

# Transformational impacts of transport investment

QCA Technical Report

Department for Transport

April 2023



**FINAL REPORT**

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## 1. INTRODUCTION

### 1.1. BACKGROUND

Cambridge Economic Policy Associates (CEPA) and Ove Arup & Partners (Arup) have been appointed by the Department for Transport (DfT) to research how the context surrounding a transport investment may determine whether it leads to the economic or social transformation of an area.

The main objective of the assignment is to describe how, and under what contexts, transport interventions have had what might be considered a ‘transformational’ impact on a locality or region, and how this has affected the economy and the wellbeing of the community. The DfT would like to understand, and to the extent possible quantify, the effect of contextual factors on transformational impacts (e.g. underlying socio-economic factors, inclusion of local development strategies, use of social and human capital, other related investments and wider policies). It would also like to understand the transmission mechanisms through which the transport intervention worked with contextual factors to affect the economy and wellbeing of communities.

The scope of this project includes understanding why certain transport interventions have succeeded, whereas others have failed to have the impact originally envisaged. The project findings are also intended to support scheme promoters in making the case for investment where objectives include supporting local economic growth or transforming an area.

### 1.2. PROJECT STRUCTURE

The project has two stages:

- **Stage I.** In Stage I, we undertook a literature review and 15 in-depth case studies. The literature review established the theoretical foundations of how transport investments lead to economic or social transformation, by interacting with the wider context. This resulted in a definition of transformational impact, and a list of potentially relevant contexts and actions which may result in transformational impacts. The case studies provided analysis and information on whether or not a transport scheme resulted in transformational changes, and the contexts and actions that were present or absent during the scheme.
- **Stage II.** In this Stage II, we have developed a more structured analysis of the case studies through Qualitative Comparative Analysis (QCA). QCA aims to identify the common contextual factors that may explain why a scheme ends up being transformational or not. QCA helps to identify a set of necessary and/or sufficient conditions that determine whether a scheme is ultimately transformational or not.

Our definition of transformational impact is as follows; a scheme is considered ‘transformational’ if there is empirical proof of a step-change in **any** of the following three metrics:

- A. The change in the transportation system leads to a step-change in connectivity and / or effective density, which manifests itself in a significantly increased usage of the transport network.
- B. The scheme leads to dynamic clustering<sup>1</sup> and / or land use change which can be empirically identified by a significant change in sectoral employment shares or land use shares.
- C. The scheme leads to increases in at least one of the following four metrics: employment, productivity per worker/firm, number of homes and/or land and property values.

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<sup>1</sup> Benefits that arise through close location of business and/or people.

### **1.3. REPORT STRUCTURE**

This technical report explains the process of QCA analysis. This report is structured as follows.

- In Section 2, we explain our methodology. This includes an explanation of:
  - the theory of QCA;
  - key methodological issues;
  - our selection process for case studies;
  - our selection process for contextual factors and outcomes;
  - our calibration methodology for contextual factors and outcomes; and
  - our Theory of Change (ToC).
- In Section 4, we outline our results.
- In Appendix A, we provide a full list of the case studies used.

## 2. METHODOLOGY

The objective of Stage II is to explore whether common conditions exist that enable transformational change using QCA as our research method. QCA is designed to uncover how different contextual factors interact with one another, and why different combinations of contextual factors lead to different outcomes. It is therefore well-suited to the study objective, to uncover whether common conditions exist which enable transformational change in the context of a transport investment.

### 2.1. THEORY OF QCA

QCA uncovers complex causal conditions which lead to the outcome of interest. Unlike regression analysis, QCA does not determine the size of the effect of different conditions on the outcome. Rather, it uncovers a logical relation between the conditions and the outcome. Some logical relations of interest are whether a condition is:

- **A sufficient condition:** A condition X is sufficient for an outcome O if whenever condition X is present, outcome O is also present.
- **A necessary condition:** A condition X is necessary for an outcome O if whenever condition X is not present, outcome O is also not present.
- **An insufficient but necessary part of an unnecessary but sufficient (INUS):** A condition X is INUS for an outcome O if whenever condition X is not present, a sufficient condition Y for outcome O also is not present.

To perform QCA, the conditions and outcomes are ascribed a truth value, where a truth value of 0 means that the contextual factor was not present, or a certain outcome was not achieved, and a truth value of 1 means that the contextual factor was present, or the outcome was achieved. All the cases, and their truth values, are then collated into a truth table.

In Table 2.1 we give an example of a QCA truth table with three conditions, X, Y and Z, and an outcome O. There are eight cases, labelled A – H, with varying combinations of conditions and outcomes being present.

Table 2.1: Example truth table

Case	X	Y	Z	O
A	1	1	1	1
B	1	1	0	1
C	1	0	1	1
D	1	0	0	1
E	0	1	1	1
F	0	1	0	0
G	0	0	1	0
H	0	0	0	0

The truth table sorts cases by combinations of conditions. It aims to identify the different combinations of conditions linked to a specific outcome. In effect, it tries to collate the conditions that cases with a positive outcome share, and that distinguishes them from cases with a negative outcome. This provides a solution, in the form of a logical statement, providing the combination of true and/or false conditions that are sufficient for the outcome.

The solution of a truth table can be written in Boolean algebra.<sup>2</sup> For example:

- **X + Y:** Either X, or Y, or both, are present.
- **X \* Y:** X and Y are both present.
- **X -> Y:** If X is present, then Y is present. X is a sufficient condition for Y.

QCA analysis of the example given in Table 2.1 gives the following solution:

*Solution:*  $(X + Y*Z) \rightarrow O$

The interpretation of this statement is

*Interpretation:* X is sufficient for O, and the combination of Y and Z is also sufficient for O. If X is present, then O is present. Or, if Y and Z are both present, then O is present.

In this case, X is a sufficient condition to generate an outcome. The combination of Y and Z, denoted by Y\*Z, is also a sufficient condition. Y is a necessary part of Y\*Z, since if Y is not present, then Y\*Z is not present. Furthermore, Y is not a sufficient part of Y\*Z, since Z must also be present for Y\*Z to be present. Thus, Y is an INUS condition, since (i) Y is a necessary but insufficient condition of Y\*Z, and (ii) Y\*Z is an unnecessary but sufficient condition for O. By the same reasoning, Z is also an INUS condition. None of X, Y, or Z are necessary conditions for O. If X is not present, O may still be present if Y\*Z are present. If Y or Z are not present, O may still be present if X is present.

### 2.1.1. Crisp and fuzzy set QCA

QCA can be performed using crisp sets or fuzzy sets. Above, we have used crisp set QCA (csQCA). In csQCA, the conditions and outcome are either fully absent or fully present. They are given a code of either 0 or 1. In fsQCA, the conditions and outcome can also be partially absent or partially present. They can also be given a code between 0 and 1.

Whether csQCA or fsQCA should be used depends on:

- **The nature of the outcomes and contexts:** Some outcomes and contexts are more naturally coded in binaries, while other outcomes and contexts are more continuous in nature.
- **The quality of the evidence base:** fsQCA requires a deeper evidence base than csQCA. The deeper the evidence base, the more appropriate fsQCA may be. And the poorer the evidence, the more appropriate csQCA may be.
- **The hypothesis being tested:** QCA tests hypotheses based on Theories of Change. The ToC may require the presence or absence of a context, or it may require degrees of presence of a context. In the former case, csQCA is more appropriate, while in the latter fsQCA is more appropriate.

We have employed csQCA as our evidence base was not rich enough to allow for fsQCA.

## 2.2. KEY METHODOLOGICAL ISSUES

There are several methodological challenges of QCA. Below we outline key methodological issues which have been considered in our analysis.

### 2.2.1. Theory of Change

A ToC can be used within QCA in two ways:<sup>3</sup>

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<sup>2</sup> Boolean algebra is a form of algebra dealing with variables that have true or false values.

<sup>3</sup> While QCA can be used as an exploratory tool to develop a ToC, this generally requires more observations.

- Firstly, a ToC can be used to identify specific hypotheses to test, informing collection of evidence around outcomes and contextual factors.
- Secondly, a ToC can be used to interpret the results of QCA. QCA provides a combination of necessary and sufficient conditions for the outcome. But the mechanism of how the contextual factors result in the outcome must be understood as well. A ToC helps to interpret this solution and uncover plausible transmission mechanisms.

### **2.2.2. Case study selection and grouping of cases**

The purpose of QCA is to analyse a series of cases that are:

- Sufficiently similar such that they can be considered to belong to a single set, and such that any conclusions drawn from the QCA exercise can be generalised to the whole set.
- Sufficiently varied in terms of contexts and outcomes, such that differences between them can be used to derive conclusions around how contextual factors affect the likelihood of an outcome.

Constructing a series where the cases are too different from one another, may make it challenging to draw any conclusion from the QCA, particularly where there are few cases within the series. In other words, the range of possible contextual factors that may explain differences in outcome would be too large to determine which contextual factors matter and which do not.

On the other hand, constructing a series where the cases are too similar comes at the expense of external validity, i.e. the ability to apply the conclusions to cases outside the set. It may also make it less likely that we are able to draw interesting conclusions.

