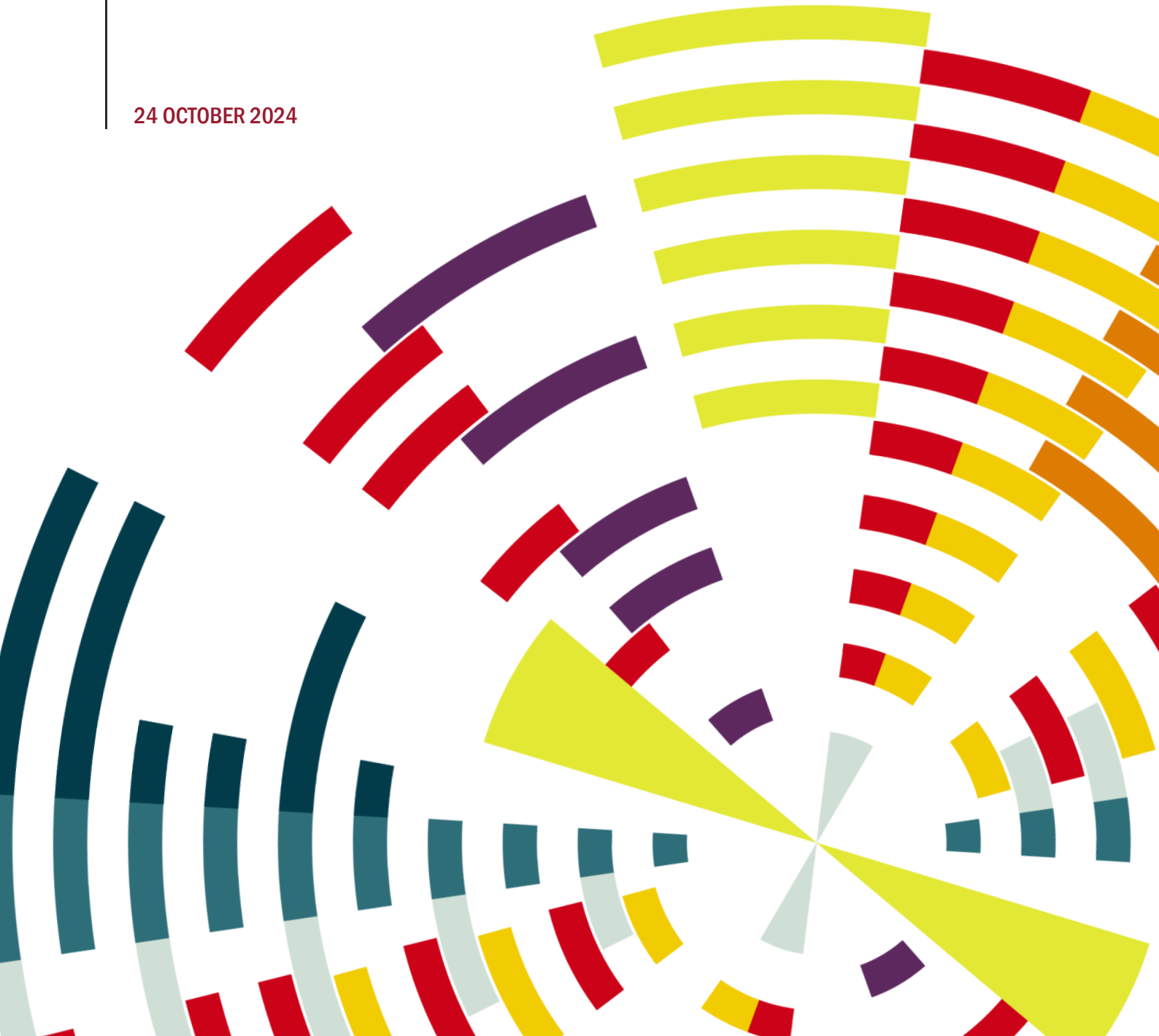


THE ECONOMIC IMPACTS OF TRANSPORT INTERVENTIONS

An evidence review for the Department for Transport

24 OCTOBER 2024



Contents

1	Summary for policy makers	4
1.1	Background	4
1.2	Methodology	4
1.3	Key findings	6
1.3.1	Unemployment and inactivity	6
1.3.2	Agglomeration and productivity	6
1.3.3	Gentrification	7
1.3.4	New Towns	7
1.3.5	Cross-cutting themes	8
1.4	Take-aways for policy makers	8
2	Introduction	10
2.1	Overview	10
2.2	Aims and objectives	10
2.3	Report structure	11
3	Methodology	12
3.1	Search protocol	13
3.2	Longlisting criteria	14
3.3	Shortlisting criteria	16
3.4	Evidence assessment and collection tool	18
4	Economic impacts of transport interventions	19
4.1	Characteristics of the evidence base	19
4.1.1	Geographical regions	19
4.1.2	Methodological approaches	20
4.2	Unemployment and inactivity	23
4.2.1	Overview of the evidence	23
4.2.2	Results	24

4.3	Agglomeration and productivity	30
	4.3.1 Overview of the evidence	30
	4.3.2 Results	32
4.4	Gentrification	35
	4.4.1 Overview of the evidence	36
	4.4.2 Results	37
4.5	New towns	40
	4.5.1 Overview of the evidence and results	40
4.6	Cross-cutting themes	41
	4.6.1 Displacement	41
	4.6.2 Endogeneity	42
5	Conclusions	44
	5.1 Unemployment and inactivity	44
	5.2 Agglomeration and productivity	45
	5.3 Gentrification	45
	5.4 New towns	46
	5.5 Take-aways for policymakers	46
6	Bibliography	48
	6.1 Papers included in the in-depth review	48
	6.2 Papers cited, but not included in the in-depth review	51

1 Summary for policy makers

1.1 Background

This report summarises an evidence review commissioned by the UK Department for Transport (DfT) which aims to deepen their understanding of how transport policies and investments affect a range of economic outcomes such as unemployment, gentrification and productivity. This review builds on previous work by examining the most recent, high-quality research published since 2015 that has not been covered before in existing evidence reviews¹. For some outcomes where previous synthesis is limited, such as displacement, agglomeration and gentrification, we also review relevant evidence published since 2004. Specifically, the focus of the review is on evidence covering the relationship between road, rail, public and active transport interventions and the following four key areas:

- **Unemployment and inactivity:** understanding the extent to which transport is enticing individuals either unable to find employment or not actively looking for it into the labour market.
- **Agglomeration and productivity:** understanding the extent to which transport investments generate agglomeration economies that improve firm productivity.
- **Gentrification:** understanding the impact of transport investment on the spatial distribution of the wider economy benefits from transport investment, including consideration of gentrification, and the displacement of firms and households.
- **New towns:** understanding the impacts of transport links within and to publicly-planned new towns across the three key areas above.

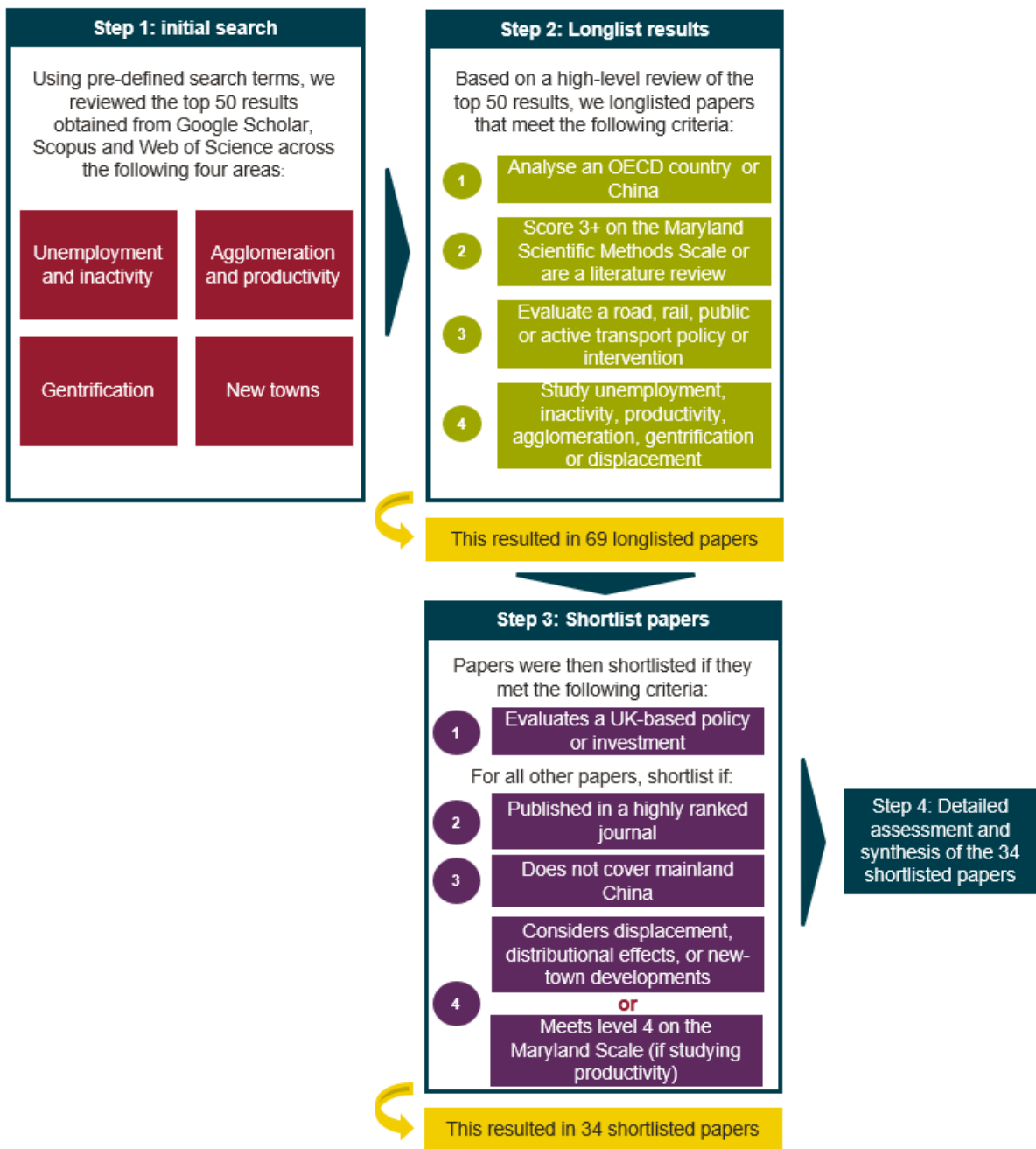
Across these areas, best practice for handling the issue of transport interventions displacing economic activity is also considered.

1.2 Methodology

To identify the most relevant and robust studies to review in depth, the four-step evidence assessment process outlined in Figure 1 was used.

¹ Primarily the What Works Centre for Local Economic Growth (2015) review

Figure 1 Shortlisting methodology



Source: Frontier Economics

Notes: The Maryland Scientific Methods Scale is a tool used to assess the methodological rigor of empirical research studies, ranking their methodology from 1 (least robust) to 5 (most robust).

Our initial searches resulted in 69 papers being longlisted. Following a more detailed assessment, the long list was reduced to 34 papers for detailed review. The shortlisted papers were split across outcomes (see Table 1 below).

