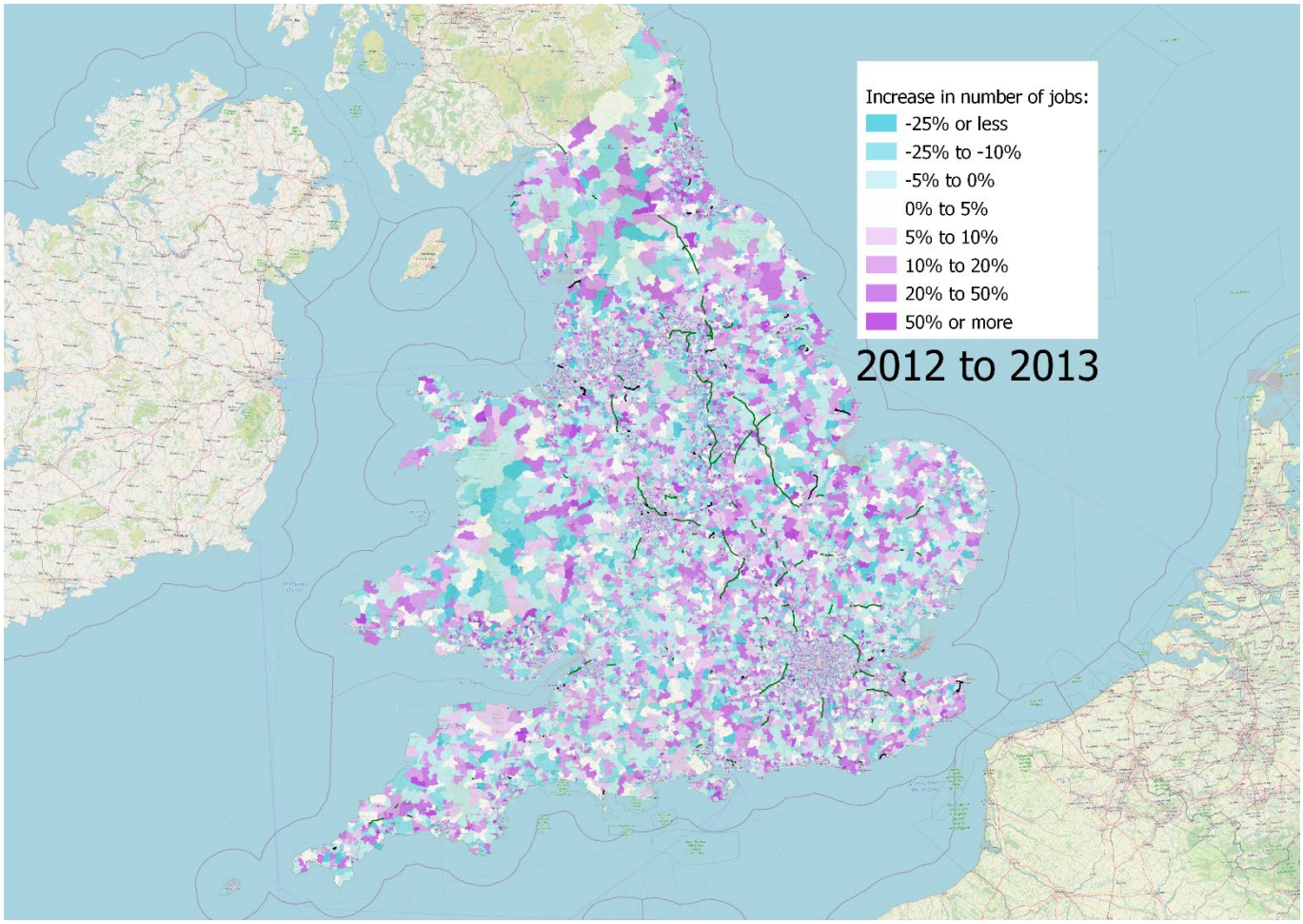


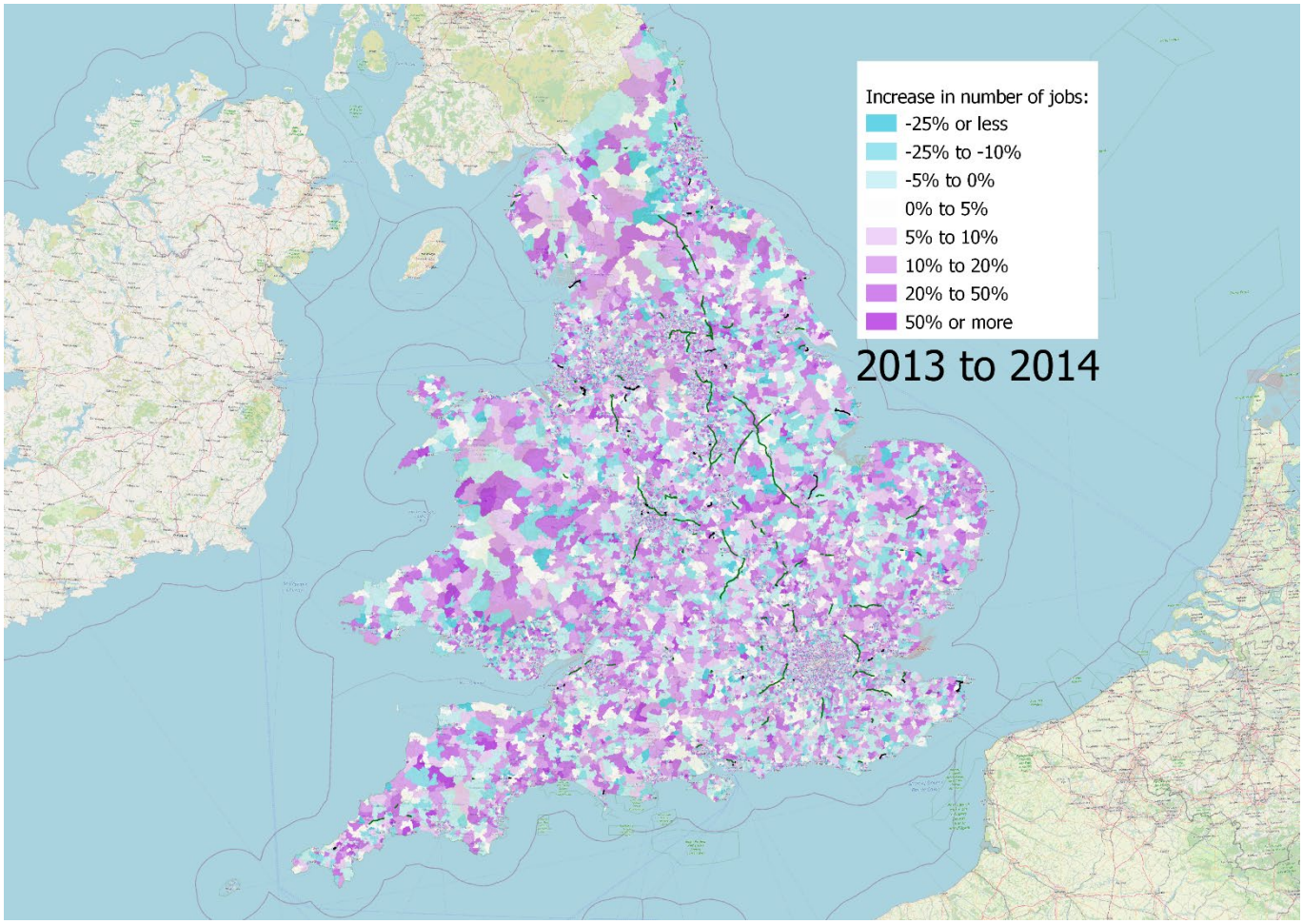
10.4 Changes in employment

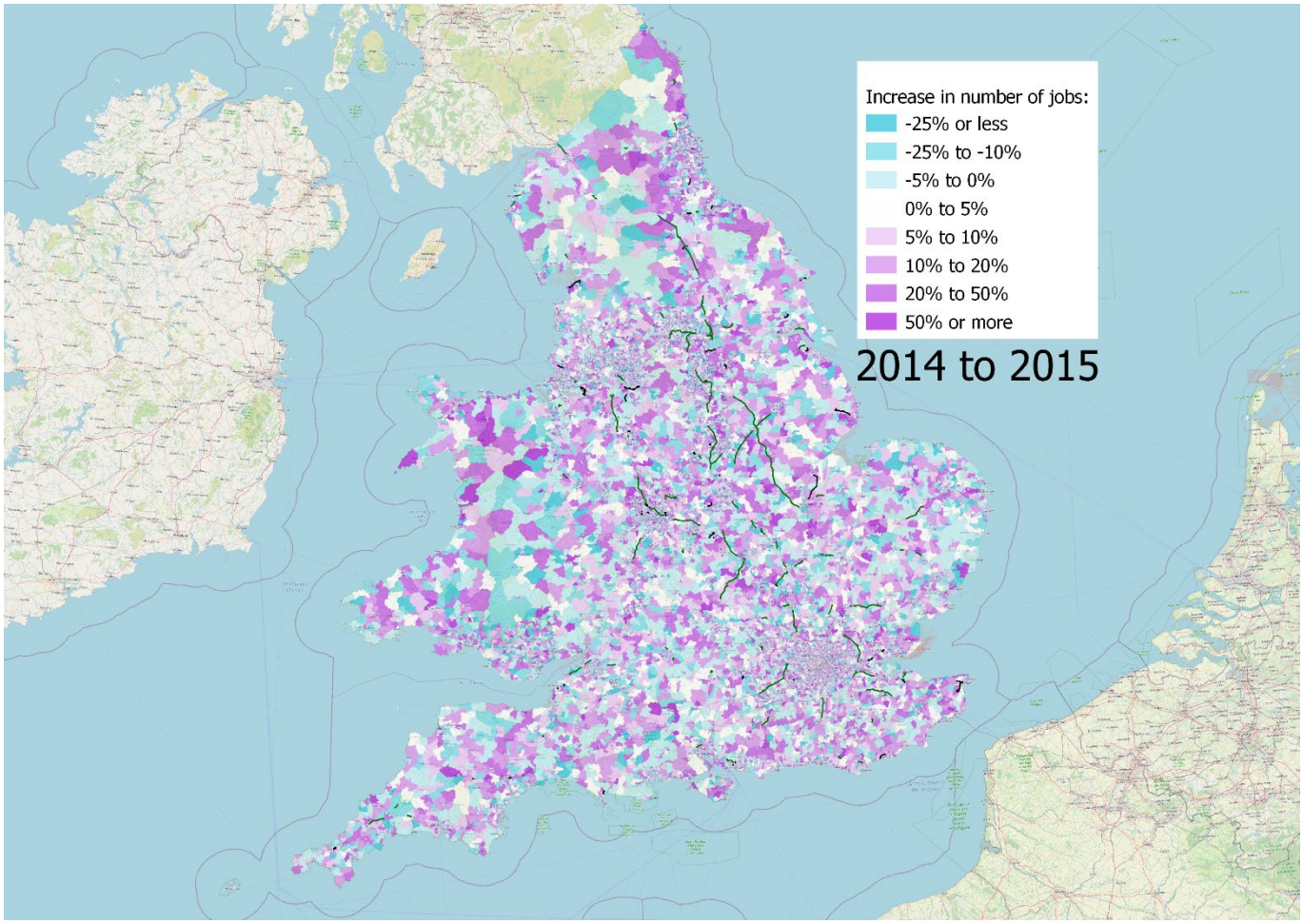
Figure 10.6: Changes in employment (2010 to 2019)