In Section 2.3, we present the full list of cases we had access to for our QCA exercise. As the ToCs we used to test our hypotheses are specific to the type of transport intervention, not all of our cases are relevant to each hypothesis tested. As a result, we have not used all of our case studies, instead grouping them by the type of connectivity the intervention was aiming to achieve and, by extension, the ToC that was likely to apply. For example, we hypothesised that, given certain conditions, transport interventions which link urban cores to their peripheries can lead to residential transformation. To test this hypothesis, we selected only the case studies that link urban cores to their peripheries.

### **2.2.3. Coding of outcome and contextual factors and calibration**

To prepare the truth table, data on contexts and outcomes must be coded, that is, the contexts and outcomes must be given a value of 0 or 1 for csQCA, or a value between 0 and 1 for fsQCA. In Sections 2.4 and 2.5, we describe how we selected and coded our outcomes and contexts.

For some contexts and for some outcomes, the coding can be performed directly from the evidence base. For example, to code the context 'land released near station', we looked for evidence that land had been released near the station. For other contexts and outcomes, the coding must be performed indirectly, through an indicator because the presence/absence of the context or outcome cannot be directly inferred. For example, to code the context 'quality of existing transport access', we used two indicators, namely (i) the presence of good quality alternative public transport, and (ii) whether the route is new or a replacement of an existing line.

The coding of the contextual factors and outcomes proved to be challenging. There were multiple issues with the coding exercise.

- **Coding using subjective evidence is difficult:** There may not be an obvious value to assign to an outcome or context. For example, the evidence may not allow for a clear division of the cases into two separate groups. This may occur if there is a lack of evidence, if the evidence is inconclusive, or if the evidence is contradictory (for example, two indicators point in different directions).
- **Quantitative data is an incomplete representation of the contextual data:** Quantitative data may seem superior to qualitative data, since it is less subjective. However, quantitative data is unable to give a



complete representation of some contextual factors of interest, such as evidence of regeneration programmes, or skills investments/activities. Qualitative data is then needed. Furthermore, quantitative evidence is open to interpretation. To use quantitative evidence for csQCA, a strict boundary must be imposed on a gradual scale. Setting such a boundary is not self-evident, but a matter of judgment.

- **Some contextual evidence does not exist:** For some contextual factors, we were unable to find enough data to code them. It is important to note that our case studies were based on extant data, and until recently evaluations for transport investments in the UK were not routinely conducted. As a result, we are limited by data availability. We filled gaps – to the extent possible – via targeted stakeholder interviews and primary research, but even in combination this is not a substitute for full scheme ex-post evaluation which is far more resource intensive than this project budget permits.

We have done three things in response.

- We developed a clear coding methodology
- We removed contextual factors where there was insufficient data
- We introduced additional contextual factors, where our existing contextual factors were insufficiently precise to test our ToC

After an initial coding, a truth table may lead to contradictions, i.e. combinations of contextual factors that lead to contradictory outcomes. One method for resolving such contradictions is to review the coding of contextual factors and outcomes and undertaking a calibration exercise. This is particularly important where the initial coding exercise is reliant on incomplete, inconclusive or subjective evidence.

#### **2.2.4. Number of cases required**

QCA is generally used for a number of cases between 10 and 100, with the rule of thumb being that there should be four times as many cases as contextual factors. If the number of cases is too small, the process of QCA is unlikely to result in a solution or the solution may have limited validity. It will not result in a combination of true and/or false conditions that are sufficient for the outcome. Increasing the number of cases therefore increases the number of contextual factors that can be included in the QCA, allowing more complex theories to be tested.

However, if the number of cases is too large, preparing the in-depth case studies that inform the cases can become time-consuming, and the coding and calibration of contexts and outcomes can become extremely complex. These issues set a lower and upper boundary on the number of cases.

In Stage I, we prepared 15 case studies. As this is generally at the lower bound of cases required within QCA analysis we increased the number of cases for this Stage II using two methods.

- We added one new case study (Sheffield Supertram – Line 1).
- We split selected cases into multiple observations, based on a set of rules. Cases were split by phases if the phases were not undertaken concurrently. This was on the basis that if the different phases occurred at different times, the contexts and/or outcomes may have been different per phase. Cases were split by geographical location if the geographical locations were sufficiently different. In this case, the contexts and/or outcomes may have been different per geographical location.

An advantage of splitting case studies by phase or geographical location, is that it allows for an increase in the number of potential cases, while not being overly time-consuming. The full case studies analysed schemes based on phase or location so splitting cases by phase or location was a time-efficient method of increasing the number of observations.

#### **2.2.5. Contradictory cases**

It is possible that cases with the same conditions have different outcomes. These cases are then said to be contradictory. For example, case A and B in Table 2.2 below are contradictory.

Table 2.2: Example contradictory cases

Case	X	Y	Z	O
A	1	0	0	1
B	1	0	0	0

This is a common result in QCA analysis. The difference in outcomes may be the result of a difference between the cases which is not easily captured in QCA analysis. When contradictory outcomes were present, we have tried to use our in-depth knowledge of the case studies to explain how the contradiction came about. [Sometimes, we introduce a further condition, in which the cases differ, to resolve the contradiction.] The contradiction may also be the result of insufficient information, so that differences in conditions and/or outcomes are not accurately reflected in the QCA analysis.

### 2.3. CASE STUDY SELECTION

The cases we had access to for our QCA exercise are presented in the table below.

Table 2.3: Stage I case studies

Case study	Description
<b>Stage I Case Studies</b>	
<b>Manchester Metrolink</b>	The light rail (tram) transport system in Greater Manchester. The network now has eight lines which radiate from Manchester city centre.
<b>Jubilee Line Extension</b>	To Stratford via Canary Wharf opened in 1999. The first significant addition to the London Underground network since 1979. The project involved building six new stations and enlarging or rebuilding five existing stations.
<b>Nottingham Express Transit</b>	New light rail (tram) transport network with two lines and subsequent new route extensions.
<b>High Speed 1</b>	The high-speed rail line that connects London with the Channel Tunnel, and then onwards to the continental Europe rail network. Domestic stations on the Southeastern Network also served by high-speed services.
<b>High Speed Rail Network - Spain</b>	The development of two significant lines as part of the Spanish High Speed Rail Network – the Madrid-Seville line opened in 1992 and the Madrid-Barcelona line opened in 2008.
<b>West Coast Mainline Upgrades</b>	A series of track upgrades and introduction of new rolling stock that allowed speeds of 125 mph along most of the line and substantial increases in capacity for both passenger and freight trains. Completed in 2008.
<b>Borders Railway</b>	Reopening the rail line connecting Edinburgh with the regions of Midlothian and the Scottish Borders. The project was the longest domestic railway built in the UK in over 100 years and involved constructing 30 miles of new track and seven new stations.
<b>Edinburgh-Glasgow Improvement Programme</b>	Infrastructure programme to reduce capacity constraints between Scotland's two largest cities, enable more services, and improve journey times. Included a redevelopment and extension of Glasgow Queen Street, coinciding with an investment in station regeneration and an extension of Buchanan Galleries shopping centre.
<b>Reading Station Redevelopment</b>	Major redevelopment to address infrastructure bottlenecks and expand station capacity. Reading Council undertook further work on the station building, with the aim of improving the concourses and area surrounding the station.
<b>Kirkstall Forge</b>	Suburban rail station opened in 2016, positioned on the lines running between Leeds and Shipley, which unlocked an associated large mixed-use development.
<b>Corby new station and rail service</b>	New rail station to serve the town of Corby. Passenger services to London included in East Midlands franchise.

Case study	Description
<b>Falmouth Rail Improvements (Penryn Loop)</b>	New passing loop enabled a doubling of services serving Falmouth from one to two trains per hour. A capacity increase followed two years thereafter.
<b>Great Yorkshire Way</b>	7km dual carriageway linking the M18, just north of Rossington, to Robin Hood Doncaster Sheffield Airport. Part of a wider regeneration effort, considered a catalyst for investment, job creation and better housing in Doncaster, as well as better connectivity in the South Yorkshire region.
<b>Markham Vale (MEGZ)</b>	A 200-hectare business park which opened in 2009 with direct access to the M1 motorway via the construction of junction J29A. In 2017, the Seymour Link opened, connecting the northern plots of Markham Vale to the highway network, to bring the land into productive economic use.
<b>A45 Newark to Lincoln and Newark to Newark to Widmerpool Improvements</b>	Major A-road and important freight link from Grimsby and Immingham, Lincolnshire to the East Midlands and the Southwest. Two schemes, completed almost a decade apart, were intended to boost the regional economy by relieving the congestion and safety-related issues along the route; improve journey time reliability for freight operators; and unlock land for new housing development.
New Case Study	
<b>Sheffield Supertram – Line 1</b>	New light rail (tram) network with two lines. Line 1 opened in 1995 and runs from Middlewood in the north of Sheffield to Halfway in the south of Sheffield, via Sheffield’s city centre.

Source: CEPA 2021: *Transformative impacts of transport investment – Draft case study report*

The table below outlines the cases that were split either by phase or by geographical location (or both).

