Transport Investment and Economic Growth Elasticities

Department for Transport

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FINAL REPORT

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EXECUTIVE SUMMARY

Transport capital investment is one of the largest components of public infrastructure spending. Understanding its economic impact is essential for prioritising limited budgets and ensuring investment decisions are grounded in evidence.

This study provides a comprehensive assessment of how transport investment affects economic growth in the UK, by estimating the *elasticity* (or responsiveness) of economic growth to transport investment. We combine two complementary approaches to estimate this elasticity:

- a meta-analysis of international evidence, synthesising findings from 22 studies and over 300 estimates; and
- A new causal estimate for the UK, using regional data and rigorous methods to isolate the true effect of investment.

Together, these figures provide a robust, evidence-based foundation for strategic decision-making. However, such elasticities are intended to complement rather than replace standard economic appraisals of transport schemes. They are also not directly comparable to estimates of economic benefit derived from transport appraisals. As with any econometric analysis, these estimates are subject to limitations and should be interpreted as indicative benchmarks rather than precise predictions; these caveats are discussed later in the report.

KEY FINDINGS

Transport investment has positive but moderate effects on economic output

Both strands of analysis confirm that transport investment supports economic growth. This finding is robust across different methods, time periods, and contexts.

Our UK estimate suggests that a 10% increase in transport investment is associated with approximately a 0.7% increase in regional economic output. International evidence points to somewhat smaller effects, but this difference likely reflects the two approaches measuring different things. The international studies mostly examine the *transport capital stock*, the total accumulated value of roads, rail lines, and other infrastructure. Our UK analysis, on the other hand, examines *transport investment flows*, annual spending on new construction, upgrades, and renewals. These are related but distinct concepts, and the choice of measure affects both the size and the interpretation of the resulting elasticity.

Flow-based estimates are naturally larger for two reasons. First, a significant increase in annual spending translates into only a small percentage change in the total accumulated network. Second, changes in investment flows primarily capture demand-side stimulus, the direct economic activity generated by construction spending and supply chains, rather than the longer-run supply-side gains that emerge once infrastructure is built and operational. Our UK estimate is therefore best interpreted as a short-run effect driven primarily by the stimulus associated with investment spending. It is not directly comparable to the supply-side impacts typically captured in transport appraisals, which focus on the productivity and connectivity gains from completed infrastructure.

Table E.1: Summary of findings

Source	Effect of 10% increase in…
Meta-analysis	Transport *capital*, results in 0.25% to 0.4% increase in output
UK causal estimate	Transport *investment*, results in 0.6% to 0.8% increase in output

Source: CEPA analysis

Causal methods reveal effects that simple correlations miss

In our UK analysis, a simple correlation-based analysis tends to produce smaller elasticities than our approach that tries to identify a causal effect:

- **Simple correlation:** No apparent relationship between investment and growth.
- **Causal estimate:** Clear positive effect (0.7% output increase per 10% investment increase).

One possible explanation of this gap is that over the period we have assessed, UK transport investment has tended to be directed toward slower-growing regions. Simple correlation-based analysis conflates the effect of investment with the characteristics of places receiving it.

While our UK estimate remains broadly similar when London is removed, it fails a key statistical test and so, the results become less reliable without it. As London provides important data that anchors the analysis, we have much less confidence that the exact same relationship applies outside of London.

Rail investment in the UK appears to drive much of the observed effect

When we analyse modes separately, rail investment shows a stronger, more reliably estimated effect (~1.1% output increase per 10% investment increase) than aggregate transport investment, which pools across modes. In contrast, we are unable to reliably estimate a road-specific elasticity.

This does not necessarily mean road investment is ineffective, just that there is insufficient variation in the data to reliably estimate its effect on economic growth. Conversely, there is sufficient variability in the rail data to conclude that rail schemes are likely to offer strong returns in the current UK context.

Benefits appear concentrated locally

We find no evidence that investment in one region generates significant spillovers, positive or negative, to neighbouring regions. While data limitations mean we cannot rule out spillovers entirely, and our use of large ITL1 regions means within-region displacement may still exist but cannot be separately identified, the evidence suggests benefits are primarily contained within the region where the investment takes place.

What we did

Figure E.1: Summary of approach taken by this study

Meta analysis

Review existing studies that estimate transport investment elasticities, building on and updating the work of Melo, Graham and Brage-Ardao (2013) but placing greater emphasis on UK and European evidence. Aim to:

- Generate benchmark elasticity estimates
- Understand what drives variation in estimates across studies (e.g. mode)
- Assess whether more rigorous research methods produce different results

UK specific estimate

Develop UK-specific estimate of transport investment elasticity, through econometric analysis of UK-regional data on transport investment and economic growth. Aim to:

- Employ techniques designed to establish causal relationships
- Examine whether effects differ across UK regions and transport mode

Source: CEPA

Our approach combined:

Meta-analysis: We systematically reviewed international research, extracting estimates from 22 high-quality studies. We pooled these to generate benchmark elasticities and tested what factors – transport mode, geography, study methods – influence the size of effects.

UK regression analysis: We assembled 23 years of regional data (2001–2023) linking transport investment to economic output. To establish causation, we used historical infrastructure patterns (rail density in 1950, roads in 1892) to isolate variation in investment unrelated to current economic conditions.

The two approaches measure slightly different things. International studies mostly examine the transport capital stock (the accumulated network). Our UK analysis examines investment flows (annual spending). We expect flow-based estimates to naturally be larger, which partly explains why our UK estimate exceeds the international average.

Implications for policy and appraisal

These elasticity estimates are intended to support strategic thinking about transport investment. They provide high-level benchmarks for understanding how changes in investment might affect economic output. The UK elasticity range would be better suited when assessing changes in the level of transport investment on short-term economic output, while the meta-analysis range would be better suited when assessing changes in the transport capital stock.

However, it is important to note that these elasticities complement but do not replace scheme-level appraisal. They capture short-run effects on economic output (GDP), rather than overall welfare, and do not reflect the full range of impacts typically considered in appraisal, including long-term effects, user benefits, distributional outcomes, wider economic impacts, or environmental considerations.

Given the range of credible estimates, these elasticities should also be presented as ranges rather than point estimates.

Overall conclusion

Transport investment supports economic growth, but its effects are moderate and context dependent

Our UK-specific estimate, an elasticity of around 0.07, provides a credible, causally identified benchmark for policy. It implies that increasing transport investment generates a positive but moderate short-term increase in economic output, on average, though the effects of any specific investment may be larger or smaller depending on its context and design.

The results reinforce that transport investment works best as part of a broader package of policies addressing skills, housing, land use, and local economic conditions. Success depends not just on how much is invested, but on what is built, where, and how it complements wider objectives.

1. INTRODUCTION

Transport investment is a major component of government capital spending. Understanding its economic impacts is essential for making informed decisions about where and how to invest. However, estimating these impacts is challenging: transport infrastructure affects the economy through multiple channels, and it can be difficult to isolate the specific contribution of transport investment from other factors.

The Department for Transport (DfT) has commissioned CEPA to provide a robust, evidence-based assessment of how transport capital investment affects economic growth. Specifically, we have been asked to estimate the 'elasticity' of transport investment – that is, the percentage change in economic output (such as GDP or productivity) associated with a one per cent increase in transport investment.

This report brings together two complementary strands of analysis:

- **Meta-analysis**: We have systematically reviewed existing academic studies from the UK and internationally, pooling their results to generate benchmark elasticity estimates. This approach allows us to derive relevant policy insights from research across different countries, transport modes, and time periods.
- **UK regional analysis**: We have conducted new statistical analysis using regional data for the UK. This provides UK-specific evidence that is directly relevant to current policy questions and addresses gaps in the existing literature.

By combining these two approaches, we can test whether international evidence holds true in the UK context, understand where results converge or diverge, and provide a more credible basis for policy appraisal than either approach could deliver alone.

1.1. CONTEXT

Our work builds on a substantial body of research into the economic impacts of transport infrastructure.

International evidence. The most influential transport-specific meta-analysis was conducted by Melo, Graham and Brage-Ardao (2013), who synthesised results from 33 studies. They found that transport investment is generally associated with positive economic impacts, but with considerable variation depending on the type of transport infrastructure, the industrial sector being studied, and the country in question. A notable finding was that US studies tended to report larger effects than European studies, raising questions about how transferable international evidence is to the UK context.