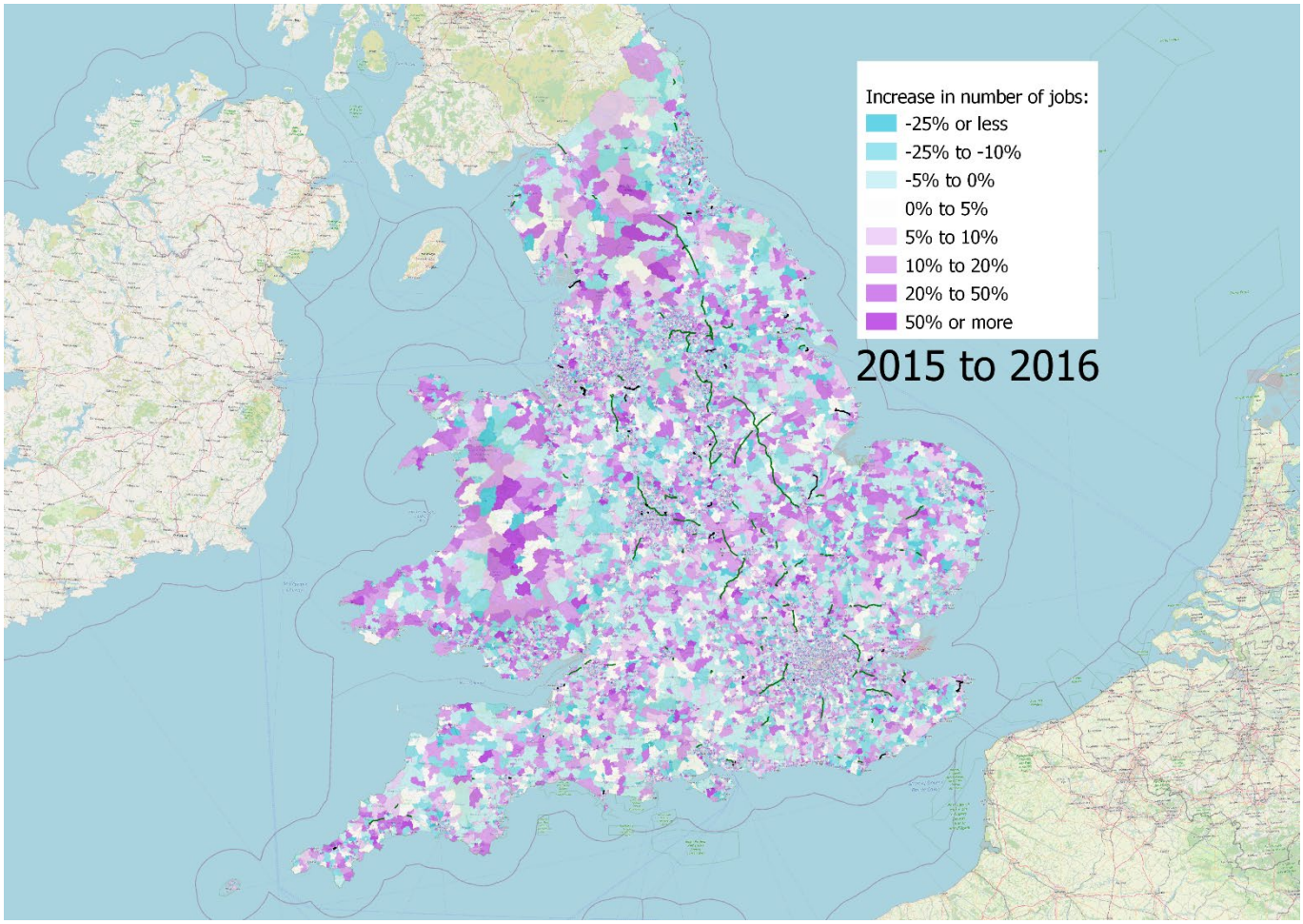


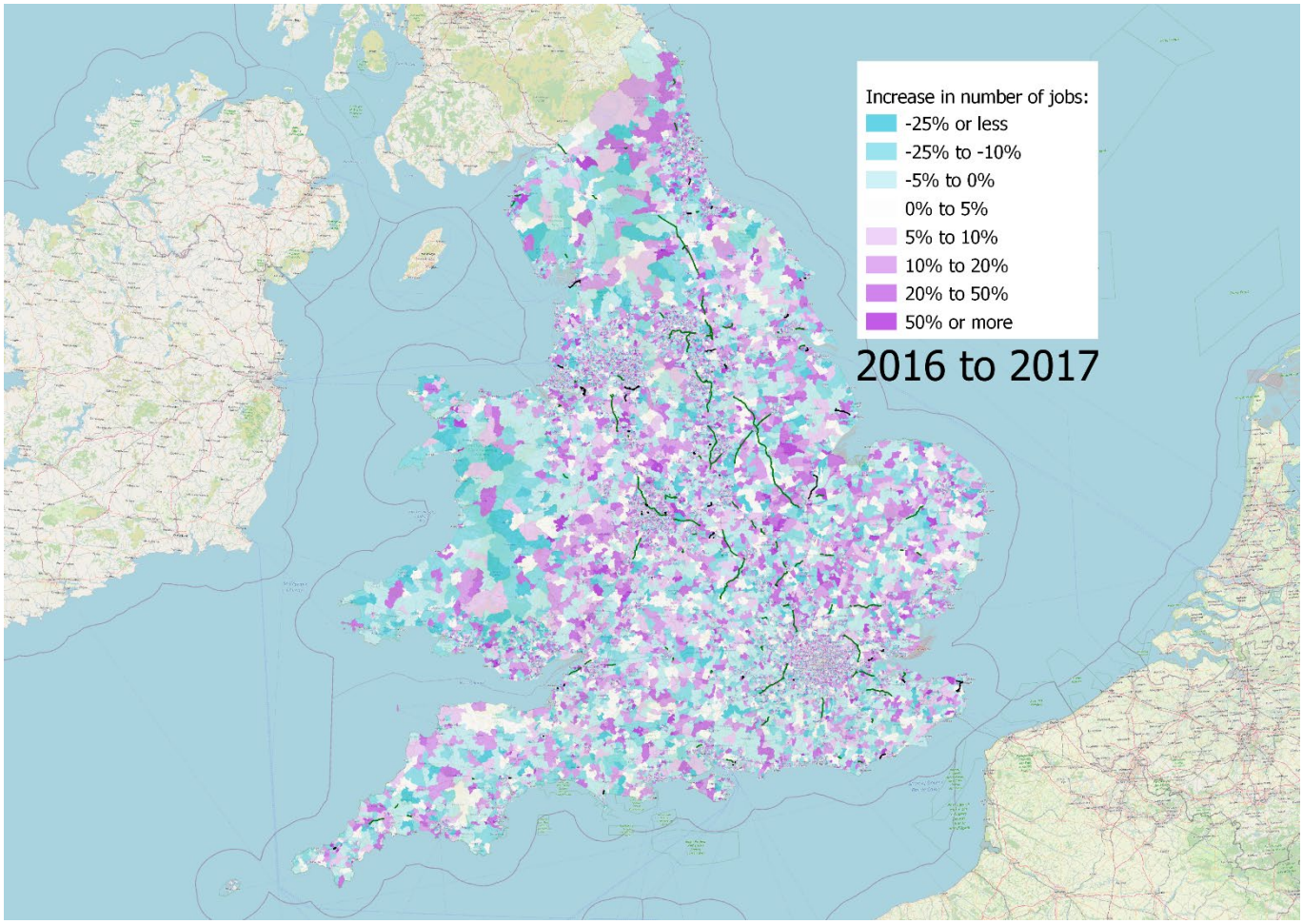

Increase in number of jobs:
-25% or less
-25% to -10%
-5% to 0%
0% to 5%
5% to 10%
10% to 20%
20% to 50%
50% or more
2011 to 2012

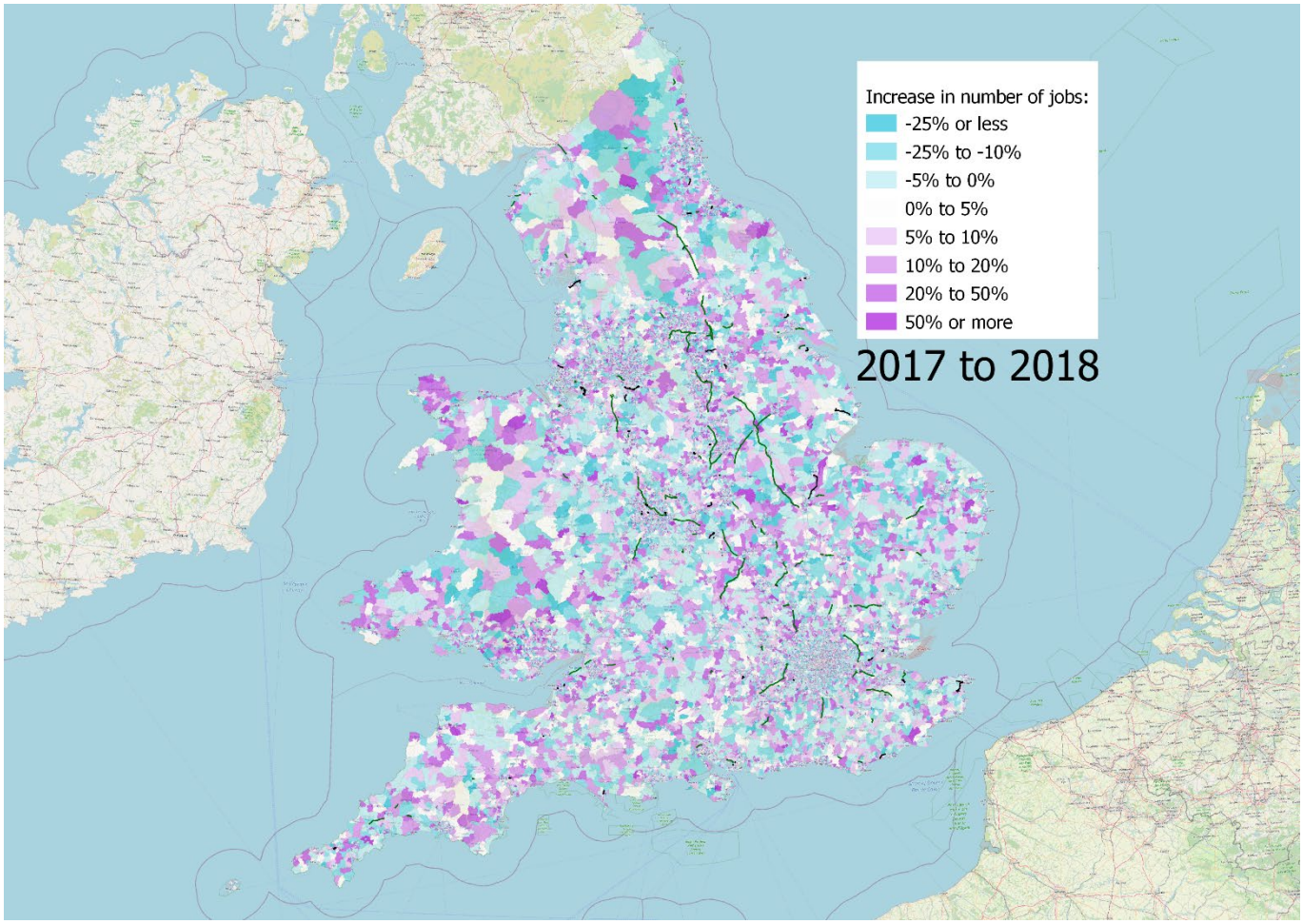

Increase in number of jobs:
-25% or less
-25% to -10%
-5% to 0%
0% to 5%
5% to 10%
10% to 20%
20% to 50%
50% or more
2012 to 2013