Table 2.4: Case study splits

Case Study	Split by phase	Split by region
<b>Manchester Metrolink</b>	This case study was split into four different phases, namely phase 1, phase 2, phase 3(a) and phase 3(b).	
<b>Jubilee Line Extension</b>		This case study was split into five geographical locations, namely (i) Waterloo / Southwark, (ii) Bermondsey / Canada Water, (iii) Canary Wharf, (iv) Canning Town, and (v) Stratford.
<b>Nottingham Express Transit</b>	This case was split into two different phases, namely phase 1 and phase 2.	Phase 2 was split into two geographical locations, namely Clifton and Beeston.
<b>High Speed 1</b>	This case was split into two different phases, namely phase 1 and phase 2.	Phase 2 was split into three geographical locations, namely (i) King’s Cross, (ii) Kent, and (iii) Stratford.

Case Study	Split by phase	Split by region
<b>High Speed Rail Network – Spain</b>	This case was split into two different phases, namely phase 1 and phase 2.	Both phases were split into geographical locations. Phase 1 was split into five geographical locations, namely (i) Madrid, (ii) Ciudad Real, (iii) Puertollano, (iv) Cordoba, and (v) Seville. Phase 2 was split into seven geographical locations, namely (i) Madrid, (ii) Guadalajara, (iii) Catalayud, (iv) Zaragoza, (v) Lleida, (vi) Tarragona, and (vii) Barcelona.
<b>West Coast Mainline Upgrades</b>	This case was split into three different phases, namely phase 1, phase 2, and phase 3.	This case was also split into four geographical locations, namely (i) Scotland, (ii) North West, (iii) Midlands, and (iv) South.
<b>Borders Railway</b>		This case was split into three different geographical locations, namely (i) Edinburgh, (ii) Midlothian, and (iii) Scottish Borders.
<b>Edinburgh-Glasgow Improvement Programme</b>	This case was split into two different phases, namely phase 1 and phase 2.	
<b>Great Yorkshire Way</b>	This case was split into two different phases, namely phase 1 and phase 2.	
<b>Markham Vale (MEGZ)</b>	This case was split into two different phases, namely phase 1 and phase 2.	
<b>A45 Newark to Lincoln and Newark to Widmerpool Improvements</b>		This case was split into two different geographical locations, namely (i) Newark to Lincoln, and (ii) Newark to Widmerpool.

The full list of cases, after splitting by phase and geographical location, can be found in Appendix A.

## 2.4. CONTEXTUAL FACTORS

### 2.4.1. Selecting contextual factors

In our literature review, we identified ten initial contextual factors that may work with (or against) a transport investment to determine its success. For the QCA we adapted this initial list of contextual factors, drawing on our experience developing the case studies and building a theory of change.

In some instances, we found that evidence for the presence or absence of certain contextual factors was often missing, meaning that we were unable to code them in our dataset. For [two] of these contextual factors, little evidence was available and as a result, we removed them from our dataset:

- commercial development; and

- benefits realisation.

In other instances, our development of the case studies and associated theories of change, has allowed us to more precisely define the contextual factor, or separate out contextual factors that were previously grouped into a single category.

The full list of contextual factors is provided in the table below.

*Table 2.5: Contextual Factors*

Contextual Factor	Rationale
<b>Used in QCA</b>	
<b>Strong background economic growth in wider region</b>	In our literature review, we identified business cycles as possibly explaining outcomes in the shorter term. Following our development of the case studies, we have extended this contextual factor to also include other evidence of strong background economic growth, which may be an indicator of latent demand for commercial or industrial space.
<b>Quality of existing transport access</b>	We include this contextual factor on the basis that transformation is more likely in areas where the transport intervention leads to a step change in connectivity, as indicated by poor existing transport access.
<b>Latent demand for housing (Area with housing deprivation)</b>	As noted in our literature review, it is possible that for an area to achieve transformation, there needs to be latent demand. In a housing context, this could be indicated by the presence of housing shortages, either within the area itself, or in the wider region.  Within our QCA, we distinguish between latent demand for housing in the specific location of the transport scheme, and latent demand for housing in the wider region. .
<b>Sites identified for commercial regeneration in urban or satellite area</b>	Similar to the above contextual factors, we theorise that for transformation to be achieved, there needs to be latent demand for specific types of land use. In the case of commercial or industrial uses, this latent demand could be indicated at a regional level by strong background economic growth, or it could be assessed at a local level.  Within this contextual factor, we attempt to capture latent demand at a local level based on whether specific sites for commercial regeneration have been identified.
<b>Regeneration potential in satellite area (Area of high deprivation)</b>	As identified in our literature review, it is possible that some areas are in economic development traps where high levels of deprivation discourage investment, which leads to further deprivation. Such traps could potentially be reversed through an anchor investment such as a transport intervention. The anchor investment would then encourage other investment within the area.  Under this contextual factor, we capture whether the scheme served an area considered to be unsafe or have poor visual amenity, which the scheme aimed to reverse.
<b>Unlocking development</b>	In our literature review, we noted that to achieve a transformational outcome, specific actions may be required to unlock development and facilitate land use change. Examples of actions include the release of land, the relaxation of planning rules, or the co-development of land.  For the QCA, we have distinguished between the following:

Contextual Factor	Rationale
<ul style="list-style-type: none"> <li>• Action taken to facilitate housing regeneration within two years of scheme opening<sup>4</sup></li> <li>• Action taken to facilitate commercial or industrial regeneration within two years of scheme opening</li> <li>• Action taken to attract specific industries to the regeneration area within two years of scheme opening.</li> </ul>	
<b>Not used in QCA</b>	
<p><b>Underemployment or underutilised skills</b></p>	<p>This contextual factor seeks to capture whether the scheme served an area where there was evidence of underemployment or underutilisation of skills that could be unlocked through a transport intervention.</p> <p>The theory behind this contextual factor is that a transport intervention may lead to substantial productivity improvements (and as a result, transformation) if it allows individuals to access jobs that better match their skillset. This is relevant to individuals who are unable or unwilling to move to access jobs (e.g. they have caring responsibilities or are a secondary earner in a two-income household, etc.).</p> <p>We did not use this contextual factor, as it was not possible to find sufficiently high-quality evidence to determine whether residents in an area were underemployed.</p>
<p><b>Skills investment or activities</b></p>	<p>Similar to the above, this contextual factor sought to consider whether the scheme took place alongside investment in human capital. The theory behind this contextual factor is that productivity enhancing transformation may only be achieved by ensuring local residents have the requisite skills to access the jobs that are unlocked through a transport intervention.</p> <p>We did not use this contextual factor as for the majority of our case studies, we did not find any evidence on whether any such activities were implemented.</p>
<p><b>Part of regeneration programme</b></p>	<p>In our literature review, we considered that a transport scheme being part of a wider regeneration programme, was potentially a relevant contextual factor. However, when undertaking the QCA, we found that this contextual factor was often implicitly captured in the other contextual factors around unlocking development.</p>
<p><b>Existence of benefits realisation strategy</b></p>	<p>In the literature review, we theorised that the presence of a clear strategy for how transformation was going to be achieved may be a necessary condition for achieving transformation.</p> <p>However, when developing our case studies, we found very few instances of formal benefits realisation strategies. In some instances, there was evidence of a coordinated approach to development that could amount to a strategy, but it was challenging to objectively determine whether a strategy existed or not.</p>

### 2.4.2. Coding contextual factors

As indicated earlier, the csQCA, which we use here, requires a value of 0 or 1 to be assigned to each contextual factor. If the contextual factor is present, a value of 1 is assigned. If the contextual factor is not present, a value of 0 is assigned. The calibration of the contextual factors proved to be challenging. There were multiple issues with calibration. We outlined these issues, and the actions we undertook to resolve them, in section 2.2.2.

<sup>4</sup> We used two years as a cut-off point for determining whether an action was associated with the transport scheme.

Below, we outline, per contextual factor, the evidence base we used and our coding methodology.

Table 2.6: Coding Methodology – Contextual Factors

Context Variable	Evidence Base	Coding Methodology
<b>Quality of existing transport access</b>	Indicators used included (i) presence of good quality alternative public transport, and (ii) whether the route is new or a replacement of an existing line. <sup>5</sup>	If the scheme drastically reduced travel times, we assigned a value of 0. If the scheme introduced a new public transport route between previously unconnected areas, we assigned a value of 0. Otherwise, we assigned a value of 1.
<b>Latent demand for housing in satellite area (Area with housing deprivation)</b>	The Barriers to Housing & Services index from the Index of Multiple Deprivation (2000).	If fewer than 30% of LSOAs within the area were in the lowest two nationwide housing deprivation deciles (i.e. most deprived), we assigned a value of 0. If more than 30% of LSOAs were in the lowest two nationwide housing deprivation deciles, we assigned a value of 1.
<b>Regeneration potential in satellite area (Area of high deprivation)</b>	The Index of Multiple Deprivation (2000).	If fewer than 30% of LSOAs were in the lowest two nationwide deprivation deciles, we assigned a value of 0. If more than 30% of LSOAs were in the lowest two nationwide deprivation deciles, we assigned a value of 1.
<b>Action taken to facilitate regeneration (housing) – within two years</b>	Whether actions were taken to unlock new housing development schemes within two years of the completion of the transport scheme, such as release of land or the relaxation of planning rules.	If there was evidence of actions to unlock new housing developments, we assigned a value of 1. Otherwise, we assigned a value of 0.
<b>Sites identified for commercial regeneration in urban or satellite area</b>	Whether the business plan for a scheme identified sites for commercial regeneration.	If the business plan identified sites for commercial regeneration, we assigned a value of 1. Otherwise, we assigned a value of 0.
<b>Strong background economic growth in wider region</b>	Indicators used were (i) business cycles, and (ii) regional growth in GVA per capita in the five years preceding the opening of the scheme.	If the scheme opened during a period of economic growth, we assigned a value of 1. Otherwise, we assigned a value of 0.
<b>Action taken to attract industries to regeneration area</b>	Indicators used were (i) whether the scheme business plan outlines industries to attract; and (ii) any schemes to attract industries to the regeneration area.	If the business plan identified specific industries to attract to the regeneration area, we assigned a value of 1. If schemes existed to attract specific industries to the regeneration area, we assigned a value of 1. Otherwise, we assigned a value of 0.