Subsequent research has confirmed these patterns. Holmgren and Merkel (2017) have examined infrastructure more broadly (not just transport), analysing 776 separate estimates. They have reinforced that estimated effects are sensitive to the type of infrastructure, the economic sector, and the country being studied. More recent work by Välilä (2025) has found that while transport infrastructure is consistently associated with positive economic outcomes, the size of these effects varies substantially depending on how studies are designed and conducted.

Country-specific studies focused on identifying causal impacts, particularly in the US and China, have been influential and help explain why estimated impacts vary across settings. In China, many papers exploit the staged rollout of high-speed rail (HSR) to identify the causal effects of improved intercity connectivity, finding positive impacts on labour market outcomes and broader measures of economic performance, alongside substantial spatial heterogeneity (Lin, 2017; Lin et al., 2021; Liao et al., 2023). Overall, these studies suggest transport investment can deliver meaningful economic benefits, but effects are highly context-dependent and may be uneven without supportive local conditions.

UK-specific evidence. In the UK, the What Works Centre for Local Economic Growth (WWCLEG) has undertaken systematic reviews of transport investment impacts in 2015 (updated in 2021). These reviews have found consistent evidence that transport investment affects employment and productivity, but they have also highlighted concerns about methodological quality in some studies and the potential for economic activity to be displaced from one area to another, rather than created overall.

More recently, DfT has commissioned targeted evidence reviews examining specific economic outcomes including unemployment, productivity, and gentrification. These reviews have confirmed that transport investment is associated with productivity improvements, but they emphasise that the scale, direction, and persistence of these impacts depend heavily on local circumstances.

Methodological considerations. An important theme in recent research, highlighted by organisations such as the OECD (2020), concerns how studies establish causation. Transport infrastructure may be built where economic growth is expected or conversely be built in regions that are lagging economically. This makes it difficult to determine whether the transport infrastructure caused the economic growth or simply responded to it (or a lack of it).

This methodological challenge is a key motivation for our work. Our meta-analysis examines whether more rigorous studies produce systematically different results, whilst our UK regional analysis employs techniques designed to establish causal relationships more convincingly.

1.2. Structure of this report

The remainder of this report is organised as follows:

- **Section 2** describes our overall approach and explains the methods we have used for each strand of analysis.
- **Section 3** presents results from the meta-analysis, showing what we can learn from synthesising international evidence.
- **Section 4** presents results from the UK regional analysis, providing bespoke evidence for the UK.
- **Section 5** draws conclusions, compares results across both strands of analysis, and discusses the implications for transport policy and appraisal.

2. APPROACH

This section explains how we have conducted our analysis and why we have chosen to use two complementary methods. We also set out the main limitations of our approach. Readers who require fuller technical detail can refer to the annexes.

2.1. OVERVIEW OF OUR APPROACH

We have used two different approaches to estimate the elasticity of transport capital investment to economic growth. This is shown in the diagram below:

Figure 2.1: Summary of approach taken by this study

Meta analysis

Review existing studies that estimate transport investment elasticities, building on and updating the work of Melo, Graham and Brage-Ardao (2013) but placing greater emphasis on UK and European evidence. Aim to:

- Generate benchmark elasticity estimates
- Understand what drives variation in estimates across studies (e.g. mode)
- Assess whether more rigorous research methods produce different results

UK specific estimate

Develop UK-specific estimate of transport investment elasticity, through econometric analysis of UK-regional data on transport investment and economic growth. Aim to:

- Employ techniques designed to establish causal relationships
- Examine whether effects differ across UK regions and transport mode

Source: CEPA

Our rationale for using two different approaches is in recognition that much of the existing literature draws on international evidence. As such, while the elasticity estimates from the literature provide a broad evidence base covering many contexts, it may not fully reflect UK circumstances. UK-specific analysis provides evidence that is more directly relevant but is limited by the data available. By combining both approaches, we can test whether international patterns hold in the UK and provide more robust estimates than either method alone could deliver.

An important distinction: stocks versus flows. In addition to the two workstreams taking different approaches, they also measure slightly different things, which affects how their results should be interpreted and means they are not directly comparable:

- **The meta-analysis** draws mainly on studies that examine the *transport capital stock* – the total accumulated value of transport infrastructure in a country or region (roads, rail lines, ports, and so on). These studies ask: what is the relationship between the size of the transport network and economic output?
- **The UK analysis** examines *transport investment flows* – annual public capital spending on transport. This asks: when government increases transport spending in a region, what happens to economic output in that region?

This distinction matters for two reasons:

1. **We expect flow-based elasticities to be larger than stock-based elasticities.** This is because a large increase in annual investment translates into only a small percentage change in the total accumulated network.
2. **The UK estimate largely captures short-term effects.** Studies looking at changes in investment flows mostly capture demand-side stimulus effects (such as from construction activity), rather than the longer-run supply-side gains that emerge once infrastructure is built and operational. Studies using stock-based measures, by contrast, mainly capture the long-run productivity of the network.

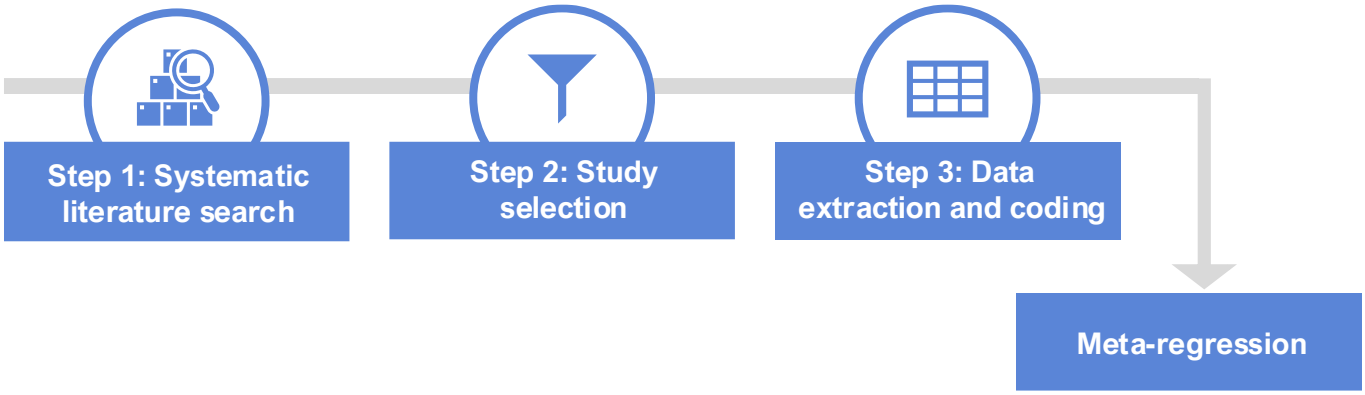
Both measures are valuable but they are not directly comparable. The meta-analysis provides a benchmark grounded in decades of international research on how transport networks support economic activity. The UK analysis provides a short-run estimate of how changes in spending affect output, driven primarily by the stimulus associated with investment spending. This is distinct from the supply-side impacts typically estimated through transport appraisals. Together, they offer complementary perspectives on the same underlying question.

Both strands have been designed to be rigorous, transparent and reproducible. All the analysis has been conducted in R, with full documentation of data sources, coding decisions, and model specifications available to DfT.

2.2. META-ANALYSIS

The meta-analysis brings together findings from existing academic research to generate benchmark elasticity estimates. This involved four main steps, as shown in the following figure.

Figure 2.2: Summary of approach for meta-analysis



Source: CEPA

Step 1: Systematic literature search. We conducted a comprehensive search for relevant studies using academic databases and examining grey literature (i.e. studies that have not undergone formal academic peer review). This search initially returned 591 papers which, following a review of the abstract and title of each paper, was reduced to 173 relevant papers.

Step 2: Study selection. We applied clear inclusion and exclusion criteria to identify high-quality, relevant studies. To be included, studies needed to satisfy the following criteria:

- ✓ Measures the relationship between transport investment and economic output (GDP, GVA, or productivity);
- ✓ Uses a methodology that would be considered robust by modern academic standards;
- ✓ Focuses primarily on UK or European contexts;
- ✓ Be published after 2010; and
- ✓ Be available in English.

This process resulted in a shortlist of 22 studies.

Step 3: Data extraction and coding. For each included study, we extracted the reported elasticity estimates and standard errors along with key study characteristics that might explain variation in results. In total, we extracted 317 elasticity estimates from 22 studies, covering a mixture of transport modes, geographies, time horizons, and statistical approaches.