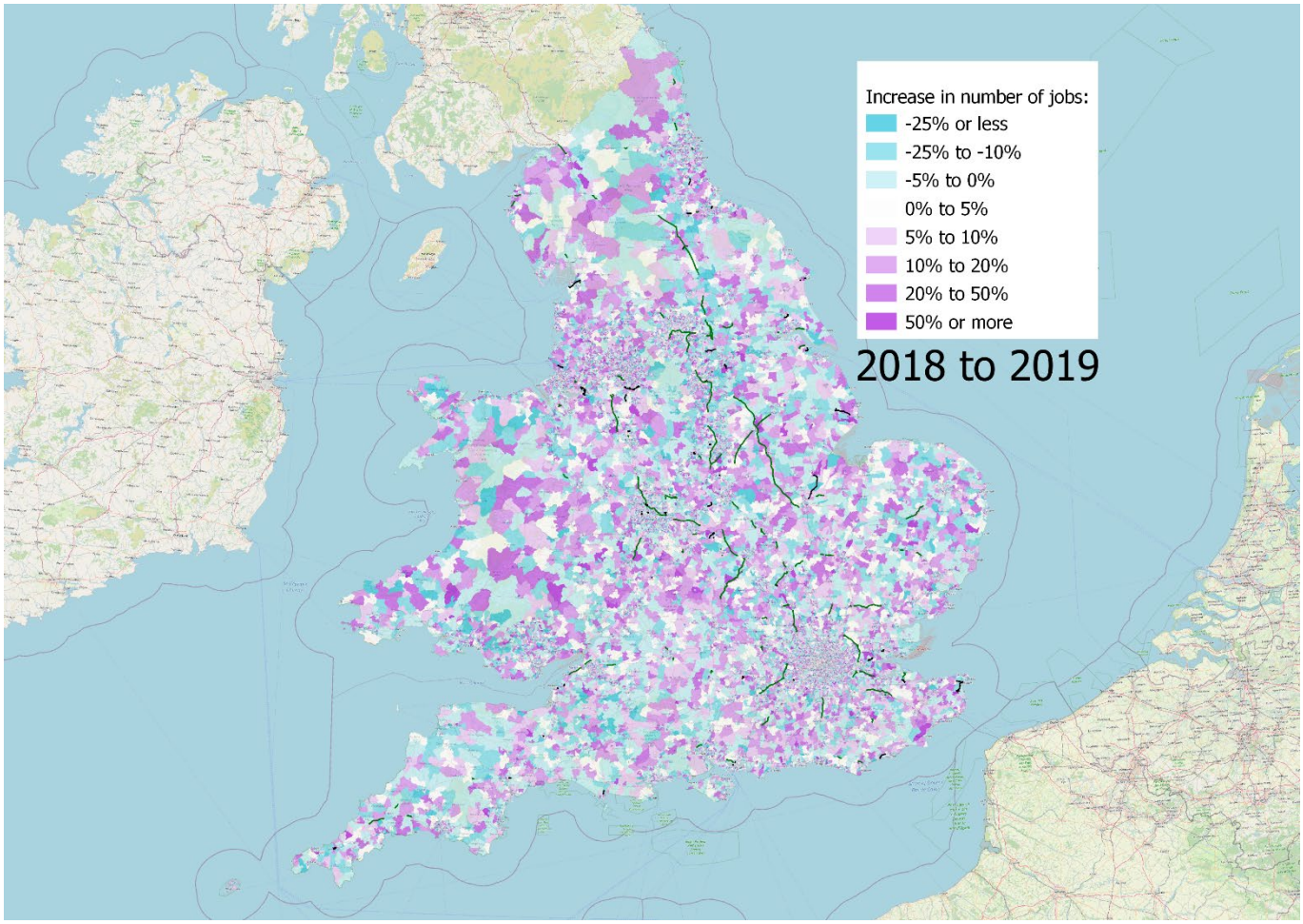

Increase in number of jobs:
-25% or less
-25% to -10%
-5% to 0%
0% to 5%
5% to 10%
10% to 20%
20% to 50%
50% or more
2013 to 2014


Increase in number of jobs:
-25% or less
-25% to -10%
-5% to 0%
0% to 5%
5% to 10%
10% to 20%
20% to 50%
50% or more
2014 to 2015

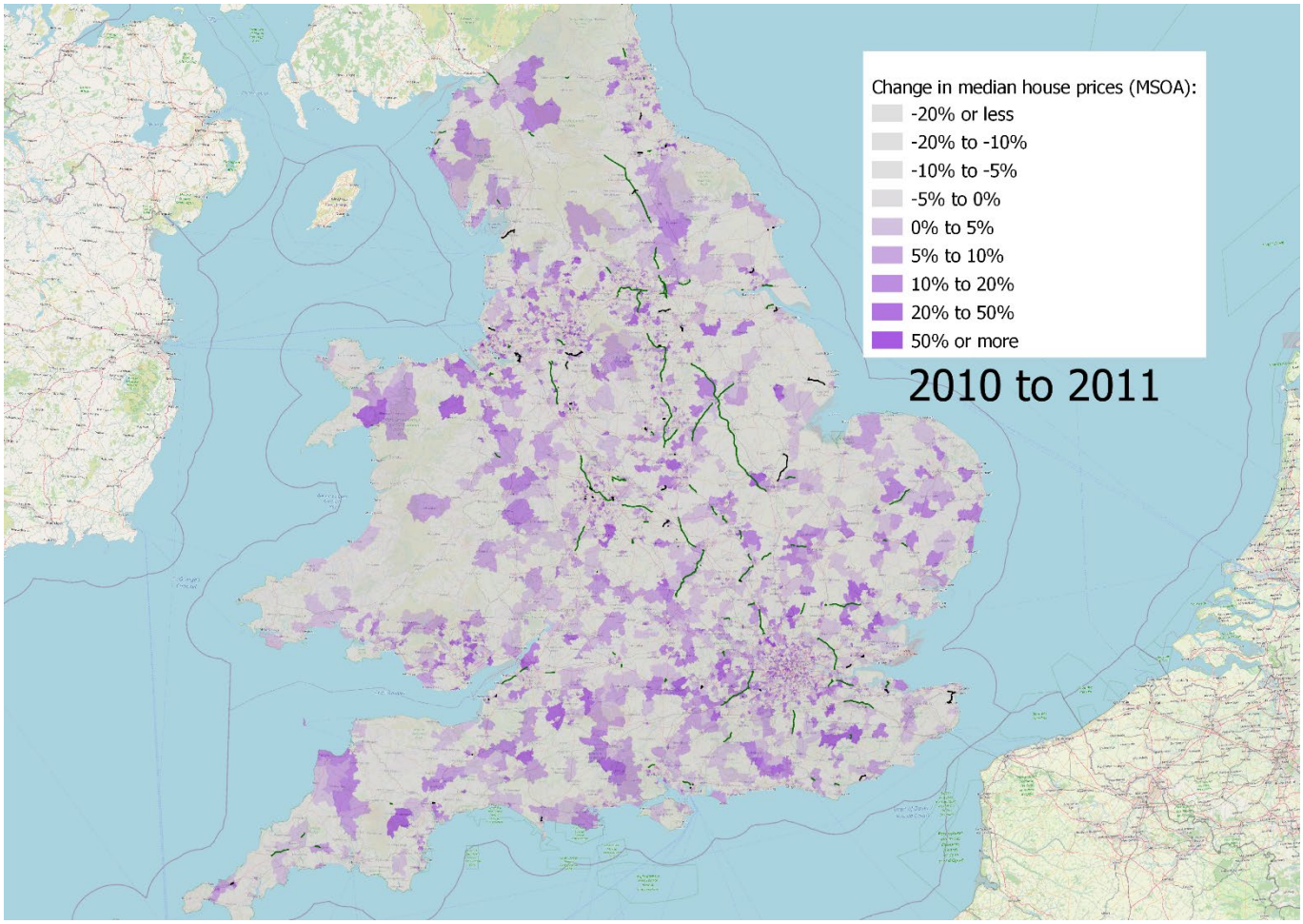

Increase in number of jobs:
-25% or less
-25% to -10%
-5% to 0%
0% to 5%
5% to 10%
10% to 20%
20% to 50%
50% or more
2015 to 2016