<sup>5</sup> Some of the schemes within our dataset included interventions where pre-existing heavy rail lines were replaced with a light-rail service. We considered it a possible indicator that where this happened, there was less of a step change in public transport provision. We did not capture this in our initial coding, but subsequently included it as an additional indicator during our calibration of contexts.

Context Variable	Evidence Base	Coding Methodology
<b>Action taken to facilitate regeneration (commercial / industrial) within two years</b>	Indicators used were (i) development of new commercial / industrial sites, or (ii) other actions to facilitate commercial / industrial regeneration.	If new commercial/industrial sites were developed near the area of the scheme within two years of the scheme opening, we assigned a value of 1. If evidence exists of other actions to facilitate commercial/industrial regeneration within two years of the scheme opening, we assigned a value of 1. Otherwise, we assigned a value of 0.

## 2.5. OUTCOMES

### 2.5.1. Selecting outcome variables

Our definition of Transformational Impact identified relevant outcomes. We assert that a scheme is transformational if there is empirical proof of a step change in **any** of the following three metrics:

- A. The change in the transportation system leads to a step-change in connectivity and / or effective density, which manifests itself in a significantly increased usage of the transport network.
- B. The scheme leads to dynamic clustering and / or land use change which can be empirically identified by a significant change in sectoral employment shares or land use shares.
- C. The scheme leads to increases in at least one of the following four metrics: employment, productivity per worker/firm, number of homes and/or land and property values.

We have used this definition to identify our outcome variables

For part A of the definition, we have identified three outcome variables. These are related to the number of passengers after the transport scheme was completed. For part C of the definition, we identified three outcome variables. These are related to employment, productivity, and housing. For part B of the definition, we used regeneration as an outcome variable indicating land use change, while recognising that it is challenging to directly measure dynamic clustering.

The six outcome variables are listed in the table below.

Table 2.7: Outcome Variables

Outcome Variable	Description
<b>Increase in Passengers</b>	Whether an increase in passengers occurred after the scheme was completed.
<b>Passenger exceeded forecasts in business case?</b>	Whether the number of passengers after the scheme was completed exceeded the forecasts in the business case.
<b>Employment</b>	Whether an increase of employment occurred after the scheme was completed. For some ToCs, we look at employment at specific locations, such as satellite areas or urban centres.
<b>Productivity</b>	Whether an increase in productivity occurred after the scheme was completed. For some ToCs, we look at productivity at specific locations, such as satellite areas or urban centres.
<b>Housing</b>	Whether an increase in housing prices occurred after the scheme was completed.
<b>Regeneration</b>	Whether regeneration occurred after the scheme was completed.



### 2.5.2. Coding outcome variables

As for contextual factors, QCA requires outcome variables to be coded 0 or 1 depending on whether the outcome was present within the case. The calibration of outcomes variables also proved to be challenging. There were multiple issues with calibration. We outlined these issues, and the actions we undertook to resolve them, in Section 2.2.2.

Below, we outline, per outcome variable, the evidence base we used and our coding methodology.

Table 2.8: Coding Methodology – Outcome Variables

Outcome Variable	Evidence Base	Coding Methodology
<b>Increase in Passengers</b>	Passenger outturn data	Assigned a value of 1 if increase was measured. Assigned a value of 0 if no increase was measured.
<b>Passenger exceeded forecasts in business case?</b>	Business Case passenger forecasts Passenger outturn data	Assigned a value of 1 if the measured passenger numbers exceeded business case forecasts. Assigned a value of 0 if the measured passenger numbers were lower than or equal to the business case forecasts.
<b>Employment</b>	Employment data Evaluation studies that estimate jobs created	Assigned a value of 1 if an increase in employment was measured over above the national average growth in employment. Assigned a value of 0 if not.
<b>Productivity</b>	Wage data. GVA and GDP data. Type of employment data. Office rents	Assigned a value of 1 if an increase in wages was measured over and above the national wage growth, there was above average GVA/GDP growth, or the general type of employment in the area changed to a higher-productivity type. Assigned a value of 0 if none of the above were the case.
<b>Housing</b>	House price data Housing developments	Assigned a value of 1 if an increase in house prices was measured over and above the national house prices, or if significant housing development projects were undertaken. Assigned a value of 0 if not.
<b>Regeneration</b>	Increased investment New business entering House price data Housing developments Building developments	Assigned a value of 1 if there was an indication of regeneration through multiple of the indicators in the evidence base. Assigned a value of 0 if not.

### 3. THEORY OF CHANGE

In Stage I, we developed scheme specific ToCs for each case study. We use these in Stage II to develop overarching ToCs which synthesise the content of the case specific ToCs. In our scheme specific ToCs we distinguished between two kinds of impacts, (i) residential impacts; and (ii) labour demand impacts. Below, we present the ToCs for these impacts. Based on these, we develop two overarching ToCs, one for residential impacts, and one for labour demand impacts. These overarching ToCs form the basis of our Stage II analysis.

#### 3.1.1. Residential Impacts

In our case study report, we developed six ToCs for residential impacts. An overarching ToC can be developed based on these. Figure 3.1 below represents a logic map articulating the ToC for Residential Impacts.

**Inputs / Activities / Outputs** – The inputs and activities are a transport investment. Based on the transport investment, we expect improved access to the city centre from the satellite towns. The extent to which this is a substantial improvement will depend on the quality of existing public transport infrastructure.

**Outcomes / Impacts** – This transport investment can lead to residential transformation, by unlocking housing development in areas that are subject to housing constraints. This increases residential density. We expect two outcomes based on the improved access to city centres from satellite towns:

- Changes in housing access through residents of other areas moving to the satellite town.
- Increased housing developments in satellite towns.

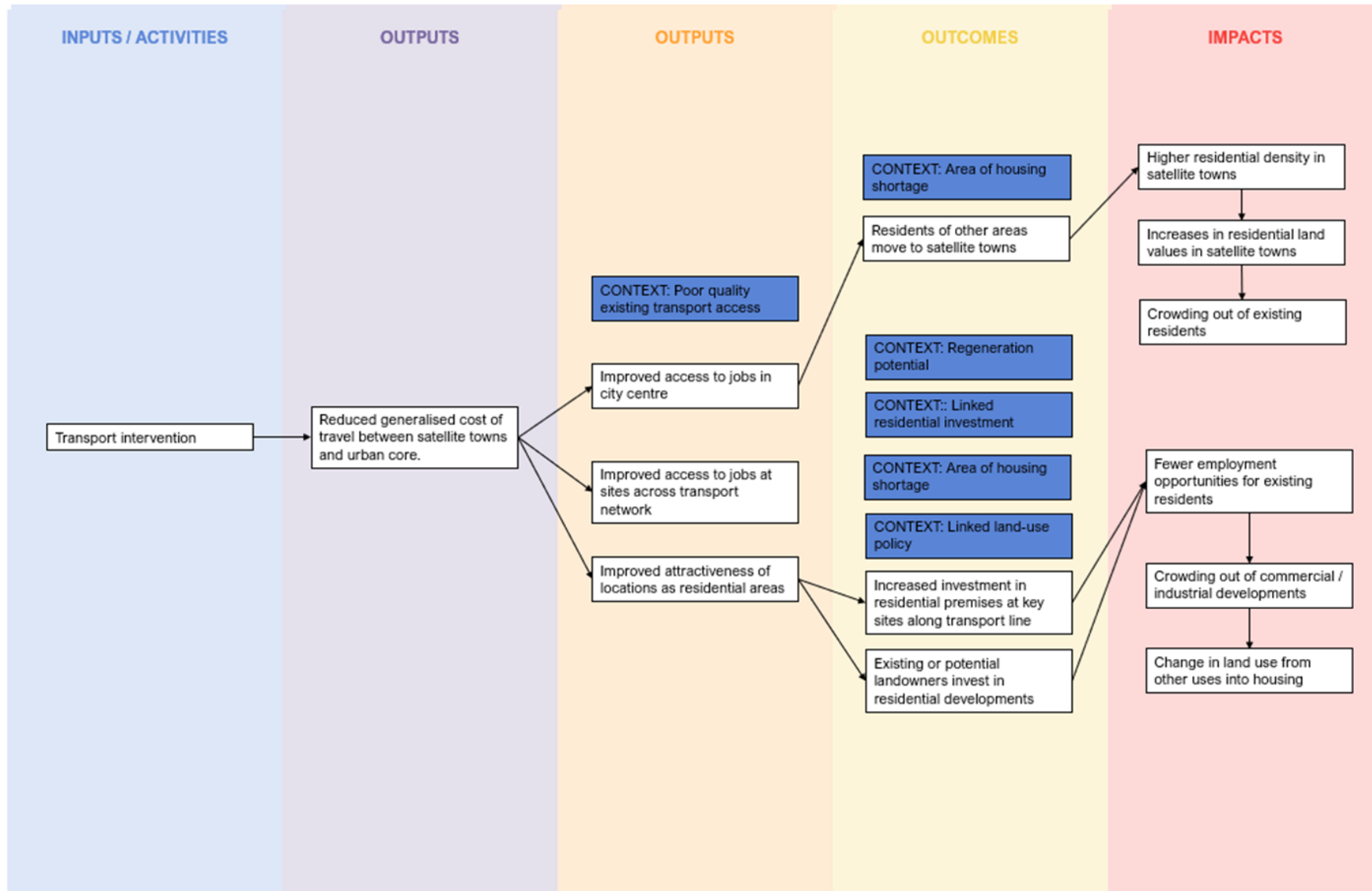
We also expect an increase in public transport usage, as more people travel between the city centre and the satellite towns.