Table 1 Summary of shortlisted studies

Transport	Unemployment / Inactivity	Gentrification	Productivity / Agglomeration	New Towns	Total*
Rail	5	5	7	2	17
Road	5	1	8	0	13
Public	6	7	6	0	17
Active	0	1	1	0	2
Total*	13	11	13	2	
of which literature reviews	1	3	2	0	
of which empirical studies	12	8	11	2	

Source: *Frontier Economics*

Note: * Excluding double counting of papers. Some papers fall into more than one mode of transport and outcome, so the "Totals" should only be read as the sum of their respective row or column header

1.3 Key findings

1.3.1 Unemployment and inactivity

Our review finds evidence that transport interventions are associated with employment growth. Most of the papers analysed only focus on employment metrics in the areas affected by an intervention, rather than assessing the specific mechanism which explains the change in employment seen. Our review identified several papers that find significant displacement of employment from neighbouring areas to those benefitting from a transport intervention. This suggests moderate to zero net impacts on local or national employment, with different papers covering different geographical scopes. Further, among the evidence reviewed, only two papers analysed unemployment rates, with only one analysing long-term and youth unemployment rates (proxies for structural unemployment). None of the papers measured the effect of an intervention on economic inactivity.

1.3.2 Agglomeration and productivity

The evidence suggests transport investments are associated with increased levels of firm and labour productivity. Behind these impacts though, there is tentative evidence of 'sorting effects' where firms from higher-productivity sectors enter areas surrounding a new transport intervention and others from less productive ones leave. It is therefore unclear whether firms

existing in the area prior to the intervention experience productivity increases, and what the impact on those firms which leave the area is. Further, the evidence of the productivity impact on neighbouring areas - both at the national and local level, depending on the scale of the intervention - is inconclusive. Some papers find positive net effects, and others negative. A feature of the literature is a lack of studies analysing specific transport interventions. Instead, many assess the links between general transport accessibility at a national, regional, or metropolitan-wide area and productivity. This limits the scope for understanding the impact of different types of transport interventions and the presence of potential 'sorting effects'.

1.3.3 Gentrification

Gentrification often refers to the process whereby less affluent residents are crowded out by more affluent ones. In the context of transport investments, the literature uses one of two proxies to measure this: changes in house prices, or in the socioeconomic and demographic composition of an area. Overall, the literature consistently finds that transport interventions are associated with increases in house prices. However, when papers analyse socioeconomic and demographic changes in areas – arguably a more direct measure of gentrification - the results are inconclusive. The evidence also indicates that the effect of a transport intervention may depend on the income group it is targeting, with light rail, tram, and metro investments as part of mixed use² developments seemingly more likely to lead to gentrification than the extension of bus lines. Further, the methods used to assess gentrification were generally found to be less robust than the literature for other outcomes covered in this review. They do not account for the endogeneity that may arise from the non-random placement of transport infrastructure, or the fact that transport developments may happen simultaneously with housing developments. In addition, the studies generally covered a relatively short time period, potentially underestimating longer-term effects.

1.3.4 New Towns

The analysis of the effect of transport investments in publicly-planned new town developments, in the UK and elsewhere, is a gap in the literature. Of the evidence reviewed, this is confined to two studies on Hong Kong's new town developments. One found evidence of gentrification from transport interventions, and the other that a travel subsidy was successful at reducing unemployment. More evidence is therefore needed to understand the impact of different kinds of transport investments on unemployment, productivity, gentrification and displacement in new towns. The sparsity of evidence may reflect the low numbers of new towns built recently in OECD countries, however it is unclear from the literature whether this is the cause.

² Mixed use in this context refers to the development of transport interventions as part of a bigger development of residential and commercial facilities.

1.3.5 Cross-cutting themes

Based on the evidence reviewed, two key themes arise that cut across the transport interventions and outcomes studied: the role of displacement (both economic activity and people) and how papers control for endogeneity.³

- Across employment, productivity and gentrification, there is evidence of varying strength that displacement takes place following transport interventions. Whether the effects are net positive, neutral or negative for the outcome of study is, however, unclear.
 - For employment, some studies found displacement from surrounding areas fully offsetting gains, while others found net positive effects.
 - While there was relatively limited evidence from the productivity literature, there was some support for "sorting" of more productive firms into transport-accessible areas.
 - For gentrification, while there was consistent evidence of house price increases near transport investments (suggesting gentrification), the evidence was mixed when considering changing resident demographics.
- For endogeneity, in both the employment and productivity literature several papers control for this issue by utilising sufficiently robust methodologies: most commonly, an instrumental variable which is considered at level 4 of the Maryland Scientific Methods Scale (SMS).⁴ This is not the case for gentrification, whose studies generally apply less robust approaches that score at level 3 of the Maryland SMS.⁵

1.4 Take-aways for policy makers

- When assessing the impact of transport interventions, the geographical scope of assessments must be wide enough to incorporate areas that may be indirectly affected. This is because there may be indirect positive or negative effects that impact the overall estimated net effect.
- To most accurately assess the distributional impact of policies and control for issues of displacement, micro data at the individual level that tracks the origins and destinations of pre-existing and new firms / people before and after a transport intervention should be used (or collected). This should cover both the area impacted by the intervention and those adjacent. If micro level data is not available, assessments should consider the

³ Endogeneity in this context refers to how the location chosen for a transport intervention might be dependent on factors that also affect the study's outcomes. For example, the placement of a new train station may be informed by the economic success of the area in question. If this pre-existing economic success isn't controlled for, then an impact estimate may attribute the economic success of the area to the new train station, rather than recognising this was partly or wholly due to the pre-existing economic conditions. This could lead to a biased impact estimate.

⁴ The Maryland SMS is a scale from 1 (lowest) to 5 (highest) that categorises the methodological quality of studies.

⁵ We discuss in Section 4.1.2 in the main body of the report the different methodological approaches followed by the literature.

composition of an area before and after an intervention (e.g. the sector of firms, and/or the sociodemographic characteristics of people).

- When estimating impacts, assessments should recognise that impacts likely differ between mode of transport, their scale, who the intended users are, and the local context of the area.
- To inform whether transport investments increase labour supply, future studies should aim to assess the impact of transport investments on unemployment and economic inactivity (rather than just employment).
- Further research that assesses the impact of specific transport interventions on productivity is required. This is because the current literature focusses mainly on the links between general increases in transport connectivity and productivity, rather than different types of interventions. Future assessments should also control for 'sorting effects' where possible, utilising micro data at the individual firm or person level (as outlined above).
- The term 'gentrification' refers to the displacement of individuals following transport interventions. It should be recognised that gentrification may happen in different directions, with more affluent individuals displacing less affluent individuals, and less affluent individuals displacing more affluent individuals, depending on the intervention. Evidence on the latter effect is however sparse, and so requires further research.
- Future studies assessing the gentrification impacts of transport interventions should include data covering a longer time period, apply the most robust methods available (level 4 or above on the Maryland SMS), and use direct (ideally micro-level) socioeconomic and demographic data to assess the origins, destinations, and impacts on incoming and outgoing individuals in the areas affected by the intervention.
- Given the lack of studies assessing the impact of transport interventions in new towns in OECD countries, policy practitioners should explore and consider the relevance of the literature pertaining to new towns arising in developing countries and / or consider commissioning studies to explore these links within the UK.

2 Introduction

2.1 Overview

The Department for Transport (DfT) has commissioned a new evidence review of existing academic literature. The focus of this review is on studies which evaluate the impact of transport policies and investments on unemployment, gentrification, productivity and establishing new settlements – and how the key methodological issue of displacement has been considered. The aim of this review is to deepen DfT’s understanding of these areas, to improve policy development, business cases and economic appraisals in future. Across the key areas of interest above, insights relating to road, rail and public transport have been prioritised. While not a priority area, insights on active travel have also been included where relevant.

This review builds on the significant work that has been published in this space. Of particular note are previous evidence reviews conducted by the What Works Centre for Local Economic Growth (WWCLEG) in 2015, and its update in 2021, which have examined labour market impacts associated with transport investment, such as employment and productivity, in detail. For these particular impacts this review has only included recent, high quality research that has not been previously covered by the WWCLEG. For other issues, such as displacement, gentrification and the impacts of transport links within and to new towns, this review has examined a longer time horizon of around 20 years. This is because there is limited existing synthesis of previous published evidence currently available.

2.2 Aims and objectives

This study has reviewed the evidence of recent studies covering the relationship between transport interventions and the following four key areas of interest:

- **Unemployment and inactivity:** understanding the extent to which transport is enticing individuals either unable to find employment or not actively looking for it into the labour market..
- **Agglomeration and productivity:** understanding the extent to which transport investments generate agglomeration economies that improve firm productivity.
- **Gentrification:** understanding the impact of transport investment on the distribution of the wider economy benefits from transport investment, including consideration of gentrification, and the displacement of firms and households.
- **New towns:** understanding the impacts of transport links within and to publicly-planned new towns across the three key areas above.

Across each of these areas, best-in-class approaches for handling the issue of displaced economic activity in terms of the key outcome variables of interest (e.g. jobs, productivity, employment or other key economic variables) have also been considered.

2.3 Report structure

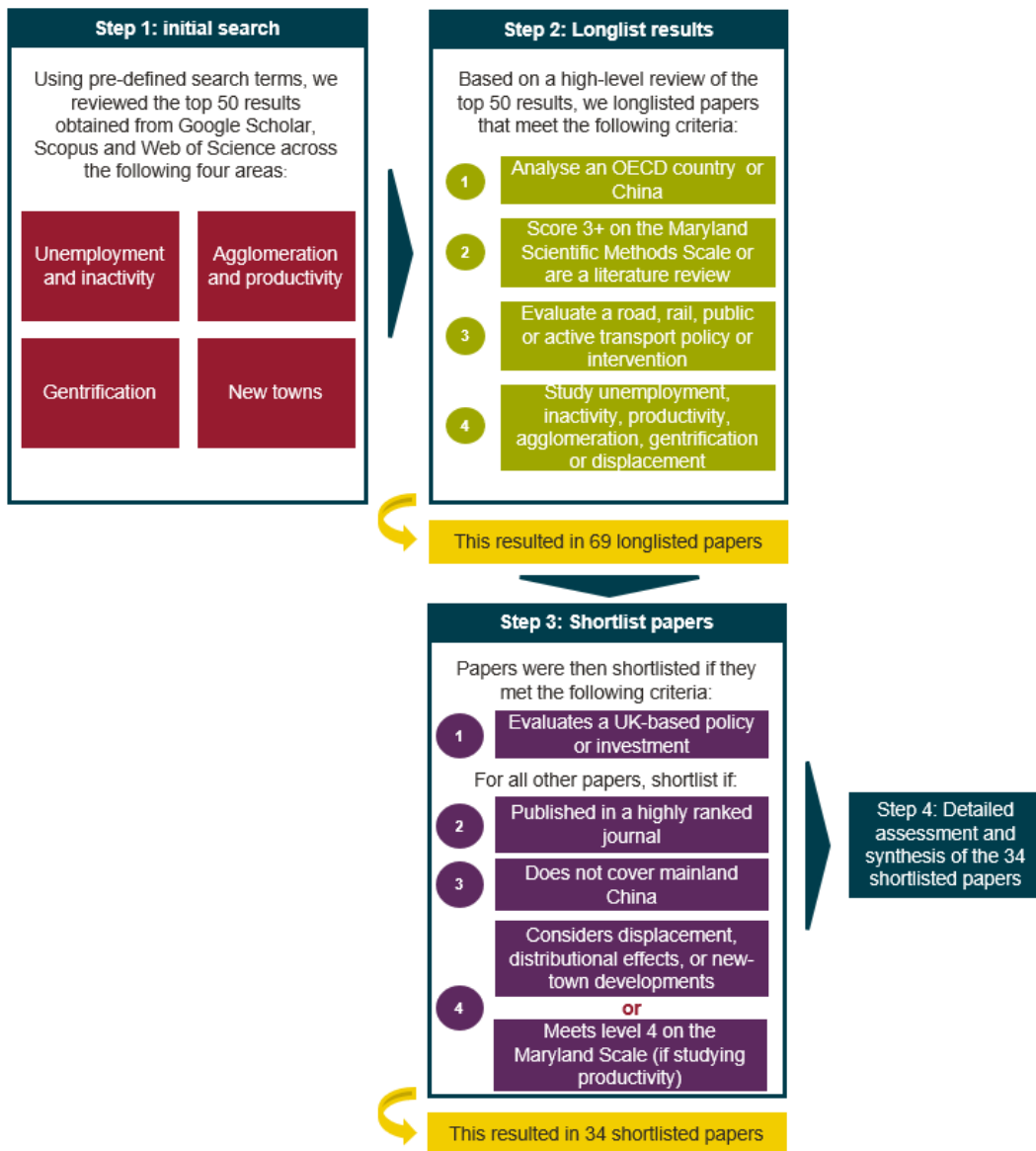
In Chapter 3, the methodology for identifying and shortlisting relevant papers for in-depth review is outlined. In Chapter 4, a high-level discussion of the features of the evidence reviewed is provided, alongside an in-depth synthesis of the papers reviewed split into the four key areas of interest above. A section on cross-cutting insights across transport modes and the four key areas of interest is also included. In Chapter 5, key conclusions arising from this review have been provided, alongside areas for future research.