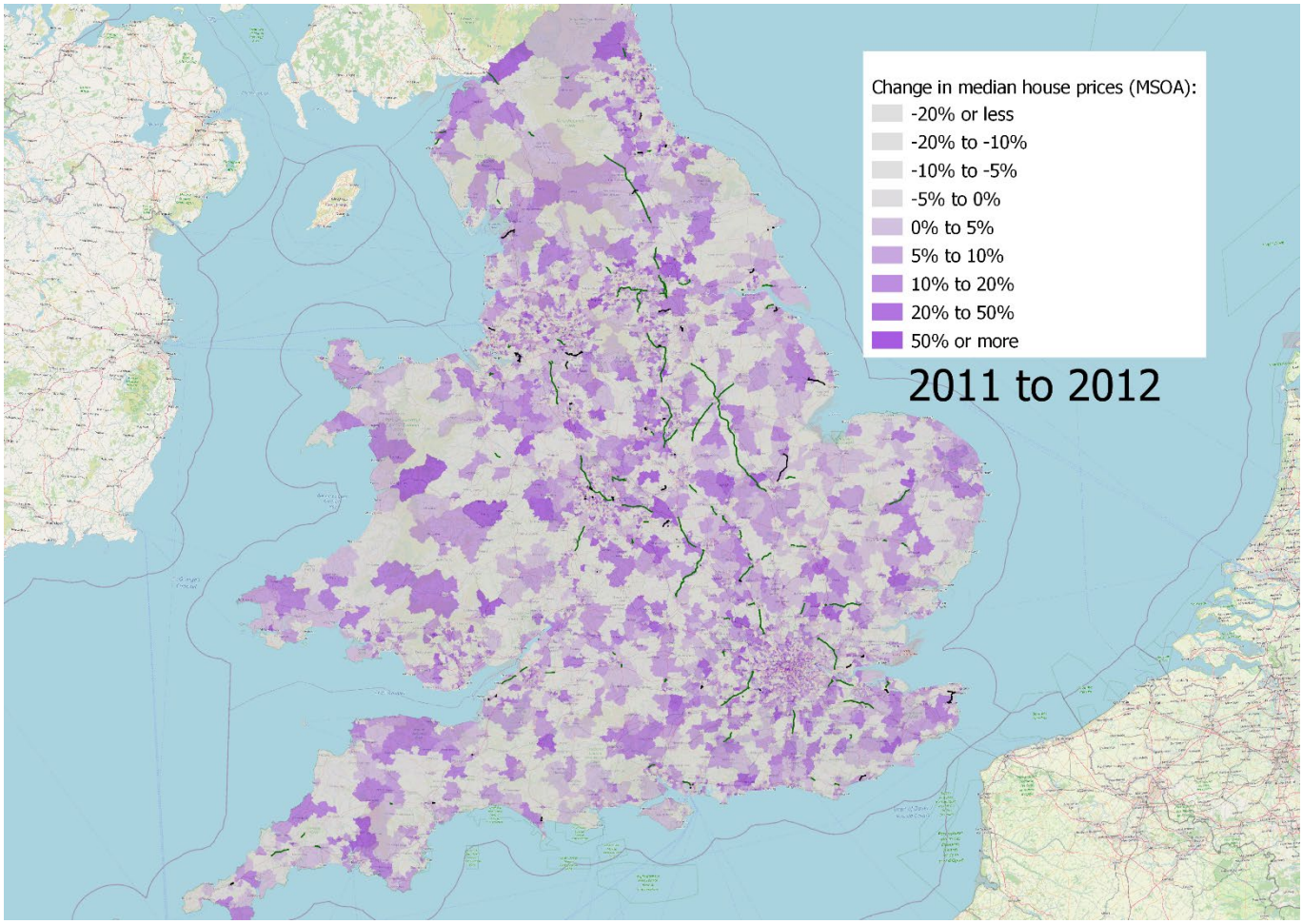

Increase in number of jobs:
-25% or less
-25% to -10%
-5% to 0%
0% to 5%
5% to 10%
10% to 20%
20% to 50%
50% or more
2016 to 2017

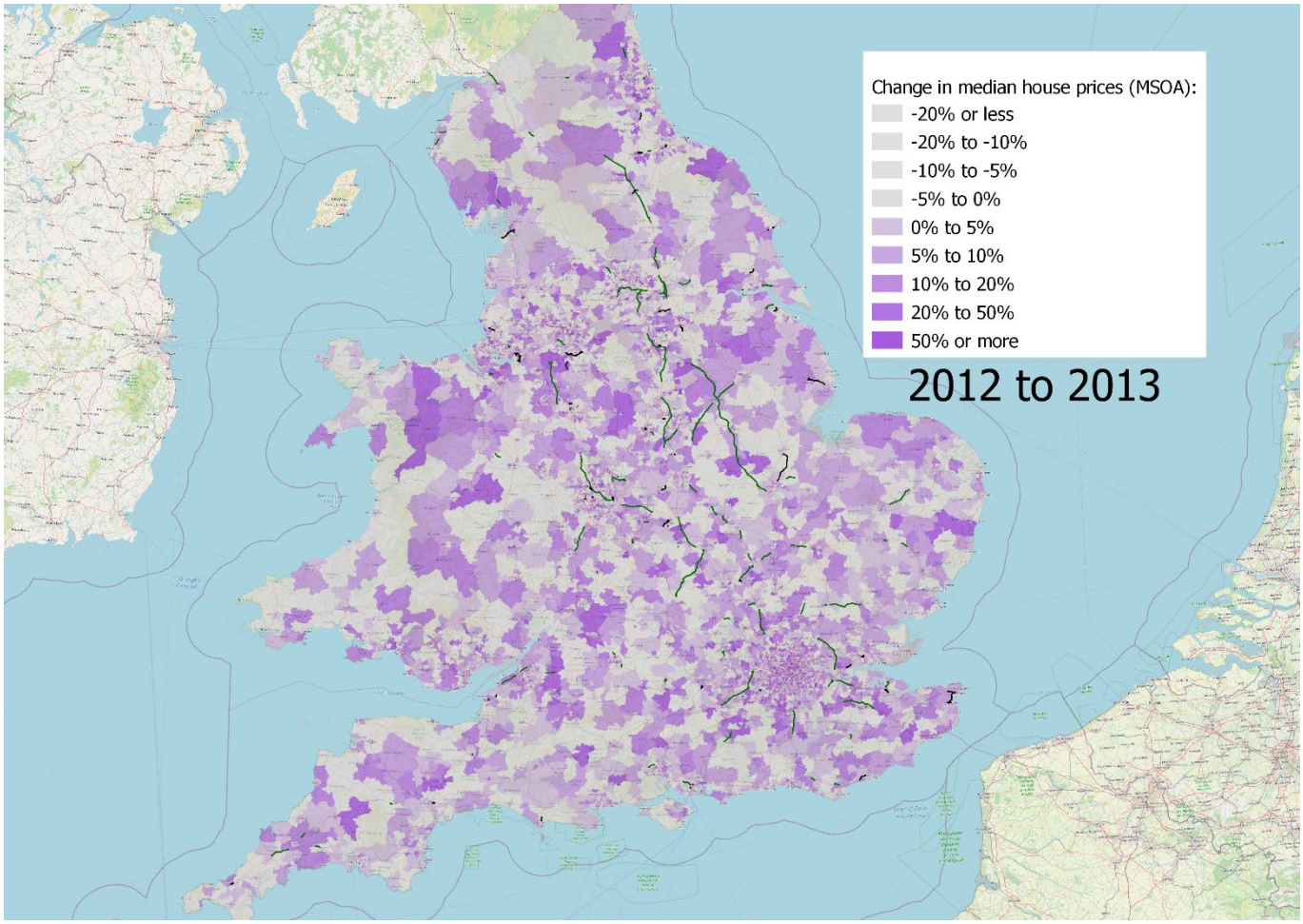

Increase in number of jobs:
-25% or less
-25% to -10%
-5% to 0%
0% to 5%
5% to 10%
10% to 20%
20% to 50%
50% or more
2017 to 2018