These impacts highlight a transformational impact we expect to materialise, with the city centre becoming a more effective employment centre and the satellite towns becoming more effective residential locations. This could lead to a restructuring of economic activity and land use. The satellite town becomes more residential, while economic activity moves to the city centre. A potential negative impact is the crowding out of existing residents, due to insufficient housing developments.

**Contexts** – We identified four contextual factors, which may act as conditions for some of these impacts to materialize. These are:

- **Quality of existing transport access** – A transport intervention is more likely to lead to residential transformation if the intervention leads to a genuine step change in transport accessibility.
- **Latent demand for housing in satellite area** – A transport intervention is more likely to lead to residential transformation if there was evidence of existing housing constraints. Housing constraints could either be within the satellite area itself, or within the wider region; the latter implying that people would move to the satellite area if the transport intervention led to the unlocking of housing development
- **Regeneration potential in satellite area** – Housing developers may be less likely to invest in housing in areas with higher levels of deprivation without the crowding in effect of transport investment.
- **Action taken to facilitate regeneration (housing)** – For residential transformation to take place, it may be necessary for there to be specific actions taken to unlock housing developments.

Figure 3.1: Logic Map for Residential Impacts



### 3.1.2. Labour Demand Impacts

In our case study report, we developed seven ToCs for labour demand impacts. An overarching ToC can be developed based on these. Figure 3.2 below represents a logic map articulating the ToC for Residential Impacts.

**Inputs / Activities / Outputs** – The inputs and activities are a transport investment. Based on the transport investment, we expect improved accessibility between towns. The extent to which this is a substantial improvement will depend on the quality of existing public transport infrastructure.

**Outcomes / Impacts** – We theorize two paths through which transport investment can have labour demand impacts.

A transport investment can lead to economic transformation, when there is already latent demand for commercial real estate. It does so by unlocking economic activity within an area. This latent demand can either come from strong background economic growth and/or regeneration efforts to attract new industry to an area. We expect three outcomes based on the unlocking of economic activity:

- Increased employment.
- Higher productivity.
- Increased land value.

A transport investment can also lead to economic transformation of an urban core by extending the size of the labour catchment, attracting more firms to the urban centre, creating more employment opportunities and potentially improving productivity both through better matching of skills to jobs and through agglomeration from dynamic clustering. Such transformation is dependent on the transport intervention representing a genuine step change in transport accessibility, and evidence of pressures on the labour market. We expect two outcomes based on the increased size of the labour catchment area:

- Increased employment.
- Higher productivity.

We also expect an increase in public transport usage, as more people travel to the employment sites.

**Contexts** – For both paths, two contextual factors may act as conditions for some of these impacts to materialize. These are:

- **Quality of existing transport access** – A transport intervention is more likely to lead to economic transformation if the intervention leads to a genuine step change in transport accessibility.
- **Strong background economic growth** – For a specific locality to attract new development and new businesses following a transport intervention, there needs to be latent demand for such development. One of the ways such latent demand can arise is through strong background economic growth.

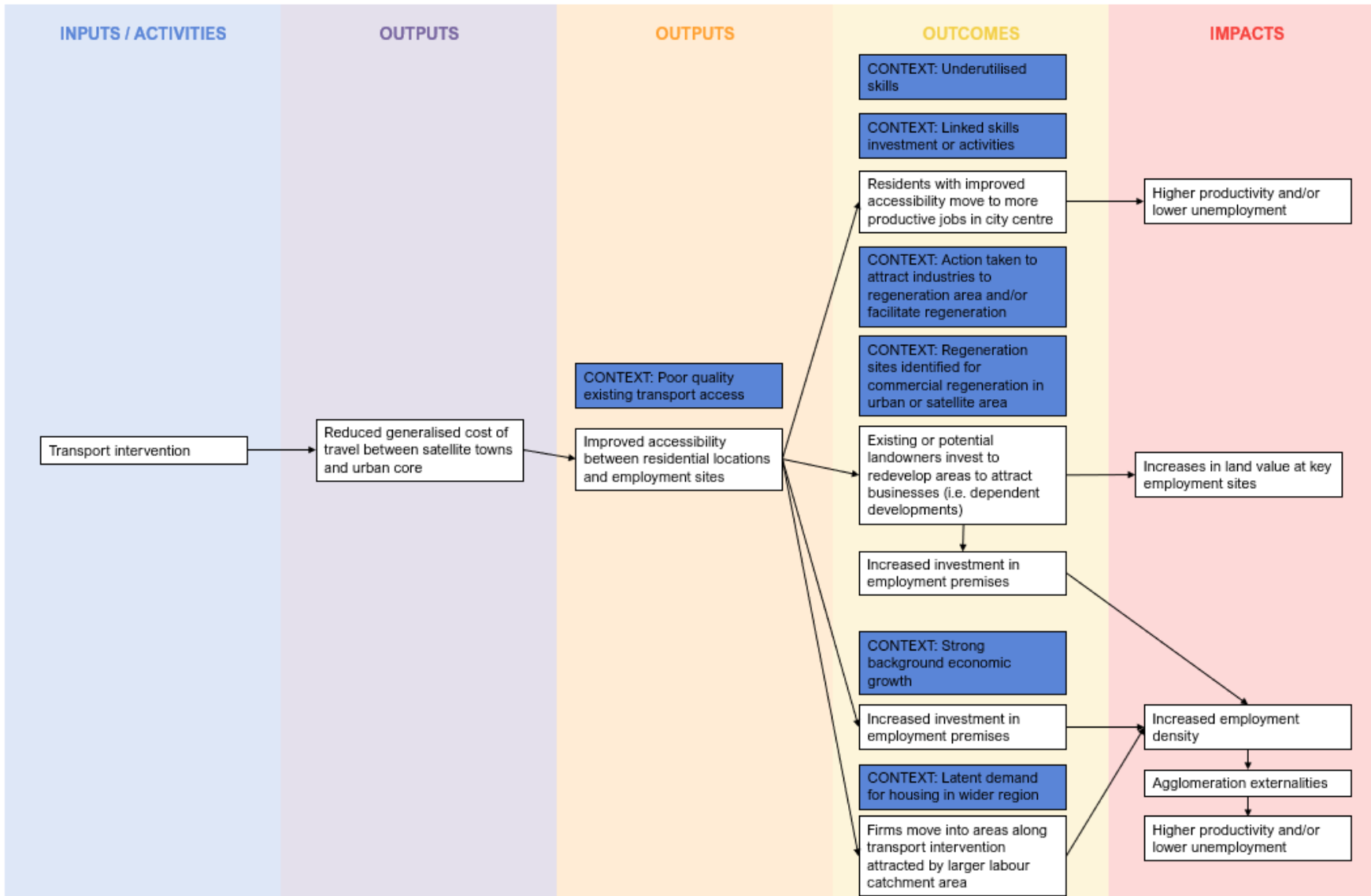
For the first path, three more contextual factors may act as conditions. These are:

- **Action taken to attract industries to regeneration area** - Latent demand can arise through specific actions taken to attract industries to the locality, e.g. by attracting an anchor tenant, engaging with businesses to relocate to the area, etc.
- **Sites identified for commercial regeneration in urban or satellite area** - Transformation is more likely to occur when specific regeneration sites have been identified for new development, often existing industrial or commercial sites that have fallen into disuse.
- **Specific actions taken to facilitate regeneration** – For economic transformation to occur, it may be necessary for there to be specific actions taken to facilitate redevelopment of the area.

For the second path, two more contextual factors may act as conditions. These are:

- **Underutilized skills or linked skills investments or activities** – For existing residents to benefit from access to more productive jobs, it may need to be the case that their existing skills are being underutilised in their existing jobs, or that they are supported by specific interventions to give them the skills required to obtain these newly accessible jobs.
- **Latent demand for housing in wider region** – We assume that evidence of housing constraints within the wider region is likely to create pressure on the labour market within the urban core, making the location less attractive for employers. A transport intervention can lead to economic transformation by improving labour access to a location that does not face such housing constraints.

Figure 3.2: Logic Map for Labour Demand Impacts



## 4. QCA FINDINGS

### 4.1. HYPOTHESIS 1 – RESIDENTIAL IMPACTS

The first hypothesis we considered was:

*Hypothesis 1:* Transport infrastructure can lead to residential transformation, by unlocking housing development in areas that are subject to housing constraints, increasing residential density and leading to an increase in public transport usage.