In addition to this report, an Excel-based evidence assessment and collection tool has been developed. This includes all of the long-listed and shortlisted papers by various criteria, with an in-depth review for the papers meeting the shortlisting criteria. This provides an easy tool which readers can use to review in further detail the papers referenced in this report.

3 Methodology

To identify the most relevant and robust studies in this evidence review, we followed a four-step evidence assessment methodology in consultation with DfT. As Figure 2 shows, this started with defining a set of keyword combinations to enter into Google Scholar, Scopus and Web of Science. After these searches were conducted, a longlisting exercise took place. This involved only keeping studies which, from a high-level review, met four longlisting criteria. To focus the in-depth review on the most relevant studies, a further shortlisting step with an additional set of four criteria was included. This narrowed down the set of papers to 34, which is what was then used for the in-depth review in Chapter 4.

Figure 2 Four-step shortlisting methodology



Source: Frontier Economics

3.1 Search protocol

Step 1 in our four-step shortlisting methodology involved creating a search strategy to identify an initial long-list of potentially relevant studies. This involved assembling a set of keywords and Boolean operators to apply on three large and commonly used global citation databases - Google Scholar, Scopus, and Web of Science to find relevant published studies. Targeted Google searches to identify grey literature, and the websites of relevant bodies such as the What Works Centre for Local Economic Growth, Department for Transport, National Infrastructure Commission, Centre for Cities and others was also performed. The top 50 results from each search were then considered for longlisting.

Databases used for the evidence review

- **Google Scholar:** a commonly used web-based academic search engine, catalogues between 2 and 100 million records of both academic and grey literature (articles not formally published by commercial academic publishers). It can be used free of charge to collate results across the Internet. Consequently, it is a convenient way of discovering literature, in particular for the purpose of detecting grey literature.
 - **Scopus:** a source-neutral abstract and citation database, run by Elsevier, offering a highly structured search function.
 - **Web of Science:** provides details of articles and other documents from more than 34,000 academic journals (mostly peer-reviewed), as well as conference proceedings, patents and other types of document.
-

To create the list of search terms, the following factors were considered:

- **Type of transport interventions:** Studies should cover at least one of rail, road and public transport as priority areas. Insights on active travel should also be included, as well as transport interventions within and to new towns.
- **Types of outcome measures:** Studies should capture at least one of the following economic outcomes: unemployment and inactivity; agglomeration and productivity; gentrification and new towns. How papers control for the issue of displacement across these four outcomes is also of key interest.
- **Time period covered:** To avoid duplicating outcomes studied in the What Works Centre's review on transport investments in 2015, evidence for unemployment, inactivity and productivity published in or after 2015 should be collected. For gentrification, new towns, agglomeration and displacement, evidence published in or after 2004 should be collected.

With these factors in mind and in agreement with the Department for Transport, we collected evidence published in or after 2015 using the following terms:

- (“evaluation” OR “impact”) AND (“rail transport” OR “road transport” OR “public transport” OR “transport” OR “active transport”) AND (“employment” OR “unemployment” OR “inactivity”)
- (“evaluation” OR “impact”) AND (“rail transport” OR “road transport” OR “public transport” OR “transport” OR “active transport”) AND “productivity”

For outcomes not covered in the What Works Centre’s 2015 review, we collected evidence published in or after 2004 using the following terms:

- (“evaluation” OR “impact”) AND (“rail transport” OR “road transport” OR “public transport” OR “transport” OR “active transport”) AND (“agglomeration” OR “displacement” OR “gentrification”)
- (“evaluation” OR “impact”) AND (“rail transport” OR “road transport” OR “public transport” OR “transport” OR “active transport”) AND “new towns”

For each of these keyword combinations, we also reviewed the top 50 results removing the first term (“*evaluation*” OR “*impact*”) to ensure we were not missing any relevant evidence by over-specifying our search terms. We also conducted searches combining the search terms for the main set of outcomes of the study (i.e., those around employment, productivity, and gentrification) and “new towns”. Finally, we also carried out more tailored searches on new towns and active transport to avoid missing relevant evidence by using not sufficiently specific terms. This covered:

- New towns – e.g., satellite cities, greenfield developments; and
- Active transport – e.g., pedestrian, bike, e-scooter, urban mobility.

3.2 Longlisting criteria

As outlined above, the top 50 results from each search were considered for longlisting. We then applied a set of criteria each study would need to meet in order to be included in the longlist. This is to ensure only the most relevant and robust studies were selected. Both academic and grey literature were permitted to be included in the review. The inclusion/exclusion criteria used were:

1. **Evaluates a relevant mode of transportation:** rail, road, public, and active transport. All scales of intervention were considered.
2. **Evaluates a relevant outcome:** unemployment, inactivity, productivity, agglomeration, displacement, and/or gentrification.
3. **Published recently in English:** only papers published in the past 20 years were considered. This was to ensure recent innovative techniques are appropriately captured.

4. **Analyses countries comparable to the UK:** only papers analysing OECD countries were included. Based on conversations with DfT, we initially included interventions based in China, given the high number of potentially relevant papers identified through the review.
5. **Utilises a robust methodology:** only review evidence with either a) a methodology that scores at level 3 or above of the Maryland Scale of Scientific Methods (SMS) or b) is a literature review that could identify further relevant evidence. In the Maryland SMS scale, levels 3 and above refer to:
 - **Level 3:** comparison of outcomes before and after an intervention in the treated groups, and a similar before and after comparison with a valid control group to provide a counterfactual (e.g., difference-in-differences).
 - **Level 4:** quasi-randomness arising from the use of a valid instrument or a discontinuity in treatment, so that treatment and control group arguably only differ in their exposure to the intervention (e.g., regression discontinuity design, instrumental variables).
 - **Level 5:** Explicit randomisation of treatment (randomised control trials).

This led to 69 papers being longlisted. The split of these 69 papers by transport mode, outcome and study type is provided in Table 2 below. Note some papers fall into more than one mode of transport and outcome, so the “Totals” should only be read as the sum of their respective row or column header. Overall, a significant literature was found covering unemployment and inactivity – with 32 papers identified for this outcome. This contrasts with new towns, where only 5 papers were identified. Splitting papers by transport mode: rail, road and public transport (metros, light-rail lines, bus, and trams) were covered in 40, 19, and 32 papers respectively, with only 3 papers covering the impact of active transport. The majority of papers across all four outcomes of interest were empirical studies, in line with the focus of this research. Literature reviews were retained, as they provided a helpful overview of the key issues in the literature. They were also helpful for identifying further relevant literature (subject to the longlisting criteria above).

Table 2 Split of longlisted studies by transport mode, outcome and study type

Transport	Unemployment / Inactivity	Gentrification	Productivity / Agglomeration	New Towns	Total*
Rail	16	10	20	5	40
Road	8	4	12	0	19
Public	14	14	12	1	32
Active	1	1	2	0	3
Total*	32	21	31	5	

Transport	Unemployment / Inactivity	Gentrification	Productivity / Agglomeration	New Towns	Total*
Literature reviews	6	4	8	0	
Empirical studies	26	17	23	5	

Source: *Frontier Economics*
 Note: * Excluding double counting of papers.

Splitting the papers by an indication of their robustness, Table 3 reveals that the majority of papers are at level 3 on the Maryland SMS – with the most robust papers, marked as level 4, making up 16 of the 69 longlisted papers. This is expected, given the empirical challenges associated with utilising more robust methods.

Table 3 Split of longlisted studies by Maryland SMS rating

Methodology, according to the Maryland SMS	Number of papers
Level 4: Regression discontinuity design, instrumental variables	16
Level 3: Differences-in-differences, propensity score matching, panel data methods (e.g. fixed effects)	39
Literature reviews	14
Total	69

Source: *Frontier Economics*

3.3 Shortlisting criteria

Having created the longlist of 69 papers, we then entered each of these into our evidence assessment and collection tool (discussed in the next section). To ensure resources were used most efficiently and only the most relevant and robust sources were read in full and used as part of the full evidence review and synthesis, we implemented a set of shortlisting criteria. The criteria were:

- 1. Include all studies that evaluate a UK-based policy or investment:** This is to ensure potentially geographically-relevant evidence isn't discarded. Overall, 6 studies on the UK were shortlisted.

2. **Only retain papers published in high quality journals:** For studies on other OECD countries (excl. UK) + China, only keep papers in the top 25% of the Ideas RePEc ranking.⁶ This is used as a proxy for identifying higher quality papers.⁷
3. **Exclude papers covering mainland China:** Following discussions with DfT, studies covering mainland China were dropped due to their lack of relevance to the UK. Studies investigating Hong Kong were however retained to capture evidence on new towns. This is because Hong Kong has carried out an ambitious new town development plan since the 1970s. Consequently, some of the better (albeit scarce) evidence on transport investment and new town developments was found for this region.
4. **Retain those covering areas of particular interest for this study:**
 - a. We kept papers considering displacement and distributional effects (including gentrification) and / or which assessed impacts on new-town developments.
 - b. Criteria a) above was too restrictive for productivity papers, with very few considering these issues. To ensure this evidence base was reviewed, for productivity only we disappplied criteria a) and instead only reviewed productivity papers scoring level 4 or above on the Maryland Scale.

To apply these additional shortlisting criteria, the relevant sections of each paper were read to assess whether any of the longlisting or shortlisting criteria had been violated. If they had, they would be excluded. As a cross-check to ensure we were not missing any potentially relevant high-quality literature, we stress-tested the longlisting and shortlisting criteria in two ways: we ran a sensitivity on the Ideas RePEc ranking threshold, increasing this from 25% to 50%. This only led to the addition of 1 more paper, indicating that the criteria used have likely successfully identified high quality papers. We then tested this criteria with our academic advisor Tom Worsley, who is an expert in transport economics and appraisal.

Overall, 34 papers were shortlisted and signed-off by DfT for in-depth review and synthesis. The split by transport mode, outcome and study type is provided in Table 4 below. Similar patterns to Table 3 arise, with most papers found for unemployment and inactivity and very few for new towns. In additional, rail and public transport modes are again cited by most studies as the mode of interest, with only two papers covering active transport. Aside from active transport and new towns, a good mix of papers across each outcome and mode of transport are found. These papers have been subject to in-depth review and synthesis in Chapter 4.

⁶ <https://ideas.repec.org/top/top.journals.all.html>

⁷ For grey literature which was not published in journals (e.g. by the OECD), we performed our own assessment based on the reputation of the publishing organisation and the authors.

Table 4 Split of shortlisted studies by transport mode, outcome and study type

Transport	Unemployment / Inactivity	Gentrification	Productivity / Agglomeration	New Towns	Total*
Rail	5	5	7	2	17
Road	5	1	8	0	13
Public	6	7	6	0	17
Active	0	1	1	0	2
Total*	13	11	13	2	
of which literature reviews	1	3	2	0	
of which empirical studies	12	8	11	2	

Source: Frontier Economics

Note: * Excluding double counting of papers.