Step 4: Statistical analysis. Once we compiled a dataset of elasticity estimates from the shortlisted studies, we used two complementary meta-analysis techniques to pool results across studies:

- **Pooled analysis**. Our first analysis estimated an overall elasticity of transport investment to economic growth, using what is referred to as a random-effects regression. This statistical approach recognises that studies differ not just because of random variation, but because they examine genuinely different contexts (different countries, time periods, and transport modes). The model estimates an overall average elasticity whilst accounting for this variation. This provides our headline pooled elasticity estimate with appropriate confidence intervals.
- **Analysis of what drives variation.** We also estimated models that explicitly test how study features influence reported elasticities. For example, this allows us to determine whether:
    - More rigorous methods at establishing causality results in different estimates relative to those that employed simpler statistical methods;
    - Road investment shows different effects than rail investment;
    - Cross-national studies differ from within country studies; and
    - Effects vary by time horizon.

Addressing publication bias. A key concern in any meta-analysis is publication bias: studies finding large, statistically significant effects may be more likely to be published than those finding small or null effects. If present, this would lead us to overestimate the true elasticity. We have tested for publication bias using standard techniques, and where we detected evidence of publication bias, we adjusted our pooled estimate accordingly.

2.3. UK-SPECIFIC ESTIMATE

To develop a UK-specific estimate of the elasticity of transport investment to economic growth, we have conducted a statistical analysis using UK regional data. Our analysis exploits variation in transport investment across UK regions and over time to estimate how this variation affects economic output, while controlling for other factors that might affect regional growth.

2.3.1. Data sources

We have assembled a dataset, largely using publicly available official statistics, summarised in the table below.

Table 2.1: Summary of key variables used in developing a UK-specific estimate and the data sources

Variable	Source
Regional output	ONS, Regional Gross Value Added
Population	ONS, Population Estimates
Transport investment	HM Treasury, County and Regional Analysis HM Treasury, Public Expenditure Statistical Analysis
Historical infrastructure	Cambridge Group for the History of Population and Social Structure

One of the key challenges with the dataset we have developed is the limited granularity with respect to historic transport investment data. This is only available at International Territorial Level (ITL) 1, which divides the UK into twelve statistical regions – nine in England, plus Scotland, Wales and Northern Ireland. This has provided limited data variation and a limited number of datapoints to exploit for the analysis.

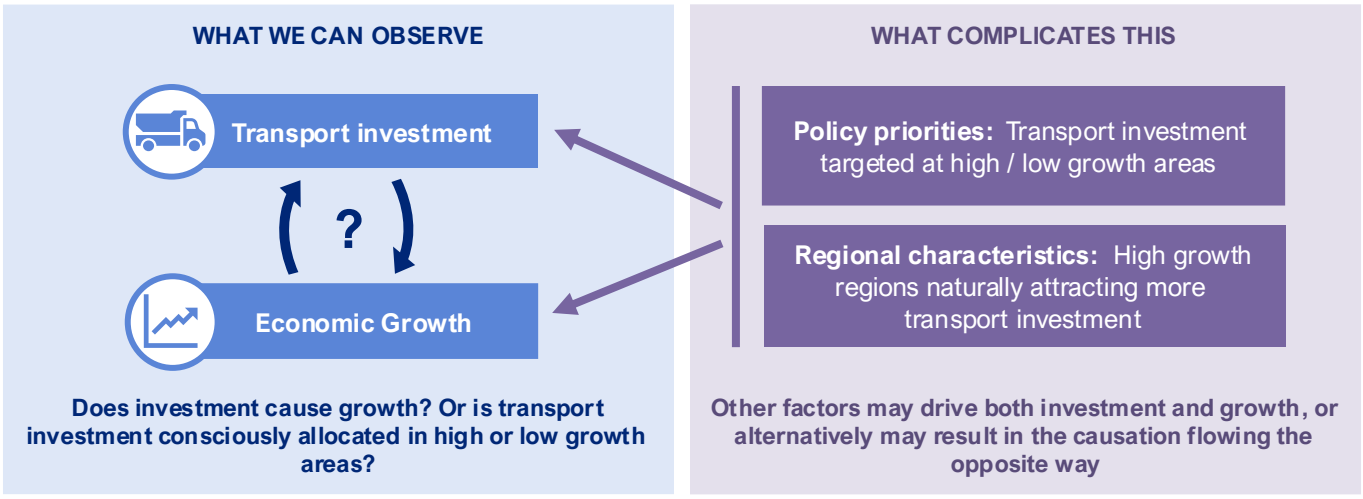
2.3.2. Statistical model

Our model assesses whether, when transport investment in a region increases, we observe a corresponding increase in that region's economic output – after accounting for permanent differences between regions (such as London's economic structure differing from Wales)[1] and national trends affecting all regions (such as recessions)[2].

2.3.3. Addressing causation: the identification challenge

A critical challenge in estimating transport elasticities is establishing causation rather than just correlation. Transport infrastructure is not randomly allocated: governments may invest in regions where they expect economic growth or alternatively, may invest in regions where economic growth has historically been poor. This creates a challenge around establishing causality – does transport investment cause growth, or does expected growth cause investment?

Figure 2.3: The causation challenge



Source: CEPA analysis

The diagram above illustrates the challenge of identifying the direction of causation. If transport investment tends to take place in areas that are already on high-growth trajectories, a simple comparison of regions with high investment to those with low investment would overestimate the effect of transport. Conversely, if transport investment trends to take place in areas that have had low growth, then the same simple comparison would underestimate the effect of transport.

To address this, we have used an approach called **instrumental variables**. The core idea of this approach is to find a source of variation in transport investment that is unrelated to current economic conditions or policy priorities, so differences in economic growth associated with that variation can be attributed to the investment itself. This in turn allows us to isolate the genuine causal effect.

Our instrument exploits a relatively simple insight: regions with more historical transport infrastructure are more likely to receive investment when national transport budgets increase, but this historical infrastructure is unlikely to be related to modern regional growth trends once we control for region fixed effects. This is because much transport spending goes toward maintaining and upgrading existing networks. Crucially, these historical patterns were established long before our study period and cannot be influenced by recent economic performance. This approach is consistent with methods used in the academic literature.

With our dataset, we present both:

[1] Using what is referred to as region fixed effects

[2] Using what is referred to as time fixed effects

- **Simple correlations** between transport investment and economic output, but may be affected by the causality issues describe above
- **Causal estimates using our instrumental variable approach**, which attempts to isolate the effect of the transport investment effect

2.3.4. Accounting for spatial spillovers

Transport infrastructure generates benefits beyond the immediate region where it is built. A new road in the Midlands may benefit businesses in neighbouring regions through improved connectivity. Conversely, improved transport in one area might attract economic activity away from neighbouring areas (displacement).

To some extent, our use of ITL1 regions within our dataset, which are relatively large areas, means that any displacement of economic activity occurring within an ITL1 region cannot be separately identified and is therefore absorbed into the estimated local effect. However, our analysis accounts for displacement between ITL1 regions by explicitly testing whether transport investment in one region affects economic output in neighbouring regions

2.3.5. Robustness checks

We have conducted extensive robustness and sensitivity analysis to test whether our findings are stable across different modelling choices. This includes:

- **Outlier sensitivity**: Re-estimating results by excluding datapoints that may be considered outliers (e.g. London).
- **Alternative specifications**: Testing different versions of our statistical model by scaling our data by population or not scaling (e.g. looking at total transport investment vs transport investment per capita).
- **Regional time trends**: Re-estimating results with the inclusion of regional time trends to allow for different long-run trajectories between regions.
- **Instrument validity tests**: Statistical tests to verify that our instrumental variables approach is sufficiently robust.

2.4. Limitations and caveats

It is important to be clear about what our analysis can and cannot tell us. All empirical research involves trade-offs and limitations, and understanding these is essential for appropriate interpretation.

2.4.1. General limitations

Elasticities are averages, rather than predictions for specific schemes. Our estimates reflect average relationships across the studies and regions we have examined. Actual impacts will depend on the context of the specific investment, such as:

- the quality of the transport investment (is it well-designed and targeted?);
- complementary factors (skills, land availability, other infrastructure);
- the existing level of transport provision (investment may have stronger effects where current infrastructure is poor);
- the type of economic activity in the area; and
- whether the investment addresses a genuine constraint or bottleneck.