For this hypothesis, based on the ToC, we considered the following contextual factors to be relevant:

- **Quality of existing transport access** – Our theory was that a transport intervention is more likely to lead to residential transformation if the intervention leads to a genuine step change in transport accessibility. For example, where an area already had access to good quality bus services, the introduction of a new light rail route may present less of an improvement in accessibility.
- **Latent demand for housing in satellite area** – Our theory was that a transport intervention is more likely to lead to residential transformation (i.e. changes in land use in favour of more housing) if there was evidence of existing housing constraints. In our ToC, we considered that this could either be evidence of housing constraints within the satellite area itself, or evidence of housing constraints within the wider region; the latter implying that people would move to the satellite area if the transport intervention led to the unlocking of housing development. In our coding of this contextual factor, we only considered the former as the evidence we had access to allowed us to more consistently capture the presence of the contextual factor.
- **Regeneration potential in satellite area** – In the context of this ToC, we considered that housing developers may be less likely to invest in housing in areas with higher levels of deprivation without the crowding in effect of transport investment. As such, the transport intervention would act to unlock regeneration.
- **Action taken to facilitate regeneration (housing)** – We theorised that for residential transformation to take place, it may be necessary for there to be specific actions taken to unlock housing developments, such as the release of land to developers, the relaxation of planning rules, etc..

We considered two different outcomes for testing this hypothesis:

- **Passengers exceeded forecasts in business case?** – We used patronage levels as an indicator of land use change, assuming that the forecasts within the business case represented the likely outturn patronage levels assuming no land use change. In respect of any substantial deviation of patronage from forecast levels, not explained by other factors, we assume is likely to mean land use has changed directly in response to the change in transport accessibility.
- **Housing** – We also considered outcome evidence on housing developments and house prices as a second indicator of whether an area experienced land use change in favour of residential uses.

We judge that a transformational outcome occurs only if both of these two outcomes were present, as each outcome in isolation is an imperfect indicator of transformation. This is consistent with our ToC, which predicted both increased housing in satellite towns, and increased public transport usage, as more people travel between the city centre and the satellite towns.

In testing this hypothesis, we restricted our case selection to transport interventions that connected an urban core to its periphery. This was based on our overarching theory that improving such transport links has the potential to extend the labour catchment of the urban centre to include the peripheral area, such that the urban core becomes

a more effective employment centre. This leads to a change in the geographic location of economic activity that favours the urban core, with the peripheral or satellite area becoming more of a residential centre.

The cases we selected to test this hypothesis were:

- Manchester Metrolink - Phase 1
- Manchester Metrolink - Phase 2
- Manchester Metrolink - Phase 3(a)
- Manchester Metrolink - Phase 3(b)
- Jubilee Line Extension - Waterloo / Southwark
- Jubilee Line Extension - Bermondsey / Canada Water
- Jubilee Line Extension - Canary Wharf
- Jubilee Line Extension - Canning Town
- Jubilee Line Extension - Stratford
- Nottingham Express Transit - Phase 1
- Nottingham Express Transit - Phase 2 (Clifton)
- Nottingham Express Transit - Phase 2 (Beeston)
- Borders Railway - Scottish Borders
- High Speed 1 - Phase 2 - Kent
- Sheffield Supertram - Line 1
- Kirkstall Forge
- High Speed Rail Network - Spain - Phase 1 - Ciudad Real

## 4.2. HYPOTHESIS 2 – REGENERATION-RELATED LABOUR DEMAND IMPACTS

The second hypothesis we considered was:

*Hypothesis 2:* Transport infrastructure can lead to economic transformation, when there is already latent demand for commercial real estate, by unlocking economic activity within an area. This latent demand can either come from strong background economic growth and/or regeneration efforts to attract new industry to an area.

For this hypothesis, based on the ToC, we considered the following contextual factors to be relevant:

- **Quality of existing transport access** – Similar to the Hypothesis 1, we consider that the transport intervention needs to represent a genuine step change improvement in transport accessibility to lead to transformational change.
- **Strong background economic growth** – Our theory is that for a specific locality to attract new development and new businesses following a transport intervention, there needs to be latent demand for such development. One of the ways such latent demand can arise is through strong background economic growth.
- **Action taken to attract industries to regeneration area** – We consider the second way latent demand can arise is through specific action taken to attract industries to the locality, e.g. by attracting an anchor tenant, engaging with businesses to relocate to the area, etc.
- **Sites identified for commercial regeneration in urban or satellite area** – We theorise that transformation is more likely to occur when specific regeneration sites have been identified for new development, often existing industrial or commercial sites that have fallen into disuse.
- **Specific actions taken to facilitate regeneration (commercial / industrial)** – Similar to Hypothesis 1, we consider that in order for transformation to occur following a transport intervention, it may be the case that



specific actions are required to facilitate the redevelopment of the area. We have separated out the contextual factor relating to demand-side interventions. For this contextual factor, we consider supply side interventions such as the release of land, the establishment of a development corporation etc..

We considered two outcome variables to test this hypothesis:

- **Passengers exceeded forecasts in business case?** – Again, we used outturn patronage levels when compared against business case forecasts, as an indicator of land use change. However, when testing this hypothesis, our focus is on the locations that act or have the potential to act as employment centres. In some instances, these are the urban centres, but in other instances they are areas along the transport corridor.
- **Employment (as measured by jobs created within regeneration area)** – We also assessed whether there was evidence of new developments within the regeneration area that created jobs.

We judge that a transformational outcome occurs only if both of these two outcomes were present as again, both outcomes are imperfect indicators of transformation. This is consistent with our ToC, which predicted both increased employment, and increased public transport usage, as more people travel between to the employment centres.

In testing this hypothesis, we restricted our case selection to the cases where our ToC was most likely to apply, i.e. transport interventions that connected an area where there was scope for commercial regeneration. In other words, the transport intervention connected an area, either in the urban centre or somewhere else along the transport corridor, which had the potential to be a site of employment.

The cases we selected to test this hypothesis were:

- Manchester Metrolink - Phase 1
- Manchester Metrolink - Phase 2
- Manchester Metrolink - Phase 3(b)
- Jubilee Line Extension - Waterloo / Southwark
- Jubilee Line Extension - Bermondsey / Canada Water
- Jubilee Line Extension - Canary Wharf
- Jubilee Line Extension - Stratford
- Nottingham Express Transit - Phase 1
- Nottingham Express Transit - Phase 2 (Clifton)
- Nottingham Express Transit - Phase 2 (Beeston)
- Borders Railway - Scottish Borders
- High Speed 1 - Phase 2 - Kent
- Sheffield Supertram - Line 1
- Kirkstall Forge
- Corby new station and rail service

### **4.3. HYPOTHESIS 3 – CATCHMENT-RELATED LABOUR DEMAND IMPACTS**

The third hypothesis we tested was:

*Hypothesis 3:* Transport infrastructure can lead to economic transformation of an urban core by extending the size of the labour catchment, attracting more firms to the urban centre, creating more employment opportunities and potentially improving productivity both through better matching of skills to jobs and through agglomeration from dynamic clustering. Such transformation is dependent on the transport intervention representing a genuine step change improvement in transport accessibility, and evidence of pressures on the labour market.

For this hypothesis, based on the ToC, we considered the following contextual factors to be relevant:

- **Quality of existing transport access** – Similar to the Hypothesis 1, we consider that the transport intervention needs to represent a genuine step change improvement in transport accessibility to lead to transformational change.
- **Underutilised skills or linked skills investment or activities** – One of our transmission mechanisms under this hypothesis relies on the transport intervention benefitting existing residents of a satellite area by unlocking access to jobs in the urban centre (or elsewhere on the public transport network) where they can be more productive. In this context, it may be that for existing residents to benefit, it needs to be the case that their existing skills are being underutilised in their existing jobs, or that they are supported by specific interventions to give them the skills required to obtain these newly accessible jobs.

However, in our case study analysis, we found limited evidence either way on whether such interventions took place or whether skills were being underutilised. As such, we have been unable to test this contextual factor specifically.

- **Strong background economic growth** – Our theory is that for a specific locality to attract new development and new businesses following a transport intervention, there needs to be latent demand for such development. One of the ways such latent demand can arise is through strong background economic growth.
- **Action taken to attract industries to regeneration area** – We consider the second way latent demand can arise is through specific action taken to attract industries to the locality, e.g. by attracting an anchor tenant, engaging with businesses to relocate to the area, etc.

However, we have not been able to find consistent evidence across all of our case studies for this contextual factor, and as a result, have been unable to test it specifically.

- **Latent demand for housing in wider region** – We assume that evidence of housing constraints within the wider region is likely to create pressure on the labour market within the urban core, making the location less attractive for employers. And as such, a transport intervention in this context can lead to economic transformation by improving labour access to a location that does not face such housing constraints. This will allow workers to move to the satellite area with low-cost housing while maintaining access to jobs.