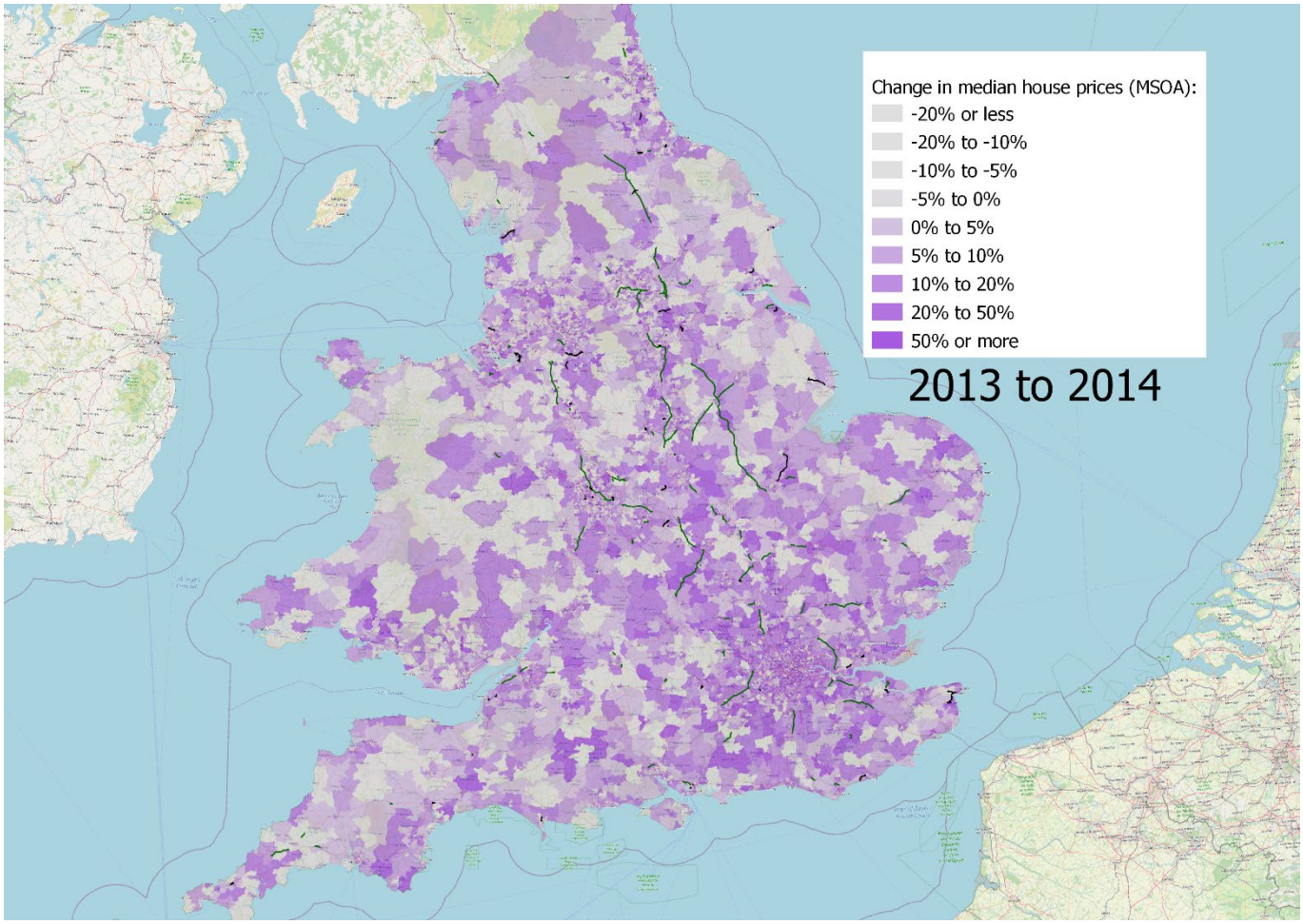


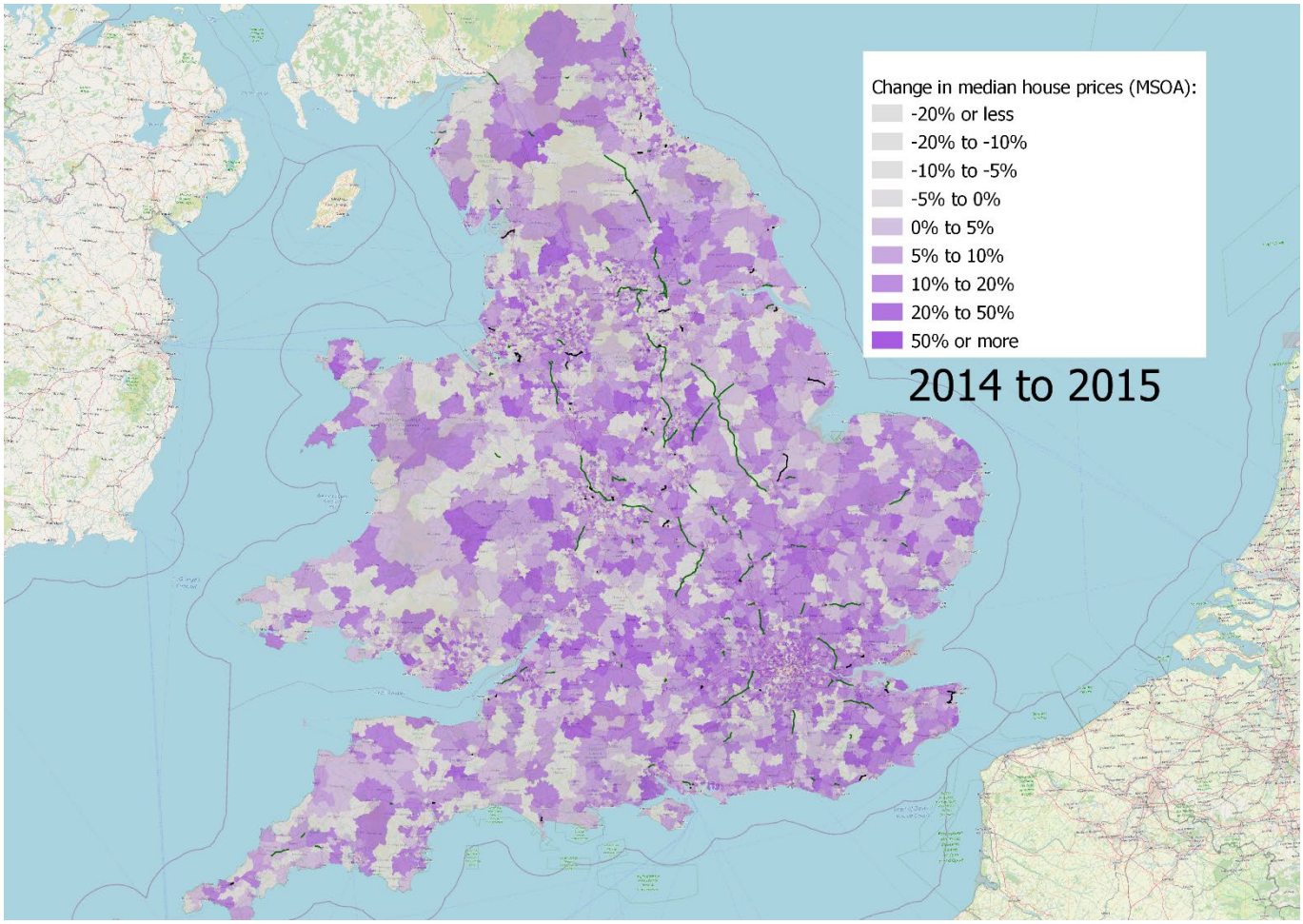
10.5 Changes in house prices

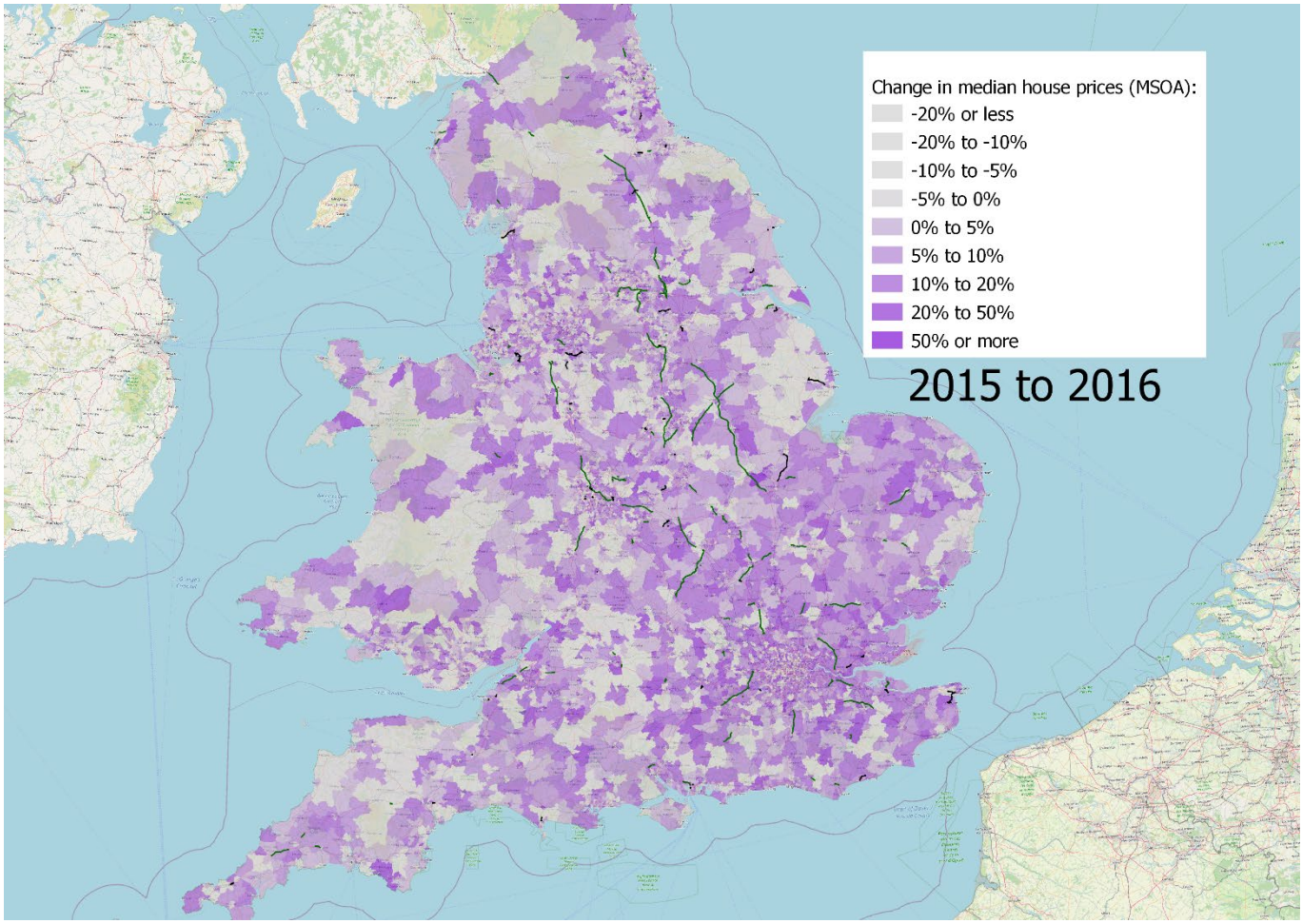

Change in median house prices (MSOA):
-20% or less
-20% to -10%
-10% to -5%
-5% to 0%
0% to 5%
5% to 10%
10% to 20%
20% to 50%
50% or more
2010 to 2011

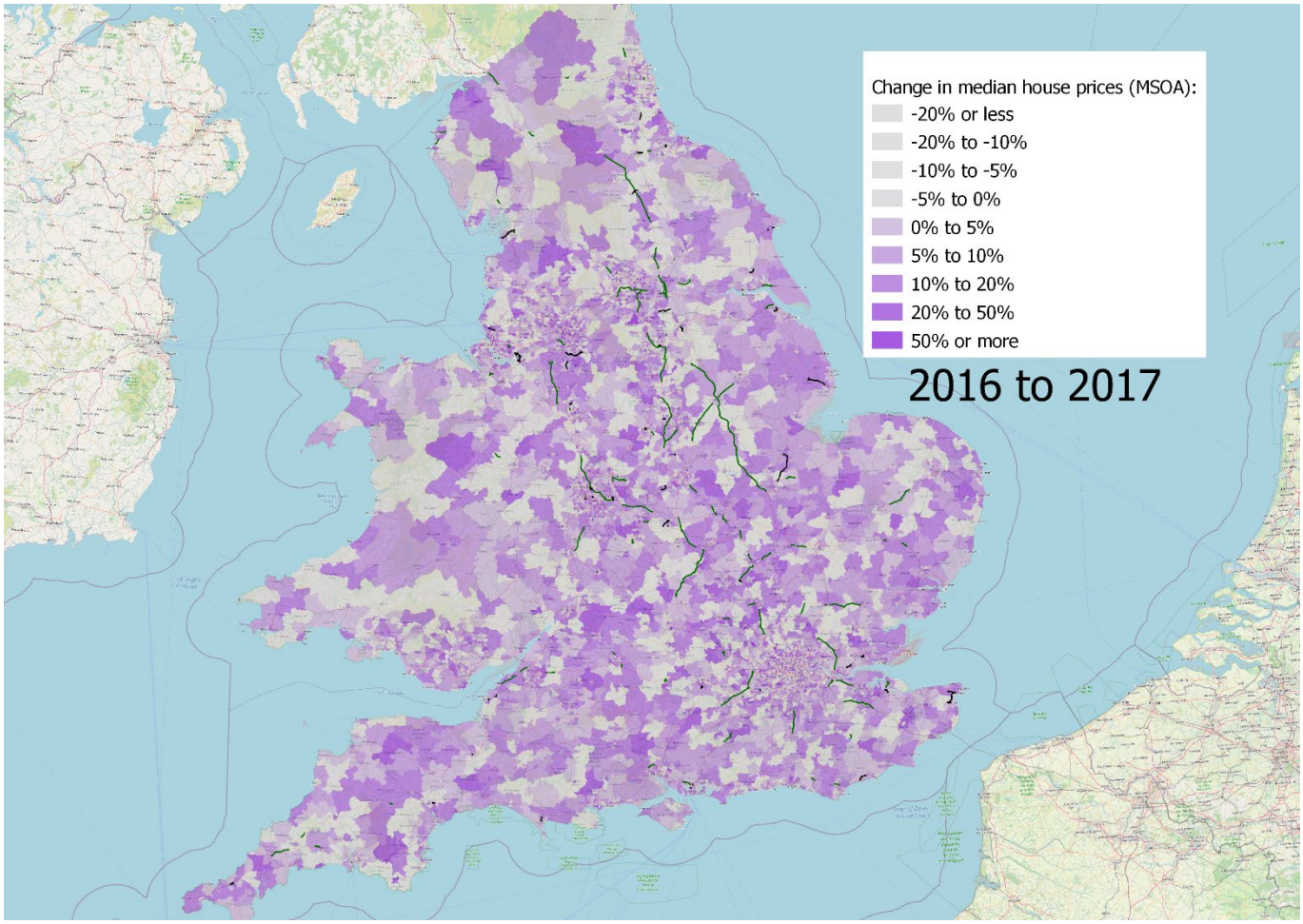

Change in median house prices (MSOA):
-20% or less
-20% to -10%
-10% to -5%
-5% to 0%
0% to 5%
5% to 10%
10% to 20%
20% to 50%
50% or more
2011 to 2012