Elasticities capture GDP effects, not welfare. Our analysis captures effects on economic output only, rather than broader measures of economic and social welfare. Our analysis does not directly measure:

- distributional effects (who benefits and who bears costs);
- environmental impacts (carbon emissions, air quality, biodiversity);

- social impacts (accessibility for disadvantaged groups, community severance); or
- agglomeration versus displacement (whether investment creates net new activity or redistributes existing activity)

As such, these elasticity estimates should not be compared with estimates of welfare benefits or wider economic impacts, as used in transport appraisals.

Uncertainty is inherent. All our estimates come with confidence intervals reflecting statistical uncertainty. Where we report a central estimate, there is a range around it. Moreover, statistical uncertainty is only one type of uncertainty; there is also model uncertainty (i.e. would different but equally defensible modelling choices produce different results?) and structural uncertainty (i.e. is the relationship stable over time and context?).

2.4.2. Limitations specific to the meta-analysis

Differences between studies. The studies we use come from different countries, time periods, and methodological traditions. While our analysis explores this variation, there may be unobserved factors that differ across studies and affect results.

Publication and reporting bias. Our testing confirms the presence of publication bias in our sample, which potentially biases our pooled elasticity estimate upwards.

Limited UK evidence. While we searched for UK and European studies, no UK studies passed our inclusion criteria. Hence, the evidence is weighted towards cross-country European studies. This motivates our UK-specific analysis but means the meta-analysis may not fully reflect UK circumstances.

Study quality variation. While we have applied quality filters, not all included studies use equally rigorous methods. Our analysis tests whether methodological quality affects results, but this relies on being able to identify study quality.

2.4.3. Limitations specific to the UK regional analysis

Data constraints. Our analysis is constrained by limitations in the available data on transport investment:

- **Short time period:** Consistent data is only available from 2001–2023, with mode-specific breakdowns (road vs rail) only available from 2009 onwards. This provides relatively little data given the lumpiness of transport investment and the limited number of major projects within the dataset.
- **Large regions:** Data is only available at the ITL1 level, which divides the UK into twelve regions. With so few regions, it is harder to detect effects precisely, even when they exist. This is particularly challenging for our instrumental variables approach, which relies on differences between regions to isolate the causal effect of investment.
- **Attribution challenges:** Allocating transport investment and economic activity to specific regions inevitably involves some imprecision, which adds noise to our estimates.

Despite these constraints, our analysis presented in Section 4 identify effects that are statistically significant and robust across different specifications. Future work could extend this study by using more geographically disaggregated regional data, allowing for sharper identification of effects and a richer analysis of spillovers.

Instrumental variables assumptions. Our instrumental variable approach relies on the assumption that historical infrastructure affects modern output only through its influence on current investment, not through other channels. While we have tried to control for other regional differences and time trends, this assumption cannot be definitively tested.

Investment flows versus long-run supply effects. Our analysis is based on transport investment *flows* rather than measures of the transport capital stock. Capital stock has been more frequently used in the studies used within the meta-analysis. Estimating the elasticity to changes in transport investment flows affects how the resultant elasticity ought to be interpreted; the resulting elasticities capture the short-run demand-side economic response to

increases in spending, rather than long-run or full equilibrium effects of transport supply. The estimates reflect a mixture of channels, including construction activity and supply-chain responses, and should not be interpreted as identifying the long-run productivity impacts of the transport network. Accordingly, these estimates are not a substitute for standard Green Book appraisal and do not, on their own, provide a basis for revisiting displacement assumptions used in scheme appraisal.

Spillovers and displacement. While we have tested for spatial spillovers, fully characterising how transport investment in one region affects neighbouring regions is complex. Our estimates do not fully capture these cross-border effects, but instead give an idea of how, holding transport investment in all other regions constant, investment in a neighbouring region may impact local GDP.

Dynamic effects. Transport infrastructure can have effects that build over many years as land use patterns, business locations, and economic structures adjust. Our analysis captures effects over the time period in the data, but very long-run effects may not be fully realised within our sample.

Limited variation. Regional panel data at the ITL1 level provide less variation than is ideal for precisely estimating the elasticity of transport investment to economic growth. Transport investment changes relatively slowly, and once region and time fixed effects are included, the remaining variation used for identification is limited.

2.4.4. What this means for interpretation

These limitations do not invalidate our findings, but they do mean that:

1. **Our estimates should be seen as indicative rather than precise predictions**. They provide evidence-based benchmarks, not mechanical forecasting rules.
2. **Local context matters**. Applying these elasticities to specific investment decisions requires careful consideration of whether the context matches the evidence base.
3. **Triangulation is essential**. This is why we use multiple approaches. Where meta-analysis and UK analysis converge, we have greater confidence. Where they diverge, we must understand why and exercise appropriate caution.

We return to these points in our conclusions and discussion of policy implications.

3. FINDINGS OF META ANALYSIS

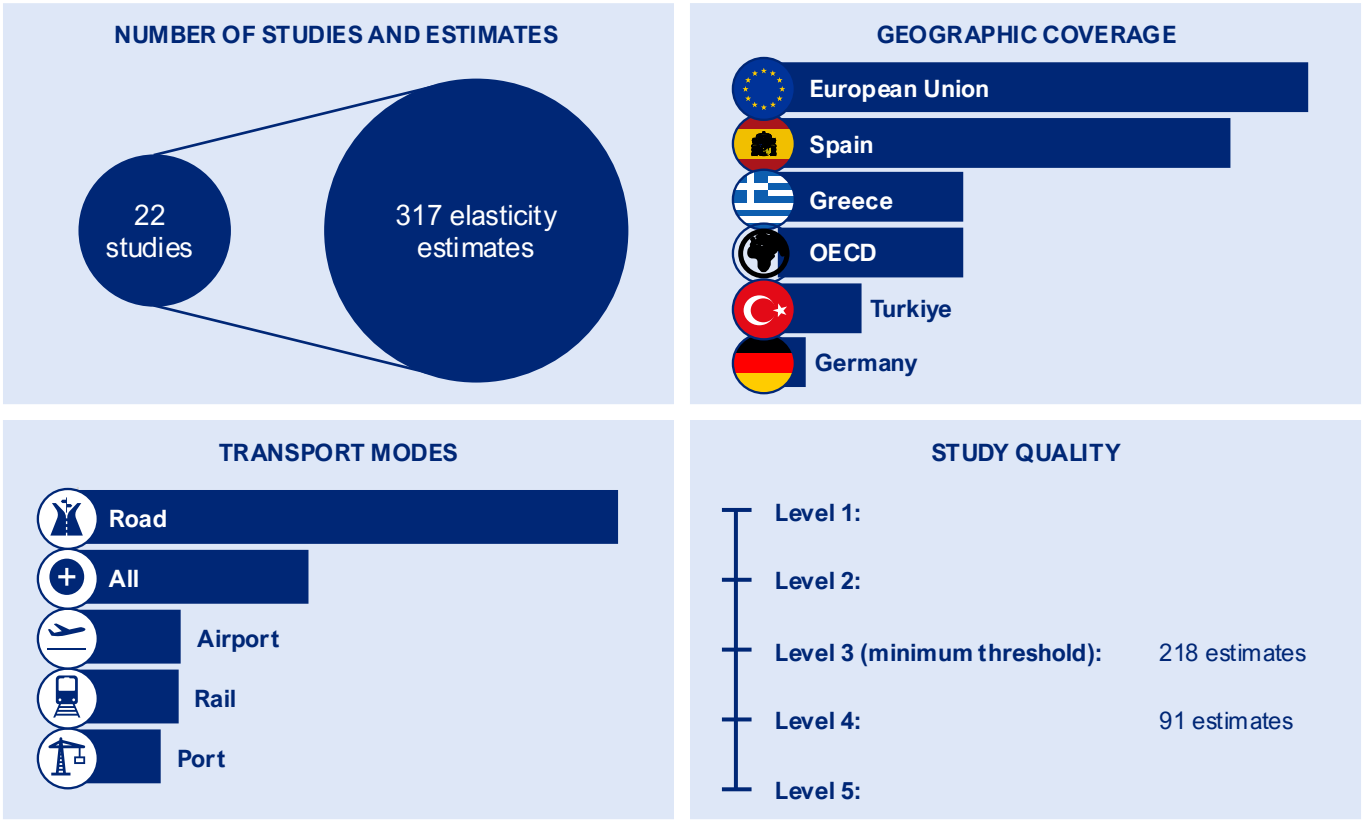
This section presents what we have learned from systematically reviewing and synthesising existing academic research from the UK and internationally.