We considered two outcome variables to test this hypothesis:

- **Employment / productivity within the urban centre** – Our ToC suggests that the extension of the labour market catchment attracts new firms to the urban centre, creating new employment opportunities. This increases the effective employment density of the urban centre, enabling agglomeration economies. Wherever possible, we have tried to use indicators that directly attribute the outcome to the transport intervention.
- **Employment / productivity of workers residing in satellite area** – We can also measure the impact on employment from the perspective of the satellite area benefitting from improved connectivity to the urban centre. We use the impact of the transport intervention on the unemployment rate of the satellite area, as our indicator. However, the case studies we have used do not allow us to distinguish whether the impact is due to a reduction in unemployment from people moving into the area or due to the existing population moving into employment (or a combination of both). Very few of our case studies have measured productivity effects and as a result, our coding relies primarily on effects on employment levels.

We judge that a transformational outcome occurs if either of these two outcomes was present. This is due to missing or incomplete data on both outcome variables. We therefore assume that one outcome being present is sufficient evidence for transformational change.

In testing this hypothesis, we restricted our case selection to the cases where our ToC was most likely to apply, i.e. there was a potential extension to the labour catchment of an area that could be considered an urban centre.<sup>6</sup> In most cases, the cases we have considered relate to connecting a city centre with nearby suburbs or towns. However, we also include cases that connect city centres or town centres together where there is a realistic possibility of commuting between them – in which case the two locations act as both satellite areas and urban centres.

The cases we selected to test this hypothesis were the following, though three of them were removed due to the evidence around contexts and outcomes being incomplete or inconclusive:

- Manchester Metrolink - Phase 1
- Manchester Metrolink - Phase 2
- Manchester Metrolink - Phase 3(a)
- Manchester Metrolink - Phase 3(b)
- Jubilee Line Extension - Waterloo / Southwark
- Jubilee Line Extension - Bermondsey / Canada Water
- Jubilee Line Extension - Canary Wharf
- Jubilee Line Extension - Stratford
- Nottingham Express Transit - Phase 1
- Nottingham Express Transit - Phase 2 (Clifton)
- Nottingham Express Transit - Phase 2 (Beeston)
- Borders Railway - Scottish Borders
- High Speed 1 - Phase 2 - King's Cross
- High Speed Rail Network - Spain - Phase 1 - Ciudad Real
- High Speed Rail Network - Spain - Phase 1 – Cordoba [removed from selection due to insufficient data]
- High Speed Rail Network - Spain - Phase 1 – Seville [removed from selection due to insufficient data]
- West Coast Mainline Upgrades - North West [removed from selection due to inconclusive evidence]
- Corby new station and rail service
- Sheffield Supertram - Line 1

#### **4.4. ANALYSIS**

For our analysis, we performed csQCA with our outcome variables and with different combinations of our contextual factors, to determine whether we were able to construct a truth table without contradictions (i.e. cases where the same contextual factors led to different outcomes).

To resolve such contradictions, we used a mixture of the following actions:

- **Calibrating our coding of contextual factors and outcomes** – We reviewed each of the case studies and the supporting evidence surrounding the case studies to reconsider whether we had appropriately coded our contextual factors and outcomes. We primarily focused on the factors and outcomes that were somewhat subjective, such as the quality of existing transport access, and were supported in our judgment by the narratives included within existing evaluations and our case study interviews.

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<sup>6</sup> One of the ways we distinguish between Hypotheses 2 and 3 is that Hypothesis 2 looks at the impact on specific localities or sites that are connected to a transport network (often a public transport network), whereas for Hypothesis 3 we consider larger areas such as a town centre or city centre.

- **Combining our outcome variables** – In the case of Hypotheses 1 and 2, we found that both of our outcome variables were imperfect indicators of a transformational outcome. As a result, we combined both indicators, assumed that a transformational outcome was only achieved if both indicators suggested so.

In the case of Hypothesis 3, we found that very few of our case studies had evidence on both the impact on employment based on workplace *and* based on residence. As a result, we combined both outcomes to present a single indicator.

- **Using additional contextual factors to explain outliers** – Finally, we investigated the detail of any cases that remained outliers to try to develop alternative explanations of why these outliers existed. In some instances, this led to the creation of additional contextual factors that explained the outcome. In other instances, we have a number of possible contextual explanations for the outcome, but none that could be incorporated into the truth table without introducing new contradictions.

## 4.5. FINDINGS

### Hypothesis 1 – Residential Impacts

The table below presents the final truth table showing the cases used to test Hypothesis 1. It presents a mapping of different combinations of contextual factors and outcomes, and lists the cases that fall into each combination. Blue rows represent the combinations of contextual factors that lead to a transformational outcome, while the red row represents a combination of contextual factors that leads to contradictory outcomes.

When analysing this hypothesis, we made the following changes to our dataset to resolve contradictions:

- **Calibrated ‘quality of existing transport access’ contextual factor** – We adjusted the coding of cases that were determined to have poor quality transport access prior to scheme opening. Specifically, we adjusted our coding so that cases where existing transport provision was being replaced were not considered to have poor existing transport access.<sup>7</sup> This affected the Phase 3b of Manchester Metrolink case which is now assessed to not have poor quality transport access prior to the introduction of the tram line.
- **Introduced a new contextual factor ‘other land use change’** – We introduced a new contextual factor to represent cases where there are competing explanations for land use change that are unrelated to the hypothesis that we were testing, which may provide an alternate explanation for why an outcome was achieved. For the Jubilee Line Extension to Stratford and Canary Wharf, this relates to land use change related to the Olympics and the regeneration of the Docklands respectively, while for the Borders Railway to the Scottish Borders, this relates to commercial land use change.

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<sup>7</sup> See footnote 5

Table 4.1: Final truth table testing Hypothesis 1

Cases	Transformational Outcome	Quality of existing transport access	Latent demand for housing in satellite area	Regeneration potential in satellite area	Action taken to facilitate regeneration	Other land use change *
Nottingham Express Transit - Phase 2 (Beeston)	0	0	0	0	0	0
High Speed 1 - Phase 2 – Kent	0	0	0	1	0	0
Sheffield Supertram - Line 1 Nottingham Express Transit - Phase 1 Kirkstall Forge	C	0	0	1	0	0
Manchester Metrolink - Phase 3(a) Manchester Metrolink - Phase 3(b) Jubilee Line Extension - Waterloo / Southwark Nottingham Express Transit - Phase 2 (Clifton)	0	0	1	1	0	0
Jubilee Line Extension - Canning Town	1	0	1	1	1	0
Jubilee Line Extension - Canary Wharf Jubilee Line Extension – Stratford	1	0	1	1	1	1
Manchester Metrolink - Phase 1 Borders Railway – Midlothian	0	1	0	0	0	0
Borders Railway - Scottish Borders	1	1	0	0	0	1
High Speed Rail Network - Spain - Phase 1 - Ciudad Real	0	1	0	1	1	0
Manchester Metrolink - Phase 2 Jubilee Line Extension - Bermondsey / Canada Water	1	1	1	1	1	0

Source: CEPA analysis

Notes:

(a) A case is considered to have led to a transformational outcome if passenger numbers exceeded levels expected within the business case and there was evidence that the transport intervention had affected housing demand.

(b) Rows highlighted blue represent cases that were assessed to have led to a transformational outcome, while those highlighted red represent cases that had different outcomes despite being subject to the same contextual factors.

\* The contextual factor 'Other land use change' has been introduced to resolve certain contradictions. It reflects cases where there are other competing explanations for land use change that do not relate to this hypothesis, which may provide an alternate explanation for why an outcome was achieved. For the Jubilee Line Extension to Stratford and Canary Wharf, this relates to land use change related to the Olympics and the regeneration of the Docklands, while for the Borders Railway to the Scottish Borders, this relates to commercial land use change.

The result from the QCA analysis was:

- (Latent demand for housing × action taken to facilitate housing regeneration) → transformational outcome

The interpretation of the result is that a combination of latent demand for housing in a satellite area (as evidenced by high levels of housing deprivation) and action taken to facilitate housing regeneration, can work collectively to transform an area in favour of more residential activity. In other words, the table shows that all cases where there was latent demand for housing **and** specific action taken to facilitate housing regeneration led to a transformational outcome, i.e. the two factors together act as a **sufficient condition**. The table also shows that there are two cases where we have found evidence of residential transformation despite this combination of contextual factors not existing, which suggests that they are **not necessary conditions**.

The two cases are:

- The **Borders Railway corridor between Edinburgh and the Scottish Borders** region experienced higher passenger growth than was anticipated within the business case. Our review of the case study and supporting evidence suggests this outcome was at least partially due to commercial developments rather than necessarily being evidence of residential transformation. In fact, other indicators of residential transformation, such as changes in the volume of housing sales, suggests the Borders region has not yet experienced the kind of transformation anticipated.<sup>8</sup>
- More interestingly, we found evidence for **Phase 1 of the Nottingham Express Transit** scheme leading to residential transformation in neighbourhoods north of the city centre, despite there not being evidence of latent demand for housing within the satellite area. Our review of the case suggests that areas to the north such as Hucknall experienced population increases, several new housing developments, and an increase in the volume of housing transactions. The qualitative and quantitative evidence shows that much of the growth in the housing market was due to people moving into the area,<sup>9</sup> suggesting that (the lack of) housing constraints within the area was a less relevant consideration. We also find that Hucknall's location on a potential commuter route into Nottingham city centre was identified prior to the introduction of NET, and land was strategically zoned to support new housing development in anticipation of NET.