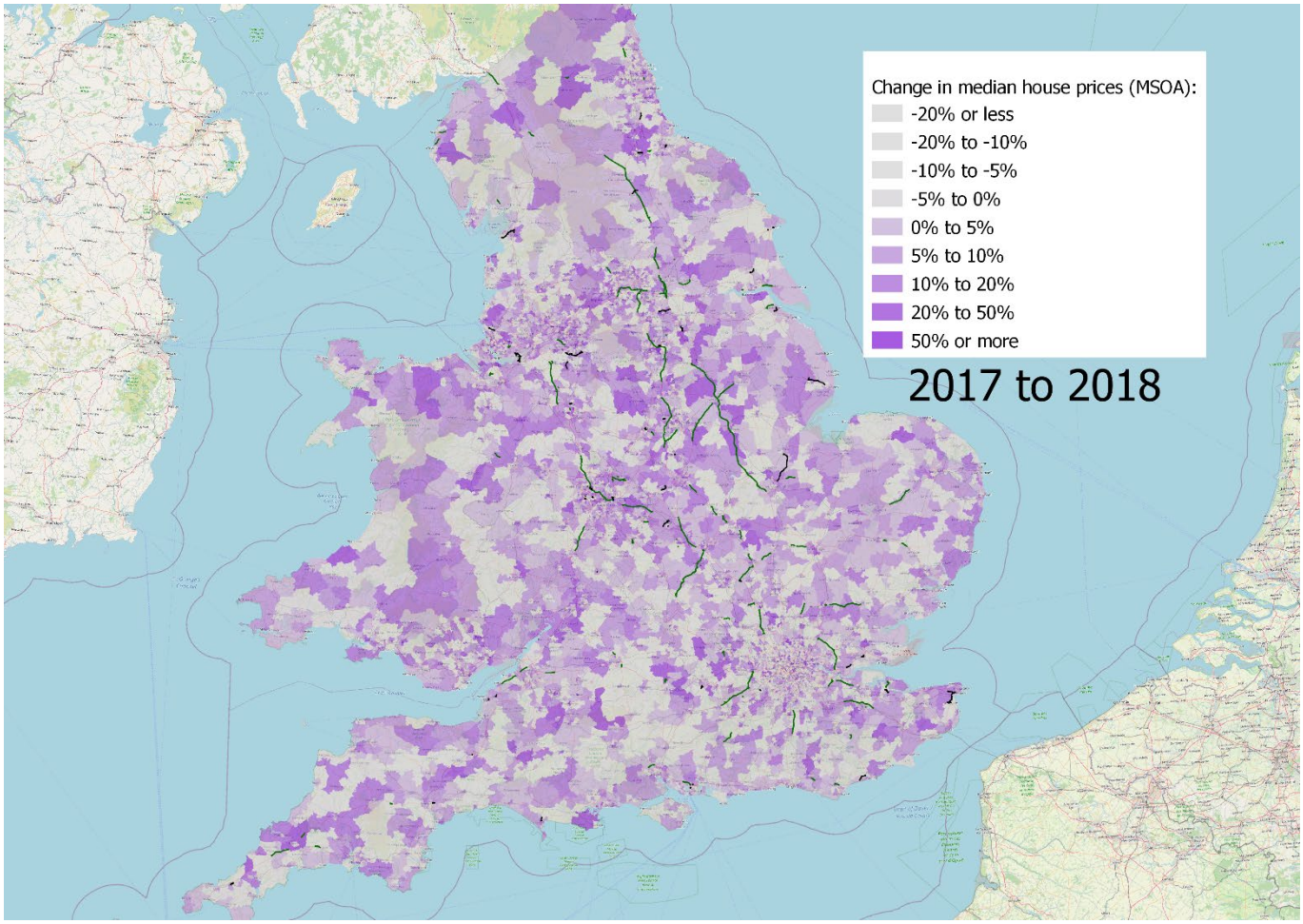

Change in median house prices (MSOA):
-20% or less
-20% to -10%
-10% to -5%
-5% to 0%
0% to 5%
5% to 10%
10% to 20%
20% to 50%
50% or more
2012 to 2013

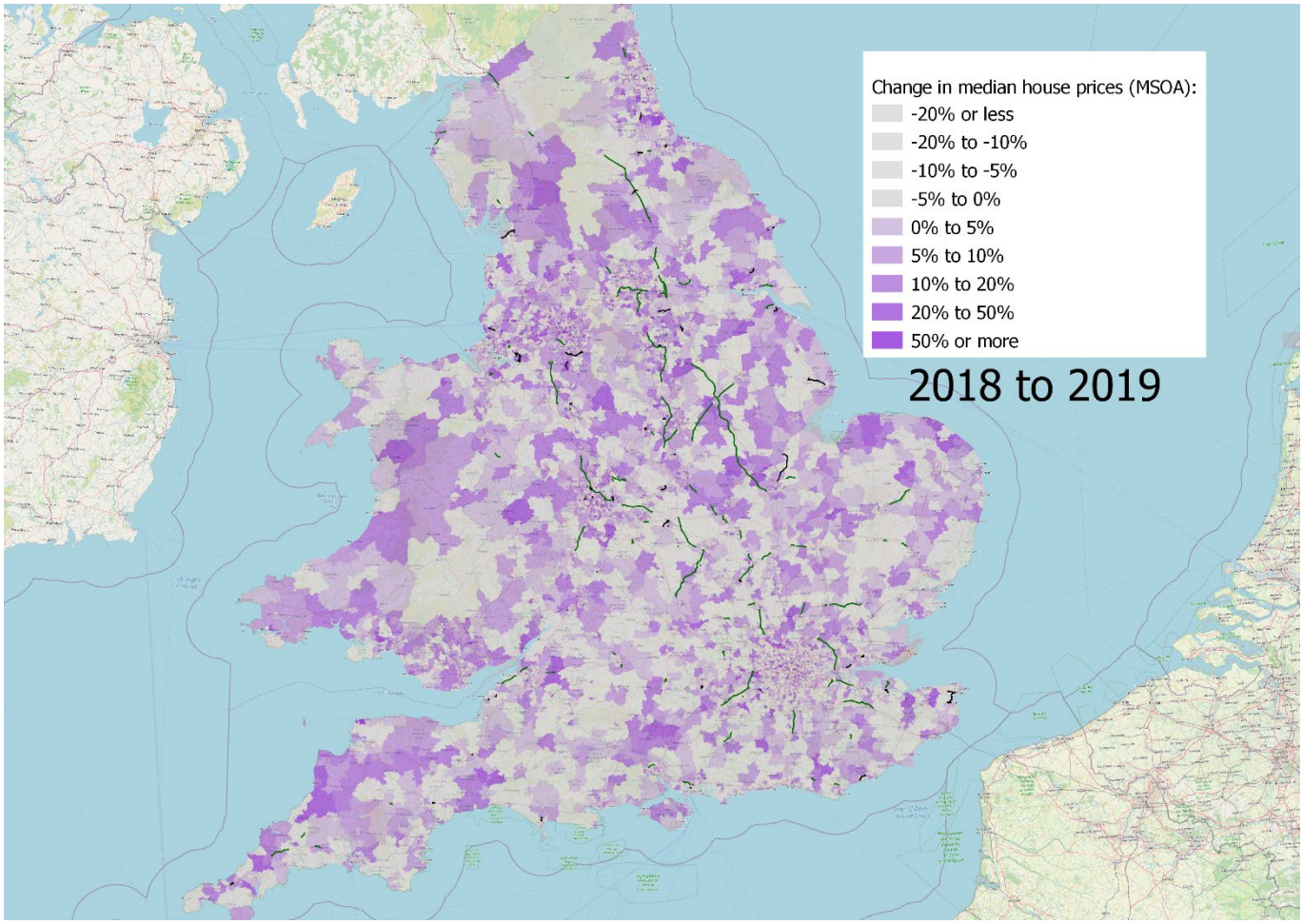

Change in median house prices (MSOA):
-20% or less
-20% to -10%
-10% to -5%
-5% to 0%
0% to 5%
5% to 10%
10% to 20%
20% to 50%
50% or more
2013 to 2014


Change in median house prices (MSOA):
-20% or less
-20% to -10%
-10% to -5%
-5% to 0%
0% to 5%
5% to 10%
10% to 20%
20% to 50%
50% or more
2014 to 2015