Our central finding is that increases in transport capital have a positive but moderate effect on economic output, with an elasticity of approximately 0.025–0.038. This means a 10% increase in transport capital is associated with roughly 0.25–0.38% higher GDP.

3.1. OVERVIEW OF EVIDENCE BASE

Our systematic literature search identified 22 studies that met our quality criteria, covering research published between 2010 and 2023. The figure below summarises the key characteristics of the studies and the elasticity estimates.

Figure 3.1: Evidence base at a glance



Source: CEPA analysis

The key features of the evidence base are as follows:

Geographic coverage. The evidence is predominantly European, though concentrated in particular countries. Around half of all estimates come from multi-country studies covering the EU, OECD, or global samples, with much of the remaining evidence coming from Spain. Specific country studies provide finer geographic detail but may struggle to isolate transport effects from other local factors. Cross-national studies provide broader variation but may be influenced by differences in institutions, measurement, and economic structures.

Notably, no UK-specific studies passed our quality threshold, a key gap that motivates our UK-specific analysis in Section 4.

Transport modes. Road investment dominates the evidence base, accounting for around half of all estimates, with just under a quarter of estimates based on aggregate transport investment not separated by mode. Rail, airports,

and ports each contribute roughly 10% or less. This uneven coverage means we should be more cautious about findings for non-road modes.

Time horizons. Most estimates focus on short-run effects (typically one year or less), with the remainder examining longer-term impacts. The limited long-run evidence reflects the difficulty of tracking effects over extended periods whilst controlling for other changes in the economy, and issue that also exists in our UK-specific analysis.

Measurement approaches. Studies are roughly evenly split between those using monetary measures of transport capital (i.e. those derived from capital expenditure on transport projects), and those using physical measures (e.g. kilometres of road or rail track). Both approaches have merit: monetary measures reflect actual resource commitment, while physical measures more directly capture network extent.

Study quality.[3] Most studies use credible methods with appropriate controls for differences across regions and time periods. Around three in ten studies used more advanced techniques to establish causation. However, no studies achieved the highest quality rating, which would require randomised experiments (and, therefore, is impractical for large infrastructure investments).

Further detail on study characteristics is provided in the technical annex.

3.2. HEADLINE ELASTICITY ESTIMATES

The central finding from our meta-analysis is that increases in transport capital have a **positive but moderate effect on economic output**.

Across the estimates, our pooled elasticity is 0.038, meaning that a 10% increase in transport capital is associated with approximately a 0.4% increase in economic output.

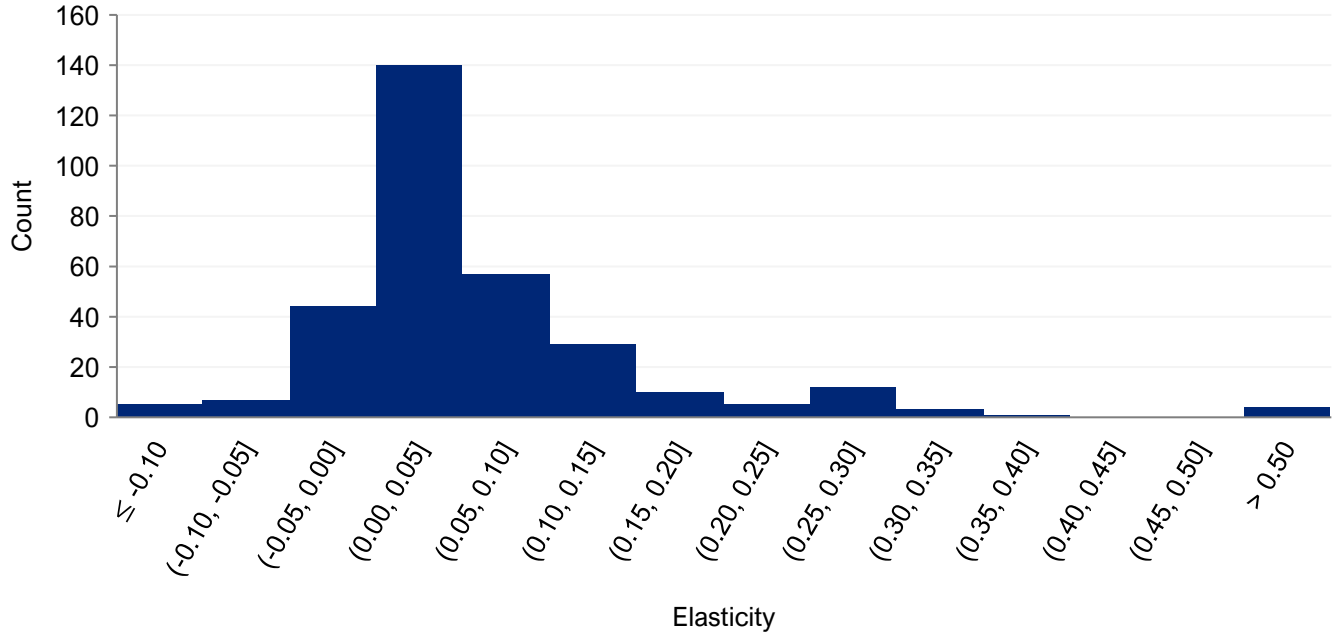
When we adjust for publication bias, the tendency for studies with larger effects to be more likely to be published, this central estimate falls to around 0.025. This suggests the "true" average effect likely lies in the range of 0.025 to 0.038.

To put this in context: these are positive effects, but modest in macroeconomic terms. Transport investment supports economic growth, but it is one factor among many rather than a transformative lever on its own.

As shown in Figure 3.2, there is considerable variation around this average. Individual study estimates range from negative values to well above 0.10. Most estimates cluster near zero, with a smaller number of larger positive estimates. This variation reflects genuine differences across countries, time periods, transport modes, and study methods, and underscores why the pooled estimate should be seen as a benchmark rather than a universal figure.

[3] Studies are rated using the Maryland Scientific Method Scale (SMS). SMS level 3 includes well developed panel data methods, while SMS level 4 includes difference-in-difference (DiD) designs, instrumental variables (IV), regression discontinuity designs, models with clear identification arguments, and exploitation of natural experiments. SMS level 5 is reserved for randomised control trails (RCTs). For more details on the scale please visit https://whatworksgrowth.org/resource-library/the-maryland-scientific-methods-scale-sms/.

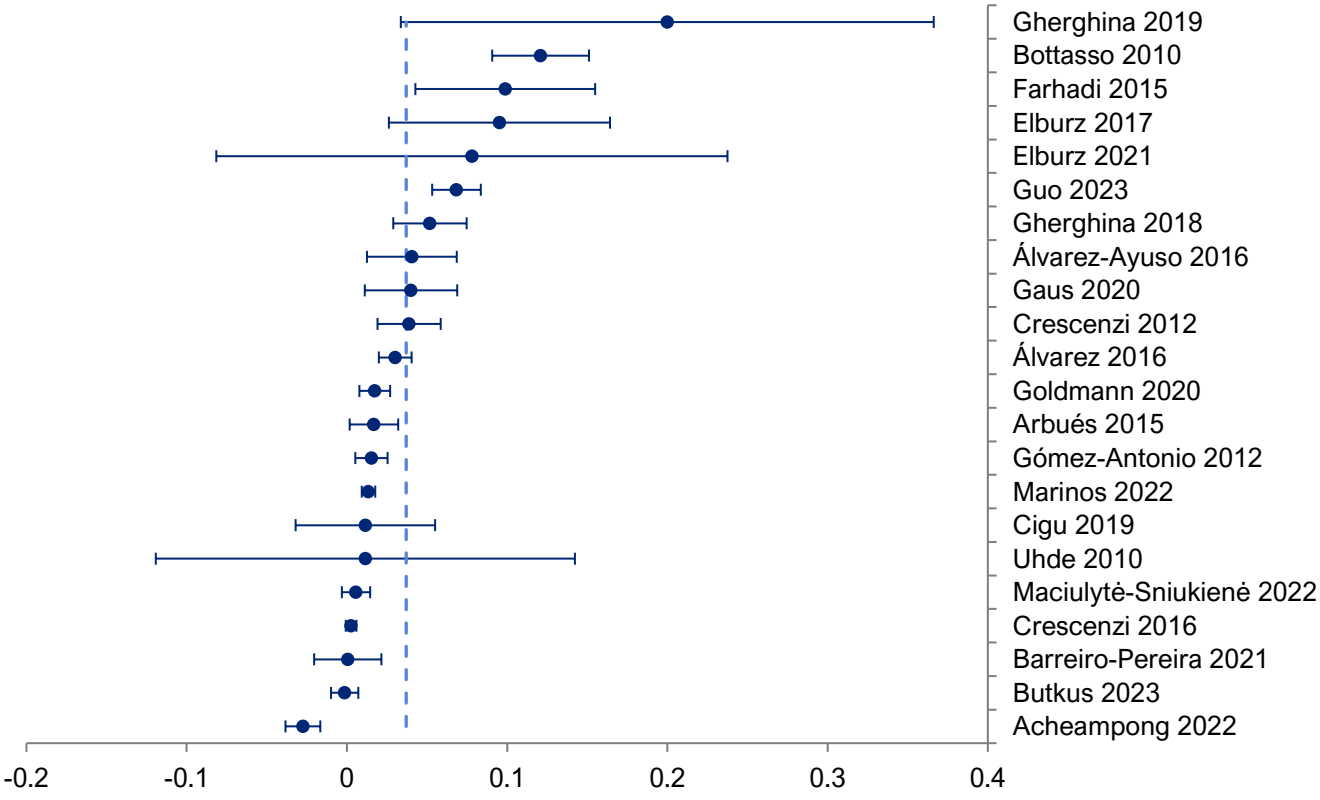
Figure 3.2: Distribution of reported elasticities