3.4 Evidence assessment and collection tool

The evidence assessment stage involved reading the shortlisted evidence in full to capture the information required. In addition to the criteria above, this information included the type of intervention (e.g. construction of new rail lines or roads, extension of existing ones, increase in service frequency), treatment variables, control groups used, the outcome variable, sign and size of effect and any methodological limitations or concerns amongst others. An initial peer-review of the first few studies was quality assured by the Project Manager to ensure quality and consistency of the review process.

In addition to the in-depth review and synthesis provided in this report for the shortlisted papers, we created an Excel-based evidence assessment and collection tool. This contains a breakdown and summary for each longlisted and shortlisted paper across the various dimensions outlined above. If you would like to find out more about a particular paper or apply your own selection criteria, we would recommend using the Excel-based tool. For this reason, the focus of this report is on synthesising the evidence and summarising the findings across each outcome of interest, rather than providing an in-depth discussion of each paper.

4 Economic impacts of transport interventions

4.1 Characteristics of the evidence base

The 34 papers reviewed in detail have been selected according to criteria outlined in Chapter 3. These papers cover a wide range of transport interventions – construction of railways and roads; construction and extensions of suburban rail, trams, and metros; increases in rail and bus service frequency, implementation of bike-sharing systems, improvements to pedestrian connectivity, and subsidies to train travel. They also include studies that evaluate a specific transport intervention and those that analyse broader changes to the multi-modal level of connectivity of a given city or region. In this section, we provide an overview of the geographical regions studied and the methodological approaches taken to assess impacts.

4.1.1 Geographical regions

Our analysis was limited to OECD countries, following a similar approach to the What Works' Centre for Local Economic Growth's reviews. The aim being to restrict our analysis to countries deemed most comparable to the UK. The split of countries analysed is outlined in Table 5. We see the majority of papers reviewed are EU countries. However, in terms of countries with the highest number of individual papers, the USA has seven followed by the UK with six. The high number of US studies appears to be a feature of the literature on the economic impact of transport investments (Padeiro et al., 2019). The high number of UK papers is explained by the decision to shortlist all papers in this country captured through the initial review that met the relevant methodological criteria. Nevertheless, we also anticipate that the high number of papers in both geographies is a consequence of our review only considering studies published in English.

Table 5 Papers reviewed in detail by region and country

EU	UK	North America	Asia & Oceania	Multi-country literature reviews
3x France	6x UK	7x USA	4x Hong Kong	4x Multi-country
2x Spain			1x South Korea	
1x Italy			1x Australia	
1x Poland				
1x Portugal				
1x Sweden				
9	6	7	6	6

Source: *Frontier Economics*

4.1.2 Methodological approaches

As discussed in Chapter 3, the shortlisting criteria meant only papers utilising methods at level three or above of the Maryland SMS were retained for detailed review. Of the shortlisted papers, 19 met level three (carrying out panel data regression with fixed effects or difference-in-differences (DiD) analysis), and 11 met level four (which exploit quasi-randomness using instrumental variables (IVs)).

The DiD approach is most commonly applied to assess whether being in the vicinity of new transport infrastructure (e.g., a new road) leads to a change in the outcome of interest. It does this by utilising data which denotes the transport infrastructure as completed using a binary yes/no condition (i.e. a dummy variable). The DiD approach then estimates the effect of a transport intervention by observing the difference in the outcome of interest (e.g. productivity) for the group affected by it (i.e. the treatment group) and subtracting this from the difference observed in a comparable group (i.e. the control group) that has not been affected by the intervention.

This ‘double difference’ approach can only be used when pre- and post-treatment data is available for both groups and the outcome of interest for both follows parallel trends before the intervention. The key assumption of this methodology is that in the absence of the intervention, these trends would have continued to follow a similar path into the future (i.e. the parallel trends assumption holds). While it is not possible to verify this condition, therefore limiting the ability of this methodology to fully account for endogeneity, assessing the trends between treatment and control before the intervention informs whether this assumption is likely to hold or not.

In its simplest form, DiD uses an interaction term in a regression model between time (pre- and post-intervention) and group (treatment and control) indicators to measure the effect of the transport intervention (Fredriksson and de Oliveira, 2019). Most of the papers choose as control groups untreated districts or areas in the city or region of study. In the evidence reviewed, we have not identified papers that apply matching techniques controlling for differences in observables between both groups – a potential drawback of this approach.

This contrasts with other papers which, instead of assessing the impact of specific transport interventions in a DiD setting, compute a single- or multi-modal accessibility index as a continuous treatment variable. They then study the effects of changes in this level of accessibility in the outcome of the study through a panel data regression, often with fixed effects. In most cases, these indices are a gravity model that measures how easily (based on distance, travel cost and the mode(s) of transport required) people can reach important destinations (with importance measured based on their employment or leisure offering).

The aim of these indices is to provide a comprehensive view of the transport offering in a given area. For example, the strength of the impact of the extension of a bus line in a suburban town

might depend on the extent to which it facilitates access to metropolitan rail lines that connect to a central business district. This is something that might be not accounted for with a DiD approach. Of the papers which do not use accessibility indices, they instead use measures of the physical stock of transport infrastructure (e.g., miles of motorways or railways) as the continuous explanatory variable. This illustrates the trade-off between these approaches: using physical stock has the benefit of identifying a direct relationship between the outcome variable and a tangible measure of transport infrastructure, but lacks the multi-modal comprehensiveness of gravity indices.

A key issue in the literature when assessing the economic impact of transport investments is endogeneity. This is because the decision to place a transport intervention in a given location might be dependent on other factors that also correlate with a change in the outcome of the study. For example, even if two areas show a similar pre-intervention trend in employment growth, the decision to place a transport facility (e.g., a new train station) in one of them and not the other might be part of a public and/or private endeavour (anticipated or actual) in creating an economic centre in that area through the construction of housing and office facilities. This construction will likely be correlated with subsequent employment growth but would not be captured by a pre-intervention comparison of the outcome variable in the treatment and control group. Not controlling for this or other factors such as pre-existing infrastructure in the treated area or prior positive trends in economic buoyancy in that location) can lead to omitted variable bias and a potential exaggeration of the impact of the intervention.

To control for this issue, several papers use IVs. An IV is a third factor, separate from the intervention being studied, that influences whether a participant receives an intervention but (unlike a control variable) is not directly linked to the outcome of the study. Some studies reviewed use measures of population density or car-ownership. The two most common strategies used were the 'inconsequential units' and 'planned-route' approaches – popularised by Chandra and Thompson (2000), and Baum (2007), respectively.

An inconsequential-units approach focuses the analysis on new stations placed in locations that are in the shortest path between two places that, due to their economic importance or high population, new transport facilities aim to link. As these stations are in the middle of two major destinations, this arguably makes the location of the new station independent of other economic factors.

In contrast, the planned-route approach uses the locations of previously planned routes (both discarded and built) as the IV. The rationale being that while the location of a past transport plan (e.g. from decades ago) may explain the location of new stations, the time passed since its construction it is unlikely to be correlated with current economic factors that might affect the location the new station. Through instrumenting the location of a new transport plan with the location of an old one, the resulting estimates should causally link the impact of the transport intervention to the outcome of the study – removing the impact of prior positive trends in economic buoyancy in that location. The planned route approach was the most common IV used in our review.

A second key issue in the literature is displacement. That is, assessing whether interventions generate net increases in employment and productivity at the national or local level, or simply ‘move’ (i.e. displace) economic activity from one place to another. A key feature of the methodologies reviewed is that they rely on the Stable Unit Treatment Value Assumption (SUTVA). This states that the outcome of any unit (e.g. firm or individual) in the treatment or control group is unaffected by the treatment assignment of other units (Rubin, 1980). In other words, the fact that people or firms affected by a transport intervention received treatment should not impact the outcome of those who did not receive it. Given the presence of displacement effects would violate SUTVA, econometric methods are needed that control for this.

The studies in our review apply different methodologies to model spatial dependencies that violate SUTVA so that treatment effects can still be estimated correctly. First, several papers (Arbués et al., 2015; Fageda and Gonzalez -Aregall, 2017; Sobieralski, 2021) apply a ‘Spatial Durbin Model’ (SDM).

The key feature of this approach is the introduction of spatial lags of independent and dependent variables as explanatory ones through a spatial weight matrix that usually captures whether two areas or districts are adjacent to each other. This allows the researcher to compute the total effects of the intervention as the sum of its direct (those on treated areas) and indirect (those on adjacent areas) effects. Rokicki and Stepniak (2018) follow a related yet different approach by applying the methodology proposed by Kelejian and Robinson (2017), which includes spatial lags of the outcome and an explanatory variable, but does not include lags of the treatment variables.

Other papers use different approaches to study the indirect effects of a transport intervention. Pogonyi et al. (2021) and Mayer and Trevien (2017) follow Redding and Turner (2015) which argues for the use of the already discussed planned-route and inconsequential units approaches, and the estimation of the treatment effect in the following way. This involves identifying the differences between the treated (next to a transport investment) and residual (zone farther away, not affected by intervention) areas, and the untreated (zones adjacent to those treated) and residual areas. In this way, they are able to disentangle which part of the effect is due to actual net growth in the outcome variable and which is due to displacement from the untreated to the treated area. Finally, Pogonyi et al. (2021) also accounts for displacement by measuring the number of firm exits and sectoral composition in the treated area.

Underpinning these methodological discussions is an overarching question about whether the goal of policymakers and therefore focus of appraisal should be estimating average treatment effects (ATE) (i.e. assuming the whole population was affected by a transport intervention, and estimating the average impact) or average treatment effects on the treated (ATT) (i.e. estimating the average impact across only those people or firms actually affected by the transport intervention). If assignment of transport interventions were random, then ATE would

equal ATT. However, the UK Government does not randomise transport interventions, meaning these two measures differ. The key question for policymakers is whether there is value in understanding how treatment effects differ in the population (i.e. which is causing ATT to differ from ATE) to better understand estimated treatment effects for the schemes that take place.

4.2 Unemployment and inactivity

Summary of results

The evidence reviewed finds evidence that transport interventions are associated with employment growth . Most of the papers analysed only focus on employment metrics in the areas affected by an intervention, rather than assessing the specific mechanism which explains the change in employment seen. Of the papers assessing impacts on neighbouring areas, significant displacement of employment from these areas is found. This suggests moderate to zero net impacts on local or national employment, with different papers covering different geographical scopes . Further, among the evidence reviewed, only two papers analysed unemployment rates, with only one analysing long-term and youth unemployment rates (proxies for structural unemployment). None of the papers measured the effect of an intervention on economic inactivity.

4.2.1 Overview of the evidence

The impact of transport investments on employment refer to changes in the number and distribution of jobs. Such investments impact employment by influencing labour supply and potentially relocating jobs to more productive areas. The impacts on employment can come through two channels:

- Transport investments can reduce travel costs, therefore improving accessibility and possibly labour market participation. This can lead to better job matching, changes in working hours, and reductions in inactivity, potentially increasing national employment (Department for Transport, 2019a).
- Transport investments can shift the spatial distribution of employment. Improved transport links may relocate jobs to areas with productivity advantages, boosting overall economic performance. However, these effects are context-specific, and depend on local characteristics like resource endowments and the presence of existing economic clusters (Department for Transport, 2019a).

The evidence reviewed generally does not deal directly with the first consideration, and so fails to discuss explicitly the channels through which transport interventions lead to better job matching or decreases in inactivity. Instead, most of the evidence studies employment growth

rather than the unemployment rate in the affected areas – and none of them studying a direct measure of economic inactivity. Some papers reviewed do however analyse a sufficiently broad area (e.g., a whole metropolitan area or country) such that any effect of transport infrastructure on employment, subject to a correct econometric strategy, would not reflect job displacement but generate net impacts.