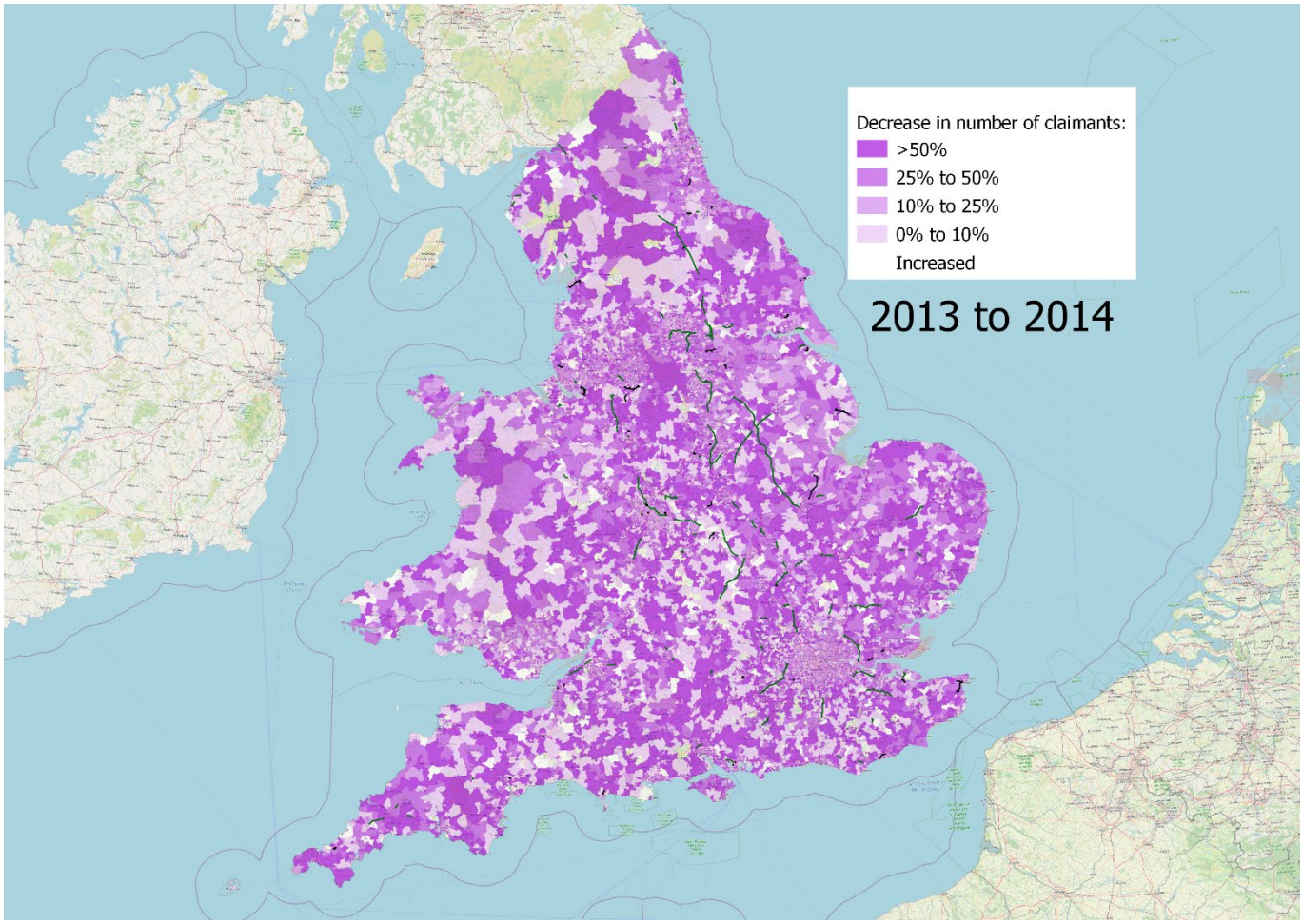

Change in median house prices (MSOA):
-20% or less
-20% to -10%
-10% to -5%
-5% to 0%
0% to 5%
5% to 10%
10% to 20%
20% to 50%
50% or more
2015 to 2016

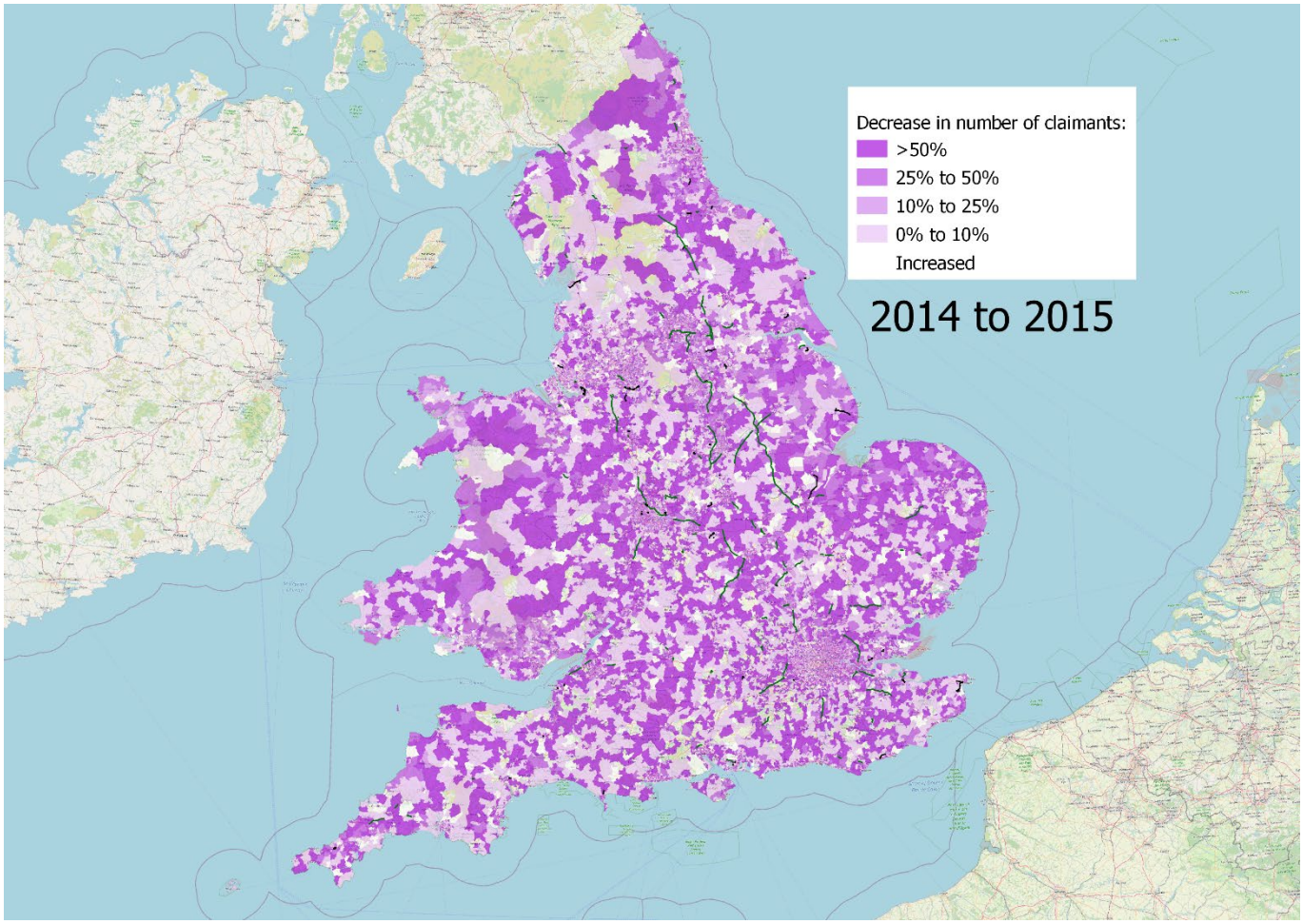

Change in median house prices (MSOA):
-20% or less
-20% to -10%
-10% to -5%
-5% to 0%
0% to 5%
5% to 10%
10% to 20%
20% to 50%
50% or more
2016 to 2017

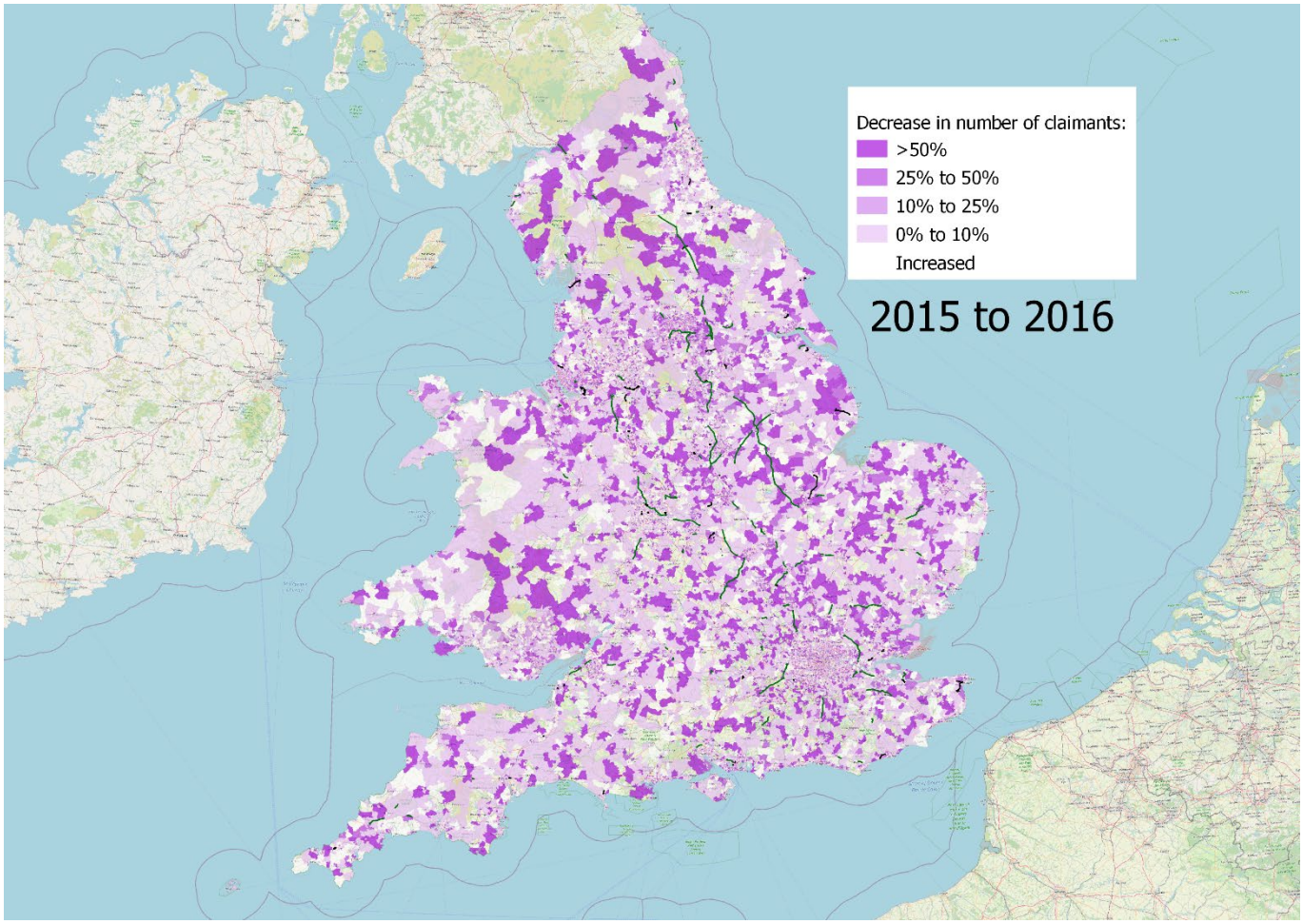

Change in median house prices (MSOA):
-20% or less
-20% to -10%
-10% to -5%
-5% to 0%
0% to 5%
5% to 10%
10% to 20%
20% to 50%
50% or more
2017 to 2018