Source: CEPA analysis

Figure 3.3 below shows the variation across individual studies, presenting the study-level effect estimates (dots) and their associated 95% confidence intervals (horizontal bars). While the overall pattern is clearly positive, some studies find effects close to zero while others find substantially larger impacts.

Figure 3.3: Study-level Forest Plot, illustrating the study-level variation around the central estimate

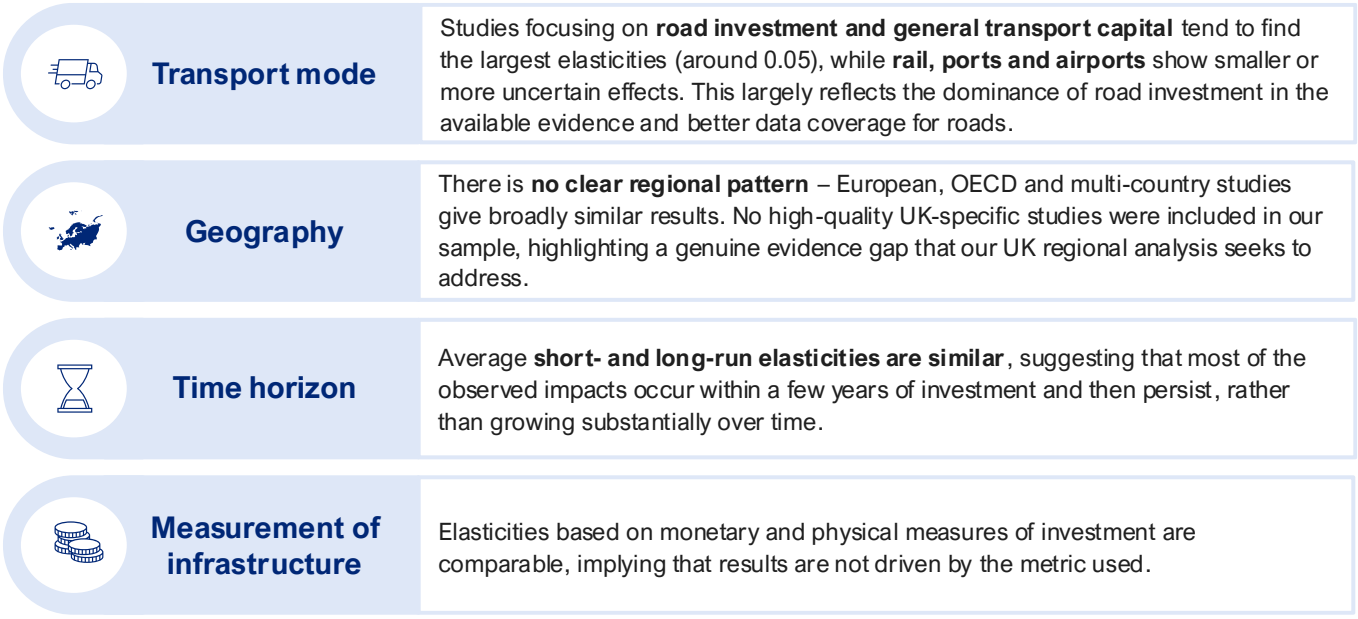


Source: CEPA analysis

3.3. What influences the size of effects?

The strength of the estimated relationship varies across transport modes, study designs, and measurement approaches, as summarised in the diagram below.

Figure 3.4: Summary of key factors influencing the size of the effects



Source: CEPA analysis

Differences in study design explain more of the variation in results than differences in geography or transport mode. Studies using methods that are considered more robust tend to produce smaller but more reliable elasticities. Additionally, models that do not account for region specific effects or time trends typically report inflated estimates, likely because they capture other factors correlated with both transport investment and growth, and underscoring the importance of accounting for these factors.

3.4. Evidence quality and confidence

We have reasonable confidence that transport investment has a positive effect on economic output, though individual contexts may see larger or smaller effects depending on local circumstances. This finding is robust across different statistical approaches and holds even after adjusting for publication bias.

However, several factors temper how precisely we can pin down the size of this effect:

- **Publication bias is likely present.** Our diagnostic tests suggest that studies finding larger effects are more likely to be published than those finding little or no effect. This can make the overall growth elasticity look bigger than it really is. Adjusting for this bias reduces the pooled elasticity slightly, but the overall conclusion remains unchanged.
- **Study quality varies.** While we applied quality filters, not all included studies use equally rigorous methods. Our analysis suggests that more rigorous studies tend to find smaller (but still positive) effects. However, instrumental variable studies, which are considered to be relatively robust, tend to report slightly higher elasticities than studies that use other methods.
- **Limited evidence for some modes.** We are unable to detangle the differential effects of transport investment by mode of transport with confidence. While many studies specifically look at road investment, few focus on rail, ports or airports. This makes it harder to draw firm conclusions about mode-specific effects.

3.5. Relevance to the UK context

The international evidence provides a useful benchmark, but its applicability to the UK is uncertain.

The key limitation is that no UK-specific studies met our quality criteria. The evidence is weighted toward cross-country European studies and single-country analyses from Spain and Greece. The UK's circumstances differ in important ways:

- **Network maturity.** The UK has a well-developed but heavily used transport network. New investment may have larger effects where it relieves genuine congestion or connectivity constraints.
- **Regional imbalances.** The UK has significant regional economic disparities and a centralised funding system. This shapes both where investment goes and how benefits are distributed.
- **Planning and housing constraints.** The UK's planning system influences how easily transport improvements translate into housing, business location, and broader economic benefits.

These factors could mean UK elasticities are higher or lower than the international average. This uncertainty is a key reason we conducted bespoke UK analysis, presented in the next section.