On the second of the two channels, understanding spatial distribution changes and potential displacement of economic activities is key to evaluating net impacts. Displacement in this context refers to the extent to which local employment changes reflect jobs shifting from other areas, rather than leading to net increases. It is key that econometric techniques identify the effect of transport interventions on neighbouring areas, in addition to those areas benefitted directly from the transport intervention. Several, but not all papers reviewed consider this issue in their econometric design.

The most common methodological approach in the evidence reviewed was either a DiD or panel data regression with fixed effects. Three papers identified used instrumental variables. This includes Pogonyi et al. (2021) who used the planned-route approach discussed in the previous section to analyse the employment and productivity impact of the extension of the Jubilee Line in London. Fageda and Gonzalez-Aregall (2017) use one- and two-year lags of employment to study the effect of the construction of railways, motorways, ports, and airports in this variable in Spain. Bastiaanssen et al. (2022) studies the effect of public transport accessibility on employment in Great Britain using population density as the IV. Two papers apply a SDM to account for indirect spillover effects – Fageda and Gonzalez-Aregall (2017) and Sobieralski (2021) – to study the employment effect of road and rail transport provision across US metropolitan areas.

We reviewed 12 empirical studies that assess the impact of transport interventions on employment. The jurisdictions studied include the UK (four papers), France, the US (two papers each), Italy, Spain, Hong Kong, and Portugal (one each). Five of these papers study the effect of a specific transport intervention, with a further five studying the effect of a multi-modal accessibility index at a city- or country-level. Three papers assess the effect of the physical stock of transport infrastructure at a metropolitan-area or country level, and one assesses the impact of a public transport subsidy.

4.2.2 Results

As shown in Table 6, the evidence reviewed generally finds positive but modest impacts of transport interventions on employment growth. Directly comparing estimates between studies is challenging given they each use different metrics to assess transport interventions. For example, some papers relate the physical stock of rail infrastructure in km to employment, whereas others relate multi-modal accessibility measured through a gravity index, or the construction of a rail line through a given district. Differences in the geographical scope analysed also makes generalising the results difficult.

Table 6 Summary of results for unemployment and inactivity

Author(s)	Transport intervention studied	Results
Bastiaanssen, et al. (2022)	Study of public transport accessibility in Great Britain	For urban areas, a 10% increase in public transport job accessibility results in a 0.13% increase in employment probability
Di Matteo, D., & Cardinale, B.	Construction of high-speed rail in Italy	Reduction of income inequality by 0.3% through an increase in employment
Dixon, et al. (2019)	Construction of Stirling-Alloa rail line (Scotland)	The main contribution is methodological, developing an accessibility index that accounts for skill-matching. They show that increased transport between the two towns would not increase skill-matching in the labour market.
Fageda and Gonzalez-Aregall (2017)	Construction or extension of motorways, railways, port and airports in Spain	For motorways, employment growth in the affected region fully offset by decline in the neighbouring ones.. For rail interventions, neither effects are statistically significant. Ports are the only mode of transport that show positive and significant total effects.
Gibbons, et al. (2019)	Study of Road accessibility in Great Britain	10% increase in accessibility associated with a 5% increase in local employment
Holl, A.	Construction of motorways in Portugal	Increase in firm births in a 10 kms radius of the new motorways and decrease in a 10-50kms radius
Mayer and Trevien (2017)	Construction of a railway connecting central Paris and	8.8% and 4.6% increases in employment and number of

Author(s)	Transport intervention studied	Results
	new suburban economic centres	firms respectively in the municipalities connected to the new railway.
Pasha, et al. (2020)	Impact of bus and rail transit service frequency (Cleveland, US)	10% increase in transit intensity is associated with 8% and 12% growth in employment one and two years after the transit increases.
Pogonyi, et al. (2021)	Extension of metro line (London)	Increase in employment in a radius of 750 metres from the station, and decrease between 750-2000 metres, with a negligible overall effect
Sari (2015)	Construction of a tramway in disadvantaged neighbourhoods in Bordeaux (France)	Decreases of 3.6, 5.4, and 23 percentage points in the rates of unemployment and unemployment for 15-24 year olds, and the percentage of unemployed individuals experiencing long-term unemployment, respectively.
Sha, et al. (2020)	Cross-district transport subsidy to low-income employees and job seekers in towns in the metropolitan area of but distant from central Hong Kong	Reductions of 2 and 1.2 percentage points in unemployment 4 and 9 years after the intervention
Sobieralski (2021)	Construction of road and rail infrastructure in metropolitan areas in the US	Overall positive total effects for road infrastructure on employment, with negative indirect effects that do not completely offset the positive direct ones. Weaker results for rail infrastructure, only showing positive effects

Author(s)	Transport intervention studied	Results
		for those metropolitan areas with lower car-ownership

Source: *Frontier Economics*

Regarding the evidence in the UK, three of the five papers analyse the elasticity of employment to a gravity-based accessibility index. Bastiaanssen et al., (2022) study the effect of public transport accessibility (including rail) and employment across Great Britain, identifying that a 10% increase in public transport job accessibility results in a small but statistically significant 0.1% increase in the probability of finding employment. Gibbons et al. (2019) conduct a similar exercise but for road accessibility across Great Britain, finding a 10% in accessibility is associated with a 3% and 5% increase in the number of establishments and employment, respectively.

Finally, Dixon et al. (2019) develop an accessibility index that takes into consideration the feasibility of combining travel modes considering the frequency of their service. Their index also considers skill matching by considering the profile of jobs in the destination and the occupations of workers at the origin. Nevertheless, the main contribution from this paper is methodological rather than empirical. While they apply their index to analyse how their index simulated the increase in accessibility due to the construction of a rail line between Stirling and Alloa (Scotland), they do not apply their index to study employment effects directly.

Most of the studies analysed only assess the impact on employment in aggregate. They do not perform their analysis at a granular-enough level to distinguish the effect of a transport intervention on different types of unemployment (e.g. frictional or structural). The exception is Sari (2015), which studies the construction of tramlines in less affluent areas of Bordeaux in France. Overall, they find material effects for each type analysed. They estimate reductions of 3.6 percentage points in the overall unemployment rate, 5.4 percentage points in the unemployment rate of 15 to 24 year olds, and a 23 percentage point reduction in the percentage of individuals who are long-term unemployed (as a portion of all unemployed individuals). Nevertheless, it is debatable the extent this paper fully accounts for the endogeneity of receiving transport investment and other factors affecting economic conditions of the district, as they did not apply an IV approach.

Several studies examine the issue of displacement – i.e. whether the transport intervention created additional economic activity or only rearranged it to the vicinity of the new infrastructure. Mayer and Trevien (2017), Pogonyi et al., (2021) and Sobieralski (2021) examine this issue at a more granular level, looking at the effect of urban and suburban rail on employment in Paris, London, and series of US major metropolitan areas respectively. This contrasts with Holl (2004), Fageda and Gonzalez-Aregall (2017), and Di Matteo and Cardinale (2023) who examine this issue at a broader geographic level, assessing the impact of new railways and motorways at the country level.

Mayer and Trevien (2017) study whether the construction of a suburban rail line connecting central Paris with new economic activity centres in the metropolitan area had an effect on the towns placed between the two. For these towns, the authors take an inconsequential-units approach and contend that the decision to place a station in these towns is independent of a prior positive economic trend, and is only influenced by the fact that they were in the shortest path between the economic centres and central Paris. This leads the authors to argue that treatment (i.e. receiving a new station) is considered “as good as random” for these locations. They find an 8.8% increase in employment and a 4.6% increase in the number of firms in these towns. In addition, they do not find a displacement effect in neighbouring regions. Nevertheless, Mayer and Trevien (2017) point out that the construction of the rail line was part of a wider decentralisation plan across the Paris metropolitan region. Therefore, displacement might have occurred through employment relocating from central Paris to the treated towns, rather than from neighbouring areas. Their econometric design does not test this hypothesis.

Similarly to Mayer and Trevien (2017), Pogonyi et al., (2021) apply a combination of the inconsequential-units and planned-route IV approaches to study the employment impact of the extension of the Jubilee line for those stations placed between central London and the new centres of economic activity that the line envisioned to connect: Canary Wharf and North Greenwich. Pogonyi et al., (2021) find a statistically significant 10% increase in employment in the immediate vicinity (0-100m) of the new stations. The positive impact decreases by around 1.3 percentage points every 100 meters, and from 750 metres to 2000 metres from the station becomes negative. Netting off the two contrasting effects, they do not find statistically significant employment growth. This points towards the Jubilee line extension having a mainly displacement, rather than an employment growth, effect. Nevertheless, the authors conduct a quadratic-form regression analysis of employment and number of units and, in this case, find net positive, yet moderate, effects. While they still consider the linear regression analysis their preferred estimation procedure, this raises the question of how robust the results are to model specification.

Finally, Sobieralski (2021) analyse the direct and indirect effects of the construction of new rail and road infrastructure in 14 major US metropolitan areas. They take a SDM approach and, similarly to Pogonyi et al. (2021) and Mayer and Trevien (2017), study the effect of this construction in areas adjacent to those treated. Although their findings vary across metropolitan areas, they find overall positive effects for highway infrastructure on employment for all metropolitan areas but only for a few for railway infrastructure. In particular, they find positive results for railways for cities with extensive pre-existing rail systems - Chicago, Detroit, New York, Seattle, and Washington, D.C, and Boston – but not for others which are more car-centric. While both direct and indirect effects of railway infrastructure are generally positive and modest (but in many cases not statistically significant) – that is, their effects reinforce each other - the construction of highway infrastructure has positive direct but also negative indirect effects. While the authors find that road investments lead to some displacement of employment, the net effects are positive overall.

Holl (2004) and Fageda and Gonzalez-Aregall (2017) find evidence of displacement effects for the construction of road and rail infrastructure. Holl (2004) observes firm births, which they

use as a proxy for employment, in radii from 10 to 50 kilometres from the construction of motorways in Portugal. They find increases in firm births within a 10kms radius, negative effects beyond that and up to 50 kms, and negligible effects after that – but do not comment on whether the net effect is positive, negative or neutral overall or the magnitude of the effects.

Fageda and Gonzalez-Aregall (2017) on the other hand analyse the impact of the construction of railways and motorways on industrial employment in Spain. As with other studies discussed, they apply a SDM that considers adjacent provinces within radii of 150kms, 300kms, and 450 kms (depending on the specification) to be indirectly treated. The results show non-significant results of motorways and rail interventions when direct and indirect effects are considered together. In the case of motorways, the direct and indirect effect are both significant - the former being positive and latter negative. In the case of railways, neither effect is significant. They find ports are the only mode of transport that shows positive and significant total effects on industrial employment, with it creating positive spillovers for industrial employment in neighbouring regions.

Finally, in a more indirect manner, Di Matteo and Cardinale (2023) study the creation of high-speed railway in Italy on income inequality. They find that being in a region with access to this new railway was associated with a reduction in income inequality within that region ranging from 0.2 percentage points to 0.3 percentage points when rent expenses are included and excluded, respectively. They find that increases in employment and GDP growth resulting from the new high-speed rail line both contribute towards the reduction in income inequality seen.

The final evaluation of a single transport intervention is Sha et al., (2020). This paper provides evidence of a different type of transport intervention, carried out in Hong Kong, directly aimed at stimulating employment supply by overcoming commuting barriers that could prevent them from being part of the labour force. This policy consisted of a grant for intertown travel to low-income and / or unemployed residents in the new town developments farthest from central Hong Kong. Such cities are farthest from the city centre, meaning individuals might have greater difficulty accessing the central area of Hong Kong where most jobs reside.