The experience of Hucknall contrasts with **Kirkstall Forge** and **Sheffield Supertram**, having similar contexts but not appearing to lead to transformational change. Our case study of the Kirkstall Forge project suggests that the lack of evidence around residential transformation is likely to be due to the residential developments still being under construction.<sup>10</sup> Therefore, it is possible that once these premises are developed, patronage levels increase more substantially. The experience of Sheffield Supertram provides an interesting case study. Although there was a development corporation established within Sheffield, the Sheffield Development Corporation (SDC), and the tram line ran through the area covered by the SDC, the governance of the two initiatives were not integrated and their respective objectives were not aligned.<sup>11</sup> For example, the SDC operated independently of the local council, being overseen by the UK Government and having a remit that did not directly refer to transport accessibility. The Supertram on the other hand, was developed and overseen by the local council, which saw the SDC as a direct challenge to its authority.<sup>12</sup>

The results of our QCA analysis suggests that where one of the ambitions of a transport intervention is to support residential transformation, identifying appropriate locations and taking supportive action can help facilitate such outcomes. The range of supportive actions that can be taken are broad – from rationalising nearby land and

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<sup>8</sup> BBC (2015) Borders Railway housing market impact still awaited. Available at [bbc.co.uk](http://bbc.co.uk)

<sup>9</sup> NDE Consultants Ltd (2007) Economic Regeneration Impact of Line 1 of NET. Available at [nottinghamcity.gov.uk](http://nottinghamcity.gov.uk)

<sup>10</sup> Kirkstall Forge (2021) Planning approval for first phase of residential development at Kirkstall Forge. Available at [kirkstallforge.com](http://kirkstallforge.com)

<sup>11</sup> Lawless and Gore (1999) Urban Regeneration and Transport Investment: A case study of Sheffield 1992-96

<sup>12</sup> Centre for Analysis of Social Exclusion (undated) Sheffield City Report. Available at [lse.ac.uk](http://lse.ac.uk)

releasing it to developers, establishing a development corporation, zoning an area for housing purposes, or simply ensuring that the upgraded transport link is marketed within development prospectuses.

## **Hypothesis 2 – Regeneration-related Labour Demand Impacts**

The table below presents the final truth table showing the cases used to test Hypothesis 2.

When analysing this hypothesis, we made the following changes to our dataset to resolve contradictions:

- **Calibrated ‘strong background economic growth in wider region’ contextual factor** – We calibrated the coding of cases that were determined to have opened during periods of strong background economic growth, to also reflect regional growth in GVA per capita in the five years preceding the opening of the scheme. Our initial coding solely relied on the stage of the business cycle during scheme opening. However, we extended our coding to reflect instances where GVA per capita was growing more strongly in the area (prior to scheme opening) than the UK as a whole. This affected our Nottingham Express Transit - Phase 1 case.
- **Calibrated ‘action taken to attract industries to area’ contextual factor** – We adjusted our coding of the Jubilee Line Extension to Stratford case. For this case we now judge that action was not taken to attract industries to the area, as it was challenging to tie actions taken by the local authority to the Jubilee Line Extension itself.

Table 4.2: Final truth table testing Hypothesis 2

Cases	Transformational Outcome	Quality of existing transport access	Strong background economic growth	Regeneration sites identified for commercial regeneration	Specific actions taken to facilitate regeneration	Action taken to attract industries to area
Nottingham Express Transit - Phase 2 (Beeston)	0	0	0	0	1	0
Nottingham Express Transit - Phase 2 (Clifton)	0	0	0	1	0	0
High Speed 1 - Phase 2 - King's Cross Corby new station and rail service	0	0	0	1	1	1
Jubilee Line Extension - Waterloo / Southwark	1	0	1	0	0	0
Sheffield Supertram - Line 1	0	0	1	0	1	0
Nottingham Express Transit - Phase 1 Jubilee Line Extension - Stratford	1	0	1	1	0	0
High Speed 1 - Phase 2 - Stratford	0	0	1	1	1	0
Jubilee Line Extension – Canary Wharf	1	0	1	1	1	1
Manchester Metrolink - Phase 3(b) Borders Railway - Scottish Borders	0	1	0	1	1	1
Manchester Metrolink - Phase 1	0	1	1	0	0	0
Jubilee Line Extension - Bermondsey / Canada Water	1	1	1	1	0	0
Manchester Metrolink - Phase 2	1	1	1	1	1	1

Source: CEPA analysis

Notes:

(a) A case is considered to have led to a transformational outcome if passenger numbers exceeded levels expected within the business case and there was evidence that the transport intervention led to a positive effect on the level of employment within the regeneration area.

(b) Rows highlighted blue represent cases that were assessed to have led to a transformational outcome, while those highlighted red represent cases that had different outcomes despite being subject to the same contextual factors.



We have been unable to develop a coherent, theory-consistent narrative for this hypothesis, with the results from our QCA exercise. While we identified cases that were supportive of our theory, we also found cases that were incompatible with it. For example in Table 4.2, comparing Line 1 of the Sheffield Supertram with the Jubilee Line Extension to Waterloo and Southwark, would suggest that not taking any action to facilitate regeneration is more likely to lead to a transformational outcome. This is incompatible with our ToC and is counterintuitive.

We believe the main reason for this outcome is there being insufficient case studies to properly reflect differences in contexts and outcomes. Many of these counterintuitive results can be explained through a more nuanced explanation of each case. For example, the outcome observed in the Sheffield Supertram case could be explained by the lack of coordination between the authorities responsible for the tram development and the authorities responsible for regeneration the Lower Don Valley. The observed outcome for the case of the Jubilee Line Extension to Waterloo and Southwark, may partly be due to other factors unrelated to the transport link, (e.g. due to other unrelated development).

However, as we have limited case studies within our dataset, we are unable to add additional contextual factors to our data matrix and truth table without sacrificing the robustness of the results.

The full list of solutions from the QCA exercise are listed below:

- (NOT poor-quality existing transport access × strong background economic growth × NOT action taken to facilitate regeneration)
  - + (poor quality existing transport access × strong background economic growth × sites identified for commercial regeneration)
  - + (strong background economic growth × action taken to attract industries to area)
 → transformational outcome

**This solution shows that there are three sets of sufficient conditions for achieving transformational outcome. The presence of strong background economic growth in all three sets of conditions implies that it acts as a necessary condition.**

**This solution includes a number of counterintuitive results including suggesting that taking action to facilitate regeneration can prevent a transformational outcome. It also includes some solutions that cannot be reconciled into a consistent theory, such as why poor-quality existing transport access sometimes leads to transformational outcomes and sometimes leads to the opposite outcome.**

- (NOT poor-quality existing transport access × strong background economic growth × NOT action taken to facilitate regeneration)
  - + (poor quality existing transport access × sites identified for commercial regeneration × NOT action taken to facilitate regeneration)
  - + (strong background economic growth × action taken to attract industries to area)
 → transformational outcome

**As above, this solution has three sets of sufficient conditions for achieving a transformational outcome, but it also leads to some counterintuitive results including suggesting that taking action to facilitate regeneration can prevent a transformational outcome.**

- (NOT poor-quality existing transport access × strong background economic growth × NOT action taken to facilitate regeneration)
  - + (poor quality existing transport access × sites identified for commercial regeneration × NOT action taken to attract industries to area)
  - + (strong background economic growth × action taken to attract industries to area)
 → transformational outcome

**As above, this solution includes a number of counterintuitive results including suggesting that taking action to facilitate regeneration or to attract industries to an area can prevent a transformational outcome.**

- (NOT poor-quality existing transport access × strong background economic growth × NOT action taken to facilitate regeneration)
    - + (strong background economic growth × sites identified for commercial regeneration × NOT action taken to attract industries to area)
    - + (strong background economic growth × action taken to attract industries to area)
- transformational outcome

**Again, this solution includes a number of counterintuitive results including suggesting that taking action to facilitate regeneration or to attract industries to an area can prevent a transformational outcome.**

- (NOT poor-quality existing transport access × NOT sites identified for commercial regeneration × NOT action taken to facilitate regeneration)
    - + (strong background economic growth × regeneration sites identified for commercial regeneration × NOT action taken to attract industries to area)
    - + (strong background economic growth × action taken to attract industries to area)
- transformational outcome

**This final solution also includes several counterintuitive results.**

The existence of counterintuitive results could be due to a few possible factors. Imperfect coding of the contextual factors and outcomes is a likely explanation, particularly when the data and evidence that has been used to code the contextual factors and outcomes is incomplete or requires judgement to interpret. Another factor is an incomplete theory of change, which means that certain contextual factors that may explain the counterintuitive results may be missing.

The presence of strong background economic growth as a necessary condition in many of the solutions, does suggest that it is challenging for transport interventions to lead to economic transformation in areas that have recently (or historically) suffered from poor economic outcomes. It also suggests that this challenge remains even when specific actions are taken to support regeneration. However, we can not present this as a strong conclusion given the limitations of the data that has fed into the analysis.

### **Hypothesis 3 – Catchment-related Labour Demand Impacts**

For Hypothesis 3, two key contextual factors were missing from our data matrix due to insufficient available information. These were:

- Underutilised skills or linked skills investment or activities, and
- Action taken to attract industries to regeneration area.

Since these key contextual factors were missing from our data matrix, it was not possible to use the structured techniques that QCA allows, to assess whether these contexts could