4. FINDINGS OF UK REGRESSION ANALYSIS

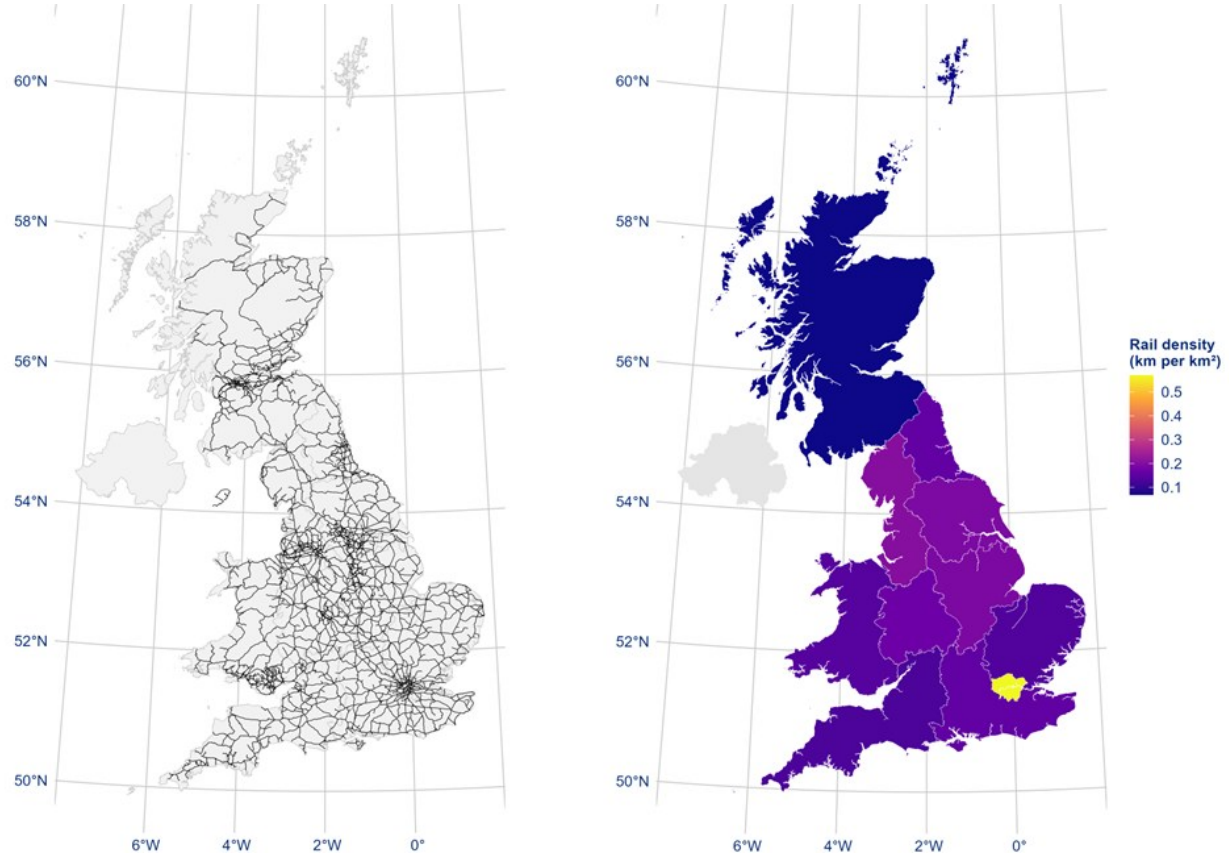
This section presents findings from our UK-specific analysis. While the meta-analysis tells us what international evidence suggests, this analysis provides direct evidence for the UK using regional data and methods designed to establish causation.

4.1. OVERVIEW OF UK DATA AND CONTEXT

We have assembled a panel dataset using publicly available sources, of transport investment and economic output, covering twelve UK regions over 23 years (2001-2023).

Regional variation. There is substantial variation in both transport investment and economic performance across UK regions. London stands out as an outlier, with much higher historical infrastructure density (as shown in the figure below), higher investment levels, and higher economic output than other regions. This variation is essential for our statistical approach, but it also means London contributes significantly to our findings.

Figure 4.1: Rail network in 1950



Source: Cambridge Group for the History of Population and Social Structure, Rail shapefile (1950), ITL1 2021 boundaries

4.1.1. Choice of investment flows rather than capital stock

A key methodological choice in this study is to use annual transport investment flows as our main explanatory variable, rather than trying to construct a measure of the transport capital stock. Capital stocks are the total accumulated transport infrastructure that exists in a region (i.e., the total rail network value) and are not directly observed. A measure of capital stocks would need to be built up from past investment using strong assumptions about asset lives, depreciation and how spending has been allocated across regions and modes over several decades. At the ITL1 level in the UK, the data needed to do this reliably does not exist.

Using annual investment flows avoids these uncertainties and reduces the risk of introducing measurement error that could weaken our results. It is also more closely aligned with our identification strategy, which exploits changes

in national transport budgets over time: these changes feed directly into current investment flows, whereas capital stocks move only slowly and are largely determined by past decisions.

While these elasticities are not a substitute for standard appraisal or Green Book-style analysis, they remain useful for policymakers who set and adjust annual investment budgets, not capital stocks. Our elasticity estimates therefore speak directly to the expected economic impact of changes in planned transport investment, rather than to the average productivity of the accumulated capital base.

We expect elasticities estimated using investment flows to be larger than elasticities using transport capital stock, as capital stocks only move gradually, so large investment translate into small year-to-year changes in capital stocks. Additionally, studies looking at changes in investment flows primarily capture demand-side stimulus. Our UK estimate is therefore best interpreted as a short-run effect driven primarily by the stimulus associated with investment spending, rather than the long-run impact on economic growth.

4.2. HEADLINE ELASTICITY ESTIMATES FOR THE UK

Our preferred estimate suggests that a 10% increase in transport investment per person is associated with a 0.7% increase in regional economic output per person. This elasticity of approximately 0.07 is our central UK-specific finding. It sits within the range of 0.06 to 0.08 across different statistical specifications, giving us confidence that the result is robust.

A striking feature of our results is the difference between simple correlations and our causal estimates:

- **Simple correlation (OLS):** We find no reliable link between transport investment and regional growth under this OLS model once we control for differences between regions and time-related effects (elasticity close to zero).
- **Causal estimate (instrumental variable):** In contrast, in our main instrumental variable model, we find a positive and statistically significant relationship, with an elasticity of around 0.07 (and a confidence range of 0.04 to 0.10). Our alternative specifications give very similar results, with central estimates in the 0.06-0.08 range and overlapping confidence intervals, indicating that the finding is robust to how the instrument is constructed.

One possible explanation of this result is that over the period we have assessed, transport investment in the UK has tended to be directed towards slower growing regions – potentially reflecting policy efforts to level up slow-growing regions. Simple correlations miss the true effect because they conflate the impact of investment with the characteristics of places that receive it. Our instrumental variable approach isolates the causal effect by using historical infrastructure patterns that cannot be influenced by recent economic performance.

4.3. FINDINGS BY TRANSPORT MODE

When we analyse rail and road investment separately, we see that rail investment shows a more reliably estimated effect, meaning that we can have more confidence in our conclusions with respect to rail investment.

Rail investment. Our estimates suggest that a 10% increase in rail investment per person is associated with approximately a 1.1% increase in regional GVA per person. This is larger than our aggregate estimate, though measured with less precision due to the shorter time period of mode-specific data (2009–2023).

Road investment. We cannot reliably estimate the effect of road investment. Our statistical approach does not generate enough independent variation in road spending to produce trustworthy estimates. This does not mean road investment has no effect – it means the available data and methods cannot tell us what that effect is.

These mode-specific findings should be interpreted with caution given data limitations.

4.3.1. Spillovers to neighbouring regions

Transport investment might benefit not just the region where it occurs, but also neighbouring regions through improved connectivity. Alternatively, it might draw economic activity away from neighbours. We tested for both possibilities.

Our estimates suggest that the benefits of transport investment are concentrated in the region that receives it. When we allow for effects on neighbouring regions, the estimated spillover is close to zero and statistically insignificant.

However, this finding should be interpreted cautiously:

- **Data limitations:** Our twelve large regions may be too aggregated to detect spillovers. Much of the benefit to neighbouring areas may already be captured within regional boundaries.
- **Statistical precision:** Our methods do not generate enough variation to precisely estimate spillover effects. We cannot rule out that spillovers exist but are too small or variable to detect.

This does not imply that transport investment does not lead to displacement effects; our analysis suggests that displacement effects are likely to be relatively localised. Analysis using more geographically detailed data would provide a stronger test of displacement effects.

4.4. How UK results compare with international evidence

Our UK elasticity of around 0.07 is higher than the pooled international estimate of 0.025–0.038 from the meta-analysis, but this difference is expected and does not indicate a problem with either estimate.

Three factors potentially explain why our UK estimate is higher:

1. **We measure different things.** The UK analysis uses investment flows whereas most international studies use capital stocks. We expect flow-based elasticities capture short-run effects and tend to naturally be larger; a given investment represents a bigger percentage change in annual spending than in the accumulated network.
2. **We use causal methods.** Our instrumental variable approach attempts to isolate the true causal effect. Many international studies use simpler methods that may underestimate the effect (if investment targets lagging regions) or overestimate it (if investment follows growth).
3. **Recent UK context.** Our analysis covers a period of significant rail investment addressing capacity constraints. These renewal-intensive programmes may generate higher returns than the mixed investment portfolios in broader international studies.