The authors study the effect of the policy through a DiD approach, comparing the treated towns with those who were slightly less remote which did not receive the subsidy. The results suggest a long-lasting effect on employment: four years after implementation, it was associated with a reduction of 2 percentage points in the unemployment rate. The overall effect slightly decreased 9 years after the policy with a reduction of 1.2 percentage points compared to the pre-intervention period. In addition, it was also associated with a 3.1 percentage point increase in cross-district employment (i.e. individuals working outside their district of residence) four years after its implementation, with this becoming insignificant after nine years.

4.3 Agglomeration and productivity

Summary of results

The evidence suggests transport investments are associated with increased levels of firm and labour productivity. Behind these impacts though, there is tentative evidence of ‘sorting effects’ where firms from higher-productivity sectors enter areas affected by transport interventions and others from less productive ones leave. It is therefore unclear whether firms existing in the area prior to the intervention experience productivity increases, and what the impact on those firms which leave the area is. Further, the evidence of the productivity impact on neighbouring areas - both at the national and local level, depending on the scale of the intervention - is inconclusive. Some papers find positive net effects, and others negative. A feature of the literature is a lack of studies analysing specific transport interventions. Instead, many assess the links between general transport accessibility at a national, regional, or metropolitan-wide area and productivity. This limits the scope for understanding the impact of different types of transport interventions and the presence of potential ‘sorting effects’.

4.3.1 Overview of the evidence

Productivity is defined as the amount of output produced from a given unit of input. An improvement in productivity is therefore the ability to produce more outputs, holding the level of inputs constant. As outlined in the Transport Analysis Guidance (TAG), transport investments can impact productivity directly by reducing travel times. This may lower costs for businesses, improve the quality of inputs they buy (by improving their access to suppliers) and increase the number of customers they can serve (Department for Transport, 2022). Such productivity benefits are called ‘direct user benefits’.

There are however additional productivity benefits that might accrue where market failures are present – that is, where free markets do not lead to an efficient allocation of goods. Agglomeration economies arise when businesses become more productive when co-locating together in urban conurbations, with their productivity increasing the more other businesses choose to co-locate there (Department for Transport, 2019b). When agglomeration economies are present in a free market, the clustering of economic activity may be sub-optimally low. By encouraging firms to co-locate, transport interventions may therefore impact productivity and address this market failure.

In our review of the literature, we analysed 13 papers in detail – 11 empirical studies and 2 literature reviews – that study the impact of transport interventions on productivity. The jurisdictions reviewed include the UK (two studies), Australia, Hong Kong, Spain, South Korea, Sweden, and the US. All of these papers study the productivity effects arising from agglomeration, rather than direct user benefits. Of these papers, only one studied the impact of a specific transport intervention in isolation in one location; Pogonyi et al. (2021), which is

discussed above. Instead, most papers analysed assess how the overall transport offering, measured through physical units such as kilometres of railways or accessibility indices, affects measures of productivity by studying a wide geographical area.

The aim of accessibility indices used by the majority of papers is to measure how easily individuals can access and interact with 'economic mass'. Economic mass is defined as the effective density of the labour market at each location (Vickerman, 2018), and is usually measured through the number of jobs, the population, or the gross value added (GVA) in a given region (Venables et al., 2014). This means the more jobs, people or economic activity there is in a given area, the greater economic mass it has. To calculate Access to Economic Mass (ATEM), an approach called 'mean effective density' (MED) is used. This weighs economic mass by a distance / travel cost impedance function with a (linear or non-linear) decay parameter. In other words, an area's ATEM is greater the 'closer' it is to economic mass. Transport interventions which bring areas 'closer' together through reduced travel costs (both financial and time) therefore increase an area's ATEM and through potential agglomeration effects their productivity too. ATEM is at the centre of the accessibility indices used in the literature.

A key question in the productivity literature is whether the people in a given area become more productive from transport interventions, or simply the affected area becomes more attractive for productive individuals or firms who then move there – often referred as the 'people vs place distinction' (SERC, 2009). On the one hand, a transport intervention can help an individual find more productive jobs. On the other, the impact can be mostly dominated by more productive firms and individuals 'sorting' into the area served by such transport intervention. If this happens, a simple before-after comparison would mistakenly attribute productivity gains to the transport investment without considering the negative effect this might have had on firms or individuals that left the area. Only by controlling for this effect - i.e., controlling for displacement – can any productivity effect be isolated.

In the studies analysed, only Pogonyi et al. (2021) directly observes the industry of firms entering and exiting the vicinity of a specific transport investment, and therefore whether 'sorting' (i.e. displacement) appears to be taking place. It does this by analysing the sectoral shifts taking place in the immediate vicinity of a new Metro line station in London, and comparing that to sectoral shifts outside the immediate vicinity of the new station. It also controls for endogeneity by using an instrumental variable: the presence of planned (realised or discarded) routes where stations have been placed.

While one study applies the SDM to account for indirect effects adjacent to treated areas, it does not directly observe firm entries and exits. Further, most studies only control for the characteristics of the firms in a given census tract using fixed effects, and do not directly account for the ones adjacent to treated areas. This highlights a trade-off in the literature: while studies like Pogonyi et al. (2021) study effects at a more granular level and take a more robust approach, their results are less generalisable than studies using accessibility indices (which take into consideration multi-modal transportation and cover a wider geographical scope but often use less robust approaches).

The papers analysed also differ in how they measure productivity: five use firm productivity and seven labour productivity (LP).⁸ Firm productivity, often measured through total factor productivity (TFP), aims to capture how efficiently all inputs into production are combined, whereas LP only captures the contribution of labour. The papers taking a TFP approach typically used gross value added (GVA) per firm or production per employee as the dependent variable of the study. They then assume a Cobb-Douglas production function, with the “technology parameter” capturing the productivity impacts of transport investments once labour and capital inputs are controlled for. For studies using LP, the main measure used is wages.

Both measures of productivity have limitations. For TFP, the agglomeration elasticity calculated may also capture non-agglomeration related effects (Grahams and Gibbons, 2019). Further, this approach requires detailed site-based data on capital and labour inputs for multi-site firms, which are often less widely available. For LP, this approach implicitly assumes wages equal marginal product. This only holds if perfect competition is assumed. As the world is unlikely to be perfectly competitive, an increase in accessibility could result in increased competition. The observed effect of the transport intervention could therefore be measuring a change in the relationship between wages and labour productivity, rather than a change in labour productivity itself.

4.3.2 Results

As Table 7 shows, 10 of the 11 papers analysed find a statistically significant positive effect of transport accessibility on productivity. These papers cover urban and rural areas and use different measures of productivity; seven studies measure productivity through firm productivity, controlling for capital and labour inputs; five use wages as a measure of productivity; and one uses sectoral shift as a proxy for productivity (with some papers using more than one approach). For labour productivity, all find positive effects – whereas for firm productivity, the results are mostly positive.

Table 7 Summary of results for agglomeration and productivity

Author(s)	Transport intervention studied	Results
Arbués et al. (2015)	Construction of motorways and railways in Spain	10% increase in road infrastructure in a province leads to an increase in its firm productivity of 0.4-0.7%, and of 0.3-0.5% in the one of neighbouring regions – hence, in total, 0.8%-1.2%

⁸ Note that some papers assess both labour and firm productivity. In addition, Pogonyi et al. (2021) studies sectoral shifts through firm entries and exits in the surrounding areas of a new transport investment, rather than studying a direct measure of productivity.

Author(s)	Transport intervention studied	Results
Börjesson et al. (2019)	Construction of tram lines and roads, capacity increases in suburban trains, and extensions of the bus network in the Middle Sweden regions, which includes the Stockholm metropolitan area	10% increase in accessibility results in a 0.3% increase in wage earnings
Chatman and Noland (2014)*	Rail and bus improvements across US metropolitan areas	10% increase in bus and rail seats per capita is associated with a 0.2-0.3% increase in wages
D'Costa (2013)*	Construction of road and rail infrastructure in Britain	10% increase in road and rail accessibility linked with 0.7% and 0.3% increase in wages
Gibbons et al. (2019)	Road construction in Britain	10% increase in road accessibility leads to 2.8% increase in firm productivity
Ivaldi et al. (2022)	Construction of rail and tram infrastructure, and extension of bus lines, in the Toulouse Metropolitan Area, France	10% increase in road accessibility is linked with 0.5% and 0.6% increase in firm productivity
Lee (2021)	Construction of rail and road infrastructure in the Seoul region	10% increase in accessibility leads to a 0.5% increase in firm productivity
Pogonyi et al., (2021)	Extension of the Jubilee metro line in London	Evidence of sorting effects, with a sectoral shift towards business firms near the stations of the new line, with an increase in firm entries and exits compared to the control group.
Rokicki and Stępniaak (2018)	Construction of motorways and express roads in Poland	No significant effect on productivity
Sheng et al. (2018)	Road and rail infrastructure in New South Wales, Australia	10% reduction in rail transport costs associated with 3.3% increase in agricultural productivity
Zhou (2022)	Construction of urban rail, roads, and pedestrian facilities in Hong Kong	10% increase in rail accessibility associated with 4.1% increase in firm productivity

Source: *Frontier Economics*

Note: * These papers were retrieved via the agglomeration evidence searches, which covered papers post 2004 (unlike productivity, which was post-2015 only).

Assessing how effects differ by mode of transportation is challenging for productivity, as most papers reviewed use multi-modal levels of accessibility. For the same reason, the geographical areas studied often covered entire cities or regions rather than subsets of them. While this means it is not possible to compare the relative merits of particular transport interventions, the advantage of this multi-modal, whole-city approach is that the results are likely less dependent on the specific local context of a particular transport intervention. They also account for the fact different modes of transport often interact (e.g. having bus routes linking to rail stations).

Regarding whether the 'sorting' of more productive firms into treated areas is the reason behind the positive effects found, the majority of papers reviewed provide limited evidence. The one paper that examines this issue most directly is Pogonyi et al. (2021). They do this by observing firm entries and exits to assess changes in the sectoral composition in areas surrounding new Jubilee line stations in London. Within a 750 metres radius of new stations, Pogonyi et al. (2021) find an increase in both the number of firms establishing in the area and those leaving. While they do not observe a significant change in the number of firms leaving the area within a 750 and 2000 metre radius from a new Jubilee line station, they do observe a significant increase in firms relocating to a 750 metres radius. The new firms entering within the 750m vicinity of the station change the area's sectoral composition, as the ratio of business sector employment in these areas increased from 37% to 45% while the one of retail and manufacturing decreased.

Rokicki and Stępnik (2018) and Arbués et al. (2015) also explore the potential displacement of economic activity from transport investments. The former analyses the effect of the construction of roads across Polish provinces on firm productivity, with the latter analysing the impact of the construction of roads and railways on firms' productivity across Spanish provinces. The results of the two papers conflict. On the one hand, Rokicki and Stępnik (2018) who utilise a spatial econometric model do not find a statistically significant relationship between road accessibility and productivity between 2004 and 2014 (instead they find a weak positive relationship with employment). Instead, they find that road investments are negatively correlated with output growth in rural areas. This suggests that in the absence of material productivity benefits for urban areas, they may still displace economic activity away from rural regions.

On the other hand, Arbués et al. (2015) take a SDM approach and only find significant positive results for roads. The strongest productivity effects are found for Spanish provinces through which the new infrastructure is built (with a 10% increase in the number of kilometres of road built being associated with a productivity increase for firms of 0.4-0.7%). For those provinces within a maximum 150 kilometres radius of those treated provinces, a 0.3-0.5% increase in firm-level productivity is found.

The remaining papers do not directly observe firm entries and exits or compute indirect effects using the SDM approach. Most do however include fixed effects and control for various characteristics at the geographical level they run their analysis at. While this allows them to isolate the effect of changes in transport accessibility on productivity from productivity impacts

arising from the changes in the average composition of firms in these areas, it does not account for potential displacement effects.