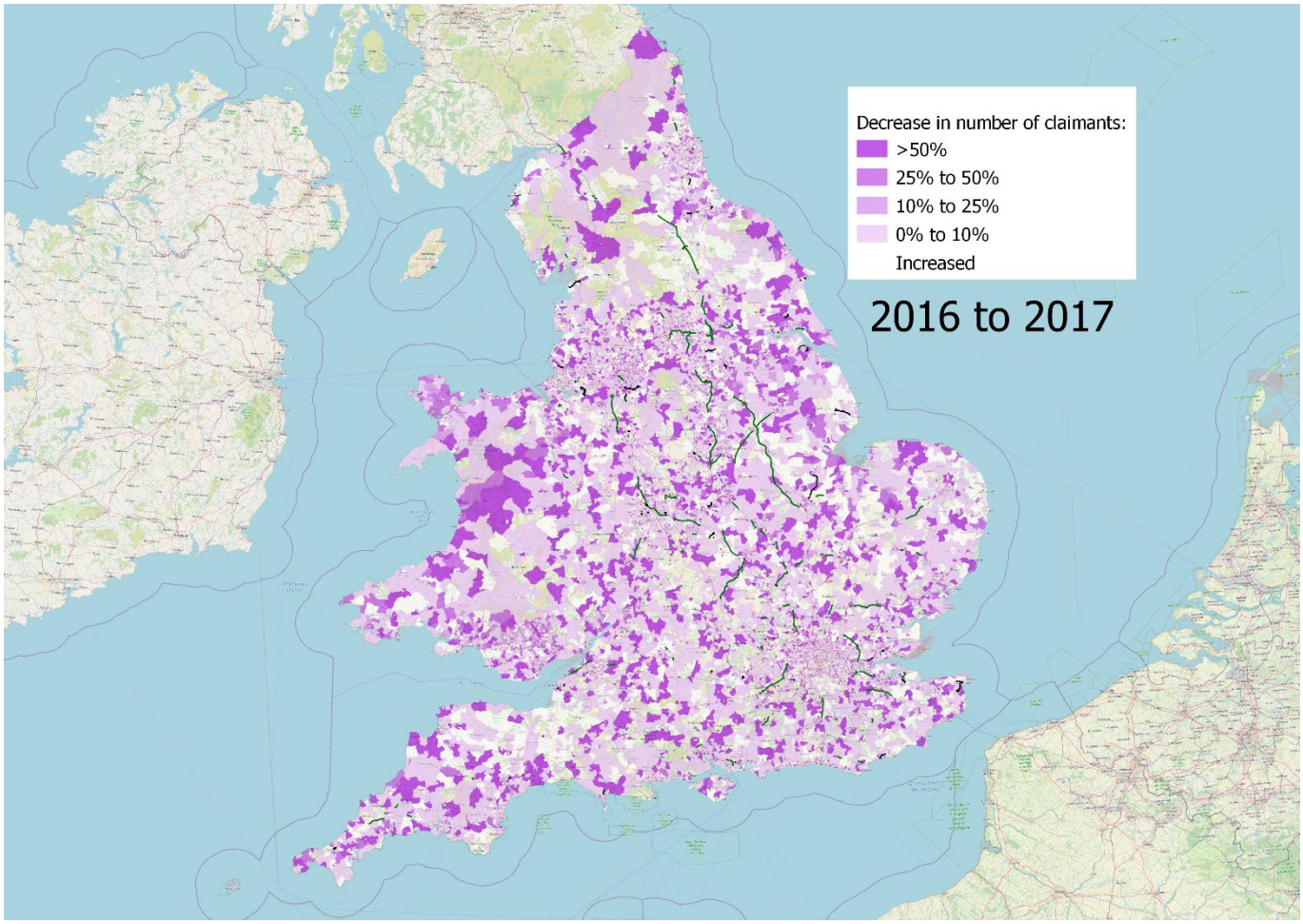


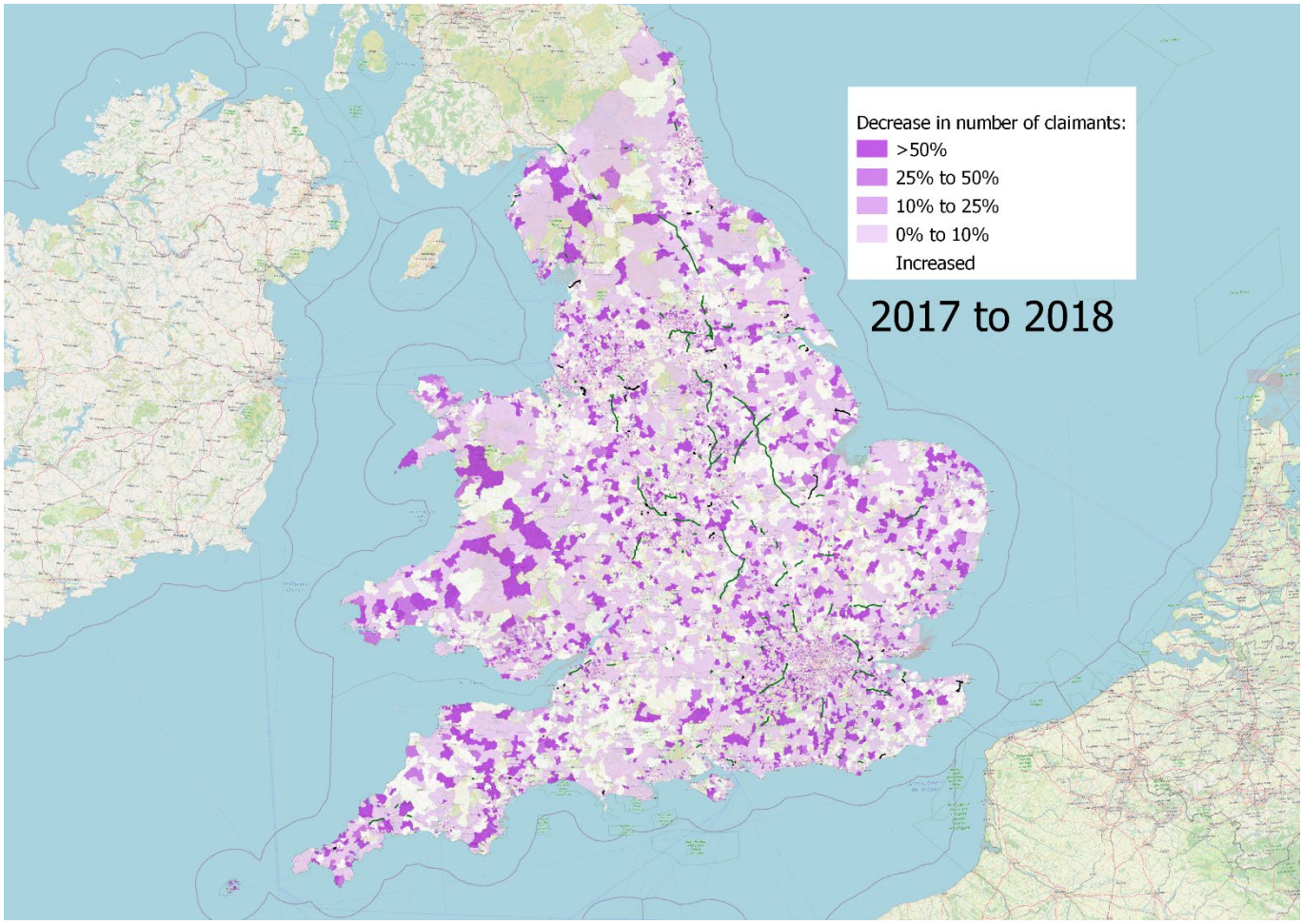
10.6 Changes in claimant count

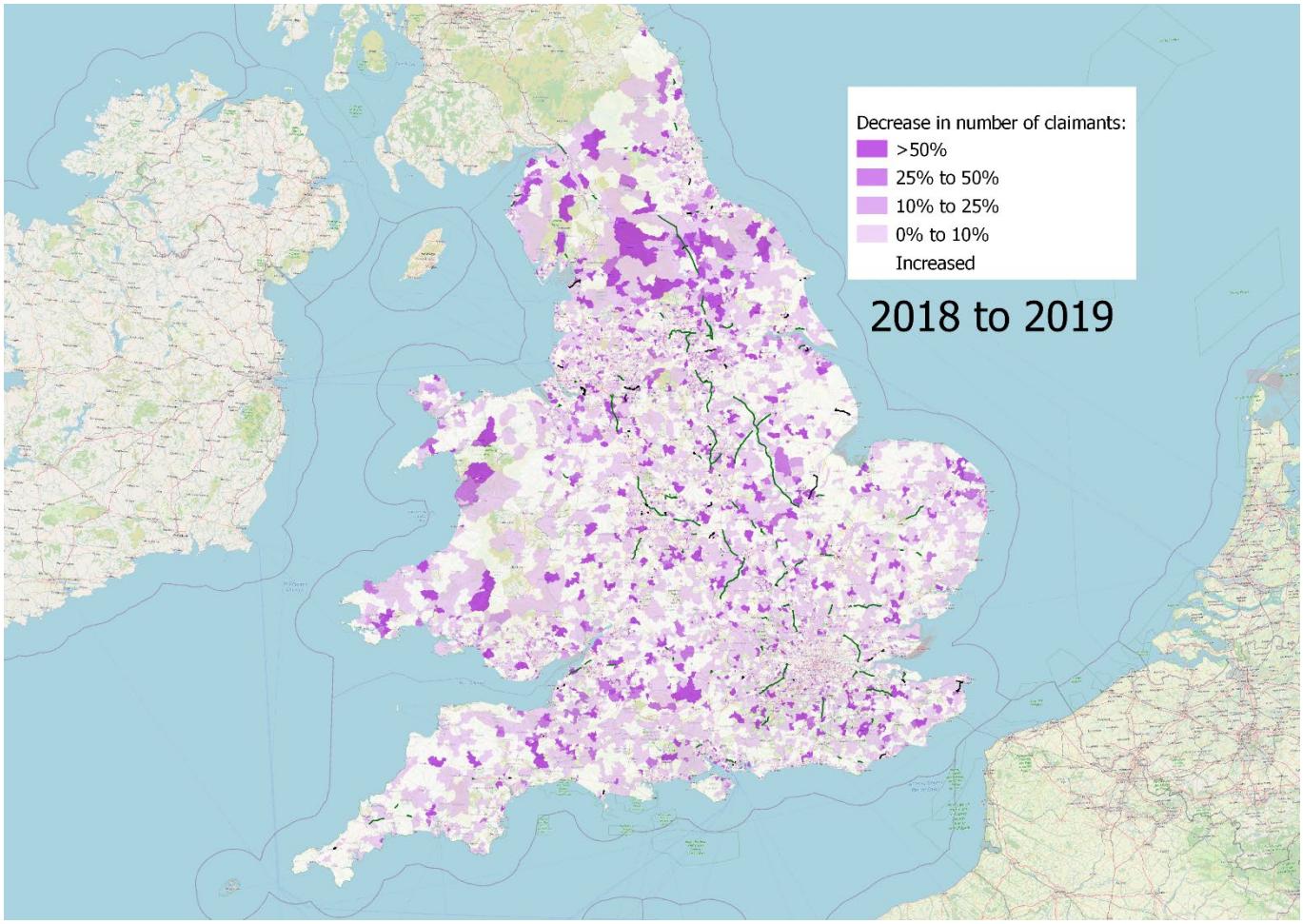

Decrease in number of claimants:
>50%
25% to 50%
10% to 25%
0% to 10%
Increased
2013 to 2014


Decrease in number of claimants:
>50%
25% to 50%
10% to 25%
0% to 10%
Increased
2014 to 2015


Decrease in number of claimants:
>50%
25% to 50%
10% to 25%
0% to 10%
Increased
2015 to 2016


Decrease in number of claimants:
>50%
25% to 50%
10% to 25%
0% to 10%
Increased
2016 to 2017


Decrease in number of claimants:
>50%
25% to 50%
10% to 25%
0% to 10%
Increased
2017 to 2018


Decrease in number of claimants:
>50%
25% to 50%
10% to 25%
0% to 10%
Increased
2018 to 2019

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