When compared to international studies that also use instrumental variables, our UK estimate sits comfortably within the range of findings. The estimates are consistent once we account for methodological differences.

4.5. Robustness and sensitivity analysis

We tested our results in several ways to check whether they depend on particular modelling choices or assumptions or are driven by unusual observations. These tests are summarised in Table 4.1 below.

Table 4.1: Sensitivity analysis results

Sensitivity	Reason	Result
Alternative instruments	Using a range of instruments allows us to check whether results are driven by particular modelling choices.	We run our models with a range of instruments (rail-only, road-only, lagged and combined), and the results remain within the 0.06-0.08 range.

Sensitivity	Reason	Result
Exclude London from sample	London is both the UK's largest regional economy and a major source of variation for the instruments. Transport investment in London accounts for around 25-30% of total transport investment.	Across all specifications, excluding London leads to weak instruments, and a loss of statistical precision. However, the point estimates do not change significantly. This pattern points to there being insufficient variation in transport investment outside of London linked to the instruments we have used. It does not imply that the causal effect is limited to London.
Total GVA instead of per capita GVA	Total GVA captures both scale (larger regions) and intensity effects, and does not normalise for population, so differences in regional size matter.	The total-GVA specifications imply an elasticity of around 0.06–0.07. This supports the conclusion that transport investment has a positive and economically meaningful effect on regional output once endogeneity is addressed.
Include regional time trends	Regional trends ensure that the instrumental variable estimate is not unintentionally driven by regions that were already on faster or slower long-run growth paths for reasons unrelated to transport investment.	Even after allowing each region to follow its own growth path, the core rail-based instrumental variable result remains strong and unchanged. This provides reassurance that the main finding is not an artefact of different long-run growth rates across regions.

Source: CEPA analysis

Overall assessment. Our core finding, an elasticity of approximately 0.07, is robust across different specifications. The main sensitivity is to excluding London, which reduces precision rather than reversing the finding. This reflects London's important role in providing the variation our statistical approach relies on.

Limitations to keep in mind:

- The estimate reflects average effects across regions and may not apply to specific schemes or locations
- We capture short- to medium-run effects; long-run impacts may differ
- Results depend on assumptions about historical infrastructure that cannot be definitively tested

5. CONCLUSIONS AND POLICY IMPLICATIONS

This section brings together the findings from both strands of analysis and sets out what they mean for transport policy and appraisal.

5.1. SUMMARY OF KEY FINDINGS

Our two approaches, synthesising international evidence and conducting new UK analysis, tell a consistent story, summarised in the table below.

Finding	Meta-analysis (International)	UK-specific estimate
Measurement	Effect of changes in the stock (of transport capital)	Effect of changes in the level of transport investment (or the flow of transport capital)
Overall effect	Positive and moderate	Positive and moderate
Size of effect	10% more transport *capital* results in 0.25–0.4% higher output	10% more transport *investment* results in 0.7% higher output

Source: CEPA analysis

The UK estimate is higher than the international average, but this likely reflects methodological differences and potential differences in context:

- The UK analysis measures investment flows whereas international studies mostly measure capital stocks
- The UK analysis uses causal methods that attempt to isolate the true effect while many international studies use simpler approaches
- The UK reflects recent rail-intensive investment that may generate higher returns than more generalised estimates

Overall, the two strands of evidence converge on three main points:

- **Transport investment has a positive effect on economic output.** Both approaches find clear evidence that transport investment supports growth.
- **The effect is moderate in macroeconomic terms.** Transport investment is one important factor among many and unlikely to be a transformative lever on its own.
- **Causal methods matter.** Simple correlations can mislead. In the UK, investment is often directed toward slower-growing regions, which masks the true positive effect. Rigorous methods reveal a stronger relationship.

5.2. WHAT THIS MEANS FOR POLICY

Transport investment supports economic growth, but expectations should be realistic

The evidence confirms that transport investment contributes positively to economic output. However, the effects are moderate. Our UK estimate implies that a 10% increase in transport investment would raise short-term regional output by around 0.7%, which is meaningful, but not transformational.

The impact of any specific investment will depend on local circumstances:

- **Is the investment addressing a real constraint?** Effects are likely larger where networks are congested or connectivity is genuinely poor

- **Is the investment well-designed?** Not all transport spending is equally productive
- **Are complementary conditions in place?** Transport works best alongside skills, housing availability, and supportive planning policies

Benefits appear concentrated locally

Our analysis finds no evidence of significant spillovers to neighbouring regions. While data limitations mean we cannot rule out spillovers entirely, this suggests:

- Investment decisions should focus primarily on local economic needs and constraints
- Expectations of wider regional uplift beyond the immediate area should be cautious

This does not mean displacement, as in appraisal, doesn't occur, but instead means we find no evidence of spatial spillovers between large ITL1 regions.

5.3. Using these estimates in practice

These elasticity estimates are intended to support strategic thinking about transport investment. They provide high-level benchmarks for understanding how changes in investment might affect economic output. The UK elasticity range would be better suited when assessing changes in the level of transport investment on short-term economic output, while the meta-analysis range would be better suited when assessing changes in the transport capital stock.

However, the following caveats ought to be acknowledged:

- **Present ranges, not point estimates.** Given uncertainty in the evidence, elasticities should be presented as ranges reflecting the spread of credible estimates.
- **These are averages, not predictions.** The elasticities reflect average relationships across regions and time periods. Specific schemes may generate larger or smaller effects depending on context.
- **These estimates capture GDP effects, not welfare.** These estimates are not intended to act as a replacement for TAG/Green Book appraisals, which estimate the welfare impact of individual schemes. The elasticity estimates only economic outcomes, and in the case of the UK estimate only short-term economic outcomes. They also do not measure distributional impacts, environmental outcomes, or whether benefits represent new activity versus displacement. As such, they should not be compared directly with welfare-based appraisal measures.
- **Short to medium run, not long run.** Our UK estimates mostly capture short-run stimulus style effects through construction activity and downstream supply chain impacts. They do not capture the supply-side effects typically captured in transport appraisal.

5.4. Areas for further research

Our work has strengthened the evidence base but also highlights several gaps:

- **Finer spatial data for the UK:** More disaggregated regional or local data would provide greater variation, reduce reliance on a small number of influential regions such as London, and allow more robust analysis of spillovers.
- **Transport capital stock data:** A validated, long duration and spatially disaggregated dataset of transport capital stocks (potentially broken down by transport mode or asset type) would allow better identification of the structural elasticity of output to transport capital stock, which should also be of interest to policy makers.
- **Mode-specific and scheme-type evidence:** There is a need for better identified studies separating different types of rail and road schemes and, where possible, extending to ports and airports.

- **Longer-run and dynamic effects:** More work is needed on how impacts evolve over time, including potential lagged effects and interactions with other factors such as housing, land use and labour markets.
- **Stronger identification strategies:** Future UK work could build on natural experiments (e.g. sudden funding changes, quasi-random programme rollouts) and richer instruments to improve causal identification, particularly for roads and spatial spillovers.
- **Integration with micro-level evidence:** Linking regional elasticities with project-level evaluations and microdata could help explain why some schemes or places generate higher returns than others.

Addressing these gaps would allow DfT to refine the elasticity estimates over time and to tailor them more closely to specific policy questions.

5.5. Final conclusions

In summary, both strands of analysis point in the same direction: transport investment supports economic growth, with effects that are positive, statistically credible and economically meaningful, but not transformational on their own.

For policy, this means DfT can use these elasticities with measured confidence as part of the evidence base for strategic decisions about transport investment levels and priorities, while recognising the inherent uncertainty and the importance of local context. The results should inform, rather than replace, detailed scheme appraisal and wider judgements about distributional, environmental and social outcomes.

Ultimately, transport investment can play a significant supporting role in the UK's growth, levelling up and decarbonisation agendas, but its success will depend on what is built, where it is built, and how it is integrated with other policies and local conditions.

Appendix A LIST OF ANNEXES

This appendix lists the annexes that have been shared with DfT alongside this report:

- Technical annex of meta-analysis of transport elasticity estimates
- Technical annex of econometric analysis to develop a UK-specific transport elasticity estimate
- Data sources and definitions
- R code for the two sets of analyses

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