Beyond the evaluation of the extension of the Jubilee line (Pogonyi et al., 2021) already discussed, two further UK-focused papers conduct Great Britain-wide analyses of the effect of accessibility. Gibbons et al. (2019) takes a panel data regression approach with fixed effects to assessing the impact of road accessibility, and finds that a 10% improvement is associated with a 2% increase in output per worker. D'Costa et al. (2013) take a more novel approach, analysing the effect of rail and road accessibility using a series of fixed effects regressions which systematically increase the number of control variables. For a 10% increase in car accessibility, the authors only find statistically significant evidence of a 0.7% growth in wages for the two specifications with the highest number of control variables. For a 10% increase in rail accessibility, the authors find evidence of significant effects for all seven specifications. The magnitude of the estimates decrease as more control variables are included. This ranges from 2.5% increase in wages with no controls, to a 0.3% increase when age (linear and squared), gender, education, occupation characteristics and industry, individual fixed effects, and area characteristics are included. This highlights the importance of correctly controlling for alternative factors when assessing the impacts of transport interventions, as not doing so may under or overestimate the effects.

4.4 Gentrification

Summary of results

Gentrification often refers to the process whereby less affluent residents are crowded out by more affluent ones. In the context of transport investments, the literature uses one of two proxies to measure this: changes in house prices, or in the socioeconomic and demographic composition of an area. Overall, the literature consistently finds that transport interventions are associated with increases in house prices. However, when papers analyse socioeconomic and demographic changes in areas – arguably a more direct measure of gentrification - the results are inconclusive.

The evidence also indicates that the effect of a transport intervention may depend on the income group it is targeting, with light rail, tram and metro developments seemingly more likely to lead to gentrification than the extension of bus lines. Further, the methods used to assess gentrification were generally found to be less robust than the literature for other outcomes covered in this review. They do not account for the endogeneity that may arise from the non-random placement of transport infrastructure, or the fact that transport developments may happen simultaneously with housing developments. In addition, the studies generally covered a relatively short time period, potentially underestimating longer-term effects.

4.4.1 Overview of the evidence

In the previous two sections, the evidence suggests that transport investments can affect the location of economic activity, with firms and jobs gathering around new transport interventions. In this section, we examine their effect on the potential displacement of people existing in an area before a transport intervention in favour of more affluent residents after an intervention – a process often called gentrification (Bardaka et al., 2018). A gentrifying neighbourhood is then one in which these changes are said to occur at a higher rate than in the overall metropolitan region (Fernando et al., 2021). While gentrification as a process is defined by the displacement of existing residents, the evidence reviewed attempts to measure it using one of two metrics: some analyse changes in house prices as an indirect measure, whereas others directly assess the socioeconomic and demographic characteristics of the people living in the affected areas before and after the intervention.

House price increases are used a proxy for the wider amenity value of transport intervention and, in turn, as a proxy for displacement of individuals. The hypothesis is that the increase in the demand for housing near the new or improved transport facility causes long-term residents to move away as living in its vicinity is no longer affordable. If being priced out is correlated with socioeconomic and demographic characteristics, then house prices act as a proxy for gentrification. These higher prices come about because housing supply is relatively inelastic, especially in densely populated areas (Howard and Liebersohn, 2021). In the UK, this elasticity appears to be even lower than in other developed countries such as the US or Australia (Ball et al., 2010).

The key question for gentrification however is whether a) the new transport intervention improves the attractiveness of the area sufficiently that an increase in demand (and therefore prices) is observed; and b) even if this appreciation is observed, whether the improved accessibility to employment the new facilities might provide allows existing residents to sufficiently improve their economic status so that are not displaced by higher prices.

Finally, the displacement effect created by housing prices will be exacerbated or mitigated depending on factors such as the home ownership rate and/or the presence of rent controls (e.g. prevalence of social housing). House prices only therefore act an indirect and partial measure of gentrification. Therefore, a study aiming to capture gentrification effects should ideally observe, at the individual level, the number of entries to and exits from the affected area (and where individuals go to and come from). However, the papers reviewed that study sociodemographic composition changes do not conduct analyses with this level of granularity. Moreover, many focus on house prices while controlling for the socioeconomic and demographic characteristics of the area analysed. This is a key methodological limitation of the literature as a whole and, in particular, house-price based analyses.

Padeiro et al., (2019), one of the literature reviews on gentrification analysed, also highlights that much of the evidence on gentrification is subject to methodological flaws. This includes studies not using appropriate control groups and not accounting for endogeneity, spatial autocorrelation, and / or spillover effects. They identify a stronger link between transport

investments and gentrification in studies that focus on the construction / expansion of one bus or rail line than if several lines are constructed simultaneously – which they attribute to a better methodological accounting for the issues discussed above rather than to a feature of the intervention itself.

We also analysed two further literature reviews on gentrification which highlight interesting nuances in the relationship between transport investments and gentrification. First, Delmelle (2021) points out that the characteristics of the development itself is one of the major drivers behind the presence of gentrification, with this phenomenon more likely to appear in developments with strong design principles (mixed land-use⁹, walkability). The paper also identifies that those in the vicinity of a new station might actually observe a decrease in property values, with property increases only being observed 250 metres from it onwards, peaking at 500 metres away. Separately, Rennert (2022) shows how different transit modes impact property values differently; commuter rail services tend to have higher premiums than light rail services, likely due to perceived permanence and higher quality of service.

4.4.2 Results

We reviewed eight empirical studies that explore the relationship between transport investments and gentrification. These are outlined in Table 8 below. Studies from the US dominate, with five papers analysed. We also analysed two papers from Hong Kong and one from the UK. Six of the papers employ a DiD approach with a binary treatment of proximity to a new transport development, with two combining multi-modal accessibility indices with panel data regressions that utilise fixed effects. As gentrification is predominantly an issue arising in densely populated regions, all studies reviewed covered urban and suburban areas. In terms of transport mode and scales, five cover urban rail (metro and light-rail), one an extension of bus routes, another on service frequency of bus and rail, and a final one covering a bike-sharing system.

Table 8 Summary of results for gentrification

Author(s)	Transport intervention studied	Results
Bardaka et al., (2018)	Construction of a new light-rail line in Denver (US)	10% increase in the proportion of directly treated neighbours (less than a mile from a station) is associated with a 25% increase in median housing values and 14.4% in household income 6 years after the opening of the rail line. No change in

⁹ Mixed land use in this context is the development of transport interventions as part of a bigger development of residential and commercial facilities.

Author(s)	Transport intervention studied	Results
		educational background of the residents.
Delmelle and Nilsson, (2020)	Construction and extension of rail lines across metropolitan areas in the US	No increase in the probability of moving out for low-income households less than 0.25 miles from station 5 year after the intervention.
Fernando et al., (2021)	Construction of a light rail line in Manchester (UK)	Long-term (10-25 years after construction) 4.9% decrease in the proportion of elderly population and 15% housing appreciation, while 6% reduction in household income less than a km from a station.
He, (2020)	Construction of a metro line in Hong Kong (China)	10% increase in rail accessibility led to an approximate 3.5% increase in property prices
Liang, et al., (2022)	Construction of a metropolitan rail service (Hong Kong, China)	Increase of 7.8% of highly educated residents and reduction of 5.85% in the number of low-income households 3-5 years after construction of the rail line 600 metres from a station.
Pasha et al., (2020)	Transit intensity of bus and rail services (Cleveland, US)	No change in housing prices and increase in the poverty rate in 1-mile radii (13%) one year after intervention.
Pathak et al., (2017)	Extension of bus routes (Atlanta, US)	Increase in the poverty rate within 1-mile of bus routes (2% for each additional bus route)
Pelechrinis et al., (2017)	Opening of bike-sharing system (Pittsburgh, US)	2.5% increase in housing prices one month after the opening

Source: *Frontier Economics*

Among the papers studying housing prices, the results found are generally positive, with four out of five papers identifying appreciation after the introduction of a new transport intervention. Most of these papers applied a DiD approach with a binary treatment indicating whether an area surrounded a transport-served location. Bardaka et al., (2018) studies the opening of a new light-rail train line in Denver and identifies strong appreciation – identifying that a 10% increase in the proportion of directly treated neighbours (with a new station less than a mile away) is associated with a 25% increase in median house values. The two papers studying

Hong Kong, He (2020) and Liang et al. (2022), find evidence for housing appreciation in the vicinity of new metro and metropolitan rail lines, respectively. Fernando et al., (2021) provide interesting evidence in the UK, showing that the construction of a metro line in Manchester led to an appreciation 15% and 20% in less and more disadvantaged districts, respectively. They do not however provide a hypothesis as to why more disadvantaged districts should experience greater appreciation.

Pelechrinis et al., 2017 provides evidence that active transport measures could lead to house price appreciation. They find the opening of a bike-sharing system in Pittsburgh (US) is associated with an increase of 1.3% in rental value in houses near the new facilities, an interesting results given the lower cost of this investment compared to the construction of rail lines. Finally, Pasha et al., (2020) studies whether rail and bus service frequency improvements in Cleveland (US) are associated with rental values but find no statistically significant effect.

The evidence does not find strong effects for gentrification using socioeconomic and demographic indicators. Four of the studies that study housing values also study individual characteristics of residents. First, Bardaka et al., (2018) finds significant increases in household income after the opening of a light-rail train line, but does not identify changes in the educational attainment of residents or the share with a managerial occupation – which could point to an improvement of the economic status of the previously residing household rather than to their substitution with more affluent ones. Fernando et al., (2021) finds for Manchester that an opening of a metro line is associated with a decrease in the proportion of elderly population (a dynamic associated with gentrification) but does not find an effect for household income.

Pasha et al. (2020) and Pathak et al. (2017) actually observe a 12.9% and 2% increase in the poverty rate respectively, after the introduction of improved bus services in Cleveland. They argue that this mode of transportation might be particularly useful for less affluent households, driving their relocation to the vicinity of its stations – therefore leading to the increase in poverty rate estimated. This demonstrates that transport investments may not always lead to gentrification in the conventional sense, and can in some cases lead to ‘reverse gentrification’ where less affluent individuals displace more affluent individuals in an area. Finally, Liang et al., (2022) finds the strongest results for gentrification, as it identifies significant reductions in the number low-income individuals and increases in the share of individuals with higher education in the areas alongside the development of a new metropolitan rail line.

4.5 New towns

Summary of results

The analysis of the effect of transport investments in new town developments is a gap in the literature. Of the evidence reviewed, this is confined to two studies on Hong Kong's new town developments. One found evidence of gentrification from transport interventions, and the other that a travel subsidy was successful at reducing unemployment. More evidence is therefore needed to understand the impact of different kinds of transport investments (e.g. the construction of rail lines, construction of motorways, and service frequency improvements) on unemployment, productivity, gentrification and displacement. The sparsity of evidence may reflect the low numbers of new towns built recently in OECD countries, however it is unclear from the literature whether this is the cause.

4.5.1 Overview of the evidence and results

In this review we aimed to capture evidence that identified the nuances of the relationship between transport interventions and employment, productivity, and gentrification on publicly-planned new town developments comparable to the post-war development plan carried out in 20th century Britain. Nevertheless, only very limited evidence on new towns has been captured as part of this review, with only two papers meeting the methodological shortlisting criteria, scoring at level 3 or above of the SMS.

Both of these papers, Sha et al. (2020) and Liang et al. (2022), cover the new town development plans carried out in Hong Kong since the 1970s. They apply a DiD approach, comparing towns affected by the transport development to other new towns comparable in distance to central Hong Kong. As discussed in Section 3.3, while China is not in the OECD, we kept papers from Hong Kong due the lack of wider literature on this topic, the prominent public development plan of new towns that was carried out there since the 1970s, and the higher economic development of this region (making it comparable enough to large cities in OECD countries).

Liang et al., (2022) finds evidence for gentrification induced by the opening of three lines of the Mass Transit Railway (MTR), a metropolitan rail system that connects central Hong Kong with its more distant towns, between 2001 and 2006. The paper identified an increase in rental prices and the share of individuals with an advanced degree in the areas where stations were placed. A corresponding decrease in the share of low income individuals is also found.

As discussed in previous sections, Sha et al., (2020) study the effect on unemployment of a transport subsidy implemented in 2007 for inter-town travel for low income and unemployed residents in the towns farthest from central Hong Kong. This is particularly relevant, as many of these remote new towns in Hong Kong were developed with the intention of providing

inexpensive and convenient housing to manufacturing workers. This is because the government expected that factories would relocate outside of the capital and into the less densely populated areas of Hong Kong. Instead, the authors observe that most of the manufacturing production moved to Mainland China, with the increasingly service-based jobs clustering in central Hong Kong - creating a spatial mismatch between workers and jobs. Sha et al., (2020) finds that the travel subsidy was successful at reducing unemployment, as its implementation was associated with a reduction of 2 and 1.2 percentage points in the unemployment rate four and nine years after its implementation, and 3.1% and 1.4% increase in the share of cross-town employment. This study highlights the success of alternative policies aiming to reduce spatial mismatches in the labour market. It also highlights the marginalisation risks associated with the development of new towns based on projections on the future location of economic activity.

4.6 Cross-cutting themes

Based on the evidence reviewed, two key themes arise that cut across the transport interventions and outcomes studied:

- the role of displacement (both economic activity and people)
- and how papers control for endogeneity.

Overall, across employment, productivity and gentrification, there is evidence of varying strength that displacement takes place following transporting interventions. Whether the effects for the outcome of study are net positive, neutral or negative is however unclear. For endogeneity, in both the employment and productivity literature several papers control for this issue by taking an inconsequential units and / or planned-route methodology. This is not the case for gentrification, whose methodologies are generally less robust.

4.6.1 Displacement

While most employment studies that account for displacement from surrounding regions find evidence of it occurring, the evidence is mixed as to whether the net (local or national, depending on the spatial unit analysed) employment effects are overall positive, negative or neutral. On the one hand, Pogonyi et al. (2021), Holl (2004) and Fageda and Gonzalez-Aregall (2017) find negative spillover effects on employment that completely offset any positive direct effects for a construction of a metro line in London, construction of motorways in Portugal, and construction of motorways and railways in Spain, respectively. Some find no displacement effect, with Mayer and Trevien (2017) finding no negative spillovers after the construction of a metropolitan rail in Paris. On the other, some studies show evidence of an overall net increase in labour supply. Sobieralski (2021) find that displacement effects are not enough to offset the direct positive effects, with Sari (2015) and Sha et al. (2020) identifying reductions in unemployment and long-term unemployment in disadvantages areas of Bordeaux and towns in Hong Kong distant from the city centre.

The evidence of displacement from productivity studies is more limited than for employment. Here, the key question is testing the “sorting” hypothesis: whether a productivity increase following a transport investment is due to more productive firms and employees crowding out less productive ones in an area, or whether existing firms become more productive. The limited evidence available shows some support for the sorting hypothesis, with increases in firm establishments and exits around new stations and a change in sectoral composition (Pogonyi et al., 2021).

For gentrification, the evidence reviewed consistently finds that transport interventions are associated with increases in house prices. This indirect measure suggests gentrification is taking place. However, for studies using a more direct measure of gentrification – whether the sociodemographic characteristics of residents in an area change following transport investments – are inconclusive. The studies reviewed also highlight that not all transport investments might drive gentrification in the traditional sense. Pathak et al., (2017) and Pasha et al., (2020) show that the extension and frequency increase of bus service in metropolitan areas in the US was associated with an increase in less affluent individuals living in the served regions. While there may be a question of how comparable UK and US transport use is by income status, these results highlight the importance of differentiating between modes of transportation when assessing potential gentrification impacts.

4.6.2 Endogeneity

An underlying theme throughout the assessment of the strength of the evidence is how papers account for endogeneity. That is, how the decision to place a transport intervention in a given location might be dependent on a prior positive trend in economic buoyancy, or other unaccounted-for factors affecting the location of the transport investment and the outcome of the study.

Several studies in the employment and productivity literatures account for this applying instrumental variables. Two commonly followed IV approaches in the evidence reviewed are inconsequential units (Chandra and Thompson, 2000) and planned-route (Baum, 2007). An inconsequential-units approach involves analysing new stations in the shortest path between two major destinations – arguably making the placement of the station independent of current economic factors in that location. Planned-route IV consists of instrumenting the location of a new transport intervention through the location of a past transport plan. The rationale is that a past transport plan would explain the location of new stations but will be independent of the current economic conditions explaining their placement.

This contrasts with the literature on gentrification, which uses methodologies which are less robust to the issue of endogeneity. This is particularly crucial for this outcome, as the displacement effect an increase in housing demand may generate will be influenced by any concurrent increase in its supply. As urban development plans often entail a simultaneous transport and housing development, it is particularly important to control for this issue. However, the evidence reviewed does not deal with this issue through the use instrumental

variables nor controls for measures of housing supply and, particularly, affordable housing supply. This is a limitation of the gentrification literature.

5 Conclusions

This report reviewed in detail 34 recent studies assessing the effect of transport policies and investments on employment, productivity, gentrification and new towns. It considered investments in road, rail, public, and active transport. The papers were also chosen on the basis of their geographical comparability to the UK and methodological robustness. The papers were evaluated to assess the strength of the evidence for each outcomes, considering both the size and direction of the effects as well as the methodological robustness of the papers' research strategy. Of particular interest was how the issue of displacement of economic activity was considered.

5.1 Unemployment and inactivity

The evidence shows an overall positive relationship between transport investments and employment in the areas immediately surrounding investments in rail, road and public transport. We are able to identify robust papers at both level 3 and 4 of the Maryland SMS, which apply regression analysis with panel data and FE, IVs and, most commonly, DiD.

While the evidence reviewed finds positive effects for employment across many different settings, it is not conclusive whether these investments are successful at increasing overall labour supply or if their effect is fully accounted for by displacement of economic activity. Several studies identified find negative spillover effects in areas adjacent to those benefitting from a transport investment that partially or completely offset the direct positive effects. Such papers cover different transport investments, from the construction of metro lines the construction of inter-city motorways and railways.

Nevertheless, the evidence is not unanimous, as we identified one paper which did not find evidence for displacement for the construction of a suburban rail line. In addition, two papers identified looked at unemployment and long-term unemployment in disadvantaged districts and settlements, and found a reduction for both measures. This provides some tentative evidence that these investments were successful at bringing people into the workforce that might otherwise have not. On balance, the evidence as a whole suggests moderate to zero net impacts on employment overall.

A current gap in the evidence is how transport interventions impact economic inactivity in particular. While there is currently a broad body of evidence on the effect of transport interventions on employment, the focus should also be on understanding whether these investments are successful at bringing individuals not actively looking for work into the labour force, rather than just affecting the geographical composition of jobs. There should also be a focus on what types of transport modes are most and least effective at achieving increases in overall labour supply.

5.2 Agglomeration and productivity

The evidence reviewed suggests a generally positive impact of transport investment on productivity (through the process of agglomeration). The literature is generally methodologically robust, with many studies applying IVs. There are however fewer ex-post evaluations of transport interventions, with many studies linking general multi-modal accessibility in wide geographical regions, such as a metropolitan area or country, with productivity increases rather than being linked with the impact of specific transport interventions.

The number of papers accounting for displacement is lower than in the employment literature, which is generally more robust. Of the productivity papers studying displacement, some evidence is provided for in favour of the 'sorting' hypothesis – i.e., that more productive firms displace less productive ones after transport investments. Of the few studies that account for spillover effects on regions neighbouring those benefitting from a transport investment find conflicting results: one paper finds positive and another one negative effects.

Future research should focus on understanding the spillover effects of productivity to firms in neighbouring regions, and the extent to which productivity gains are due to the displacement of less productive firms with more productive ones. It is crucial that future evidence also includes ex-post evaluations of specific transport interventions, so as to clearly differentiate the impact of different modes of transport.

5.3 Gentrification

The evidence consistently shows that transport investments lead to an increase in house prices in the areas that benefit from them. This indirect measure suggests that gentrification does take place. However, when assessing whether such investments affect the sociodemographic composition of districts - a more direct measure of gentrification - the evidence is inconclusive. While the evidence overall is mixed, several papers highlighted how specific characteristics of transport investments are more or less strongly associated with gentrification. One paper highlighted how mixed-use developments are more strongly linked with gentrification, while another found the extension and increase in frequency of bus routes are less so. The effect of a transport intervention may depend on the income group the transport investment aims to provide services to.

The gentrification literature appears to be less methodologically robust than employment and productivity. It does not account for the endogeneity that may arise from the non-random placement of transport infrastructure, or the fact transport developments may happen simultaneously with housing developments. Future research should aim to address these methodological limitations where possible, cover longer timespans to assess longer-term effects, identify where displaced individuals move to and any impacts on their longer-term outcomes.

5.4 New towns

The literature on the effect of transport investments in new town developments is confined to two studies of Hong Kong. One found evidence of gentrification from transport interventions (across both sociodemographic measures and rental costs), and the other that a travel subsidy for low income and unemployed residents was successful at reducing unemployment in remote new towns. The impact of transport interventions in new towns is therefore a key gap in the literature, with more evidence needed to understand the impact of different kinds of transport investments (e.g. the construction of rail lines, construction of roads, and service frequency improvements) on unemployment, productivity, gentrification and displacement. The sparsity of evidence may reflect the low numbers of new towns built recently in OECD countries, however it is unclear from the literature whether this is the cause.

5.5 Take-aways for policymakers

- When assessing the impact of transport interventions, the geographical scope of assessments must be wide enough to incorporate areas that may be indirectly affected. This is because there may be indirect positive or negative effects that impact the overall estimated net effect.
- To most accurately assess the distributional impact of policies and control for issues of displacement, micro data at the individual level that tracks the origins and destinations of pre-existing and new firms / people before and after a transport intervention should be used (or collected). This should cover both the area impacted by the intervention and those adjacent. If micro level data is not available, assessments should consider the composition of an area before and after an intervention (e.g. the sector of firms, and/or the sociodemographic characteristics of people).
- When estimating impacts, assessments should recognise that impacts likely differ between mode of transport, their scale, who the intended users are, and the local context of the area.
- To inform whether transport investments increase labour supply, future studies should aim to assess the impact of transport investments on unemployment and economic inactivity (rather than just employment).
- Further research that assesses the impact of specific transport interventions on productivity is required. This is because the current literature focusses mainly on the links between general increases in transport connectivity and productivity, rather than different types of interventions. Future assessments should also control for 'sorting effects' where possible, utilising micro data at the individual firm or person level (as outlined above).
- The term 'gentrification' refers to the displacement of individuals following transport interventions. It should be recognised that gentrification can happen in different directions, with more affluent individuals displacing less affluent individuals, and less affluent

individuals displacing more affluent individuals, depending on the intervention. Evidence on the latter effect is however sparse, and so requires further research.

- Future studies assessing the gentrification impacts of transport interventions should include data covering a longer time period, utilise methods at level 4 or above on the Maryland SMS, and use direct (ideally micro-level) socioeconomic and demographic data to assess the origins, destinations, and impacts on incoming and outgoing individuals in the areas affected by the intervention.
- Given the lack of studies assessing the impact of transport interventions on new towns in OECD countries, policy practitioners should explore and consider the relevance of the literature pertaining to new towns arising in developing countries and / or consider commissioning studies to explore these links within the UK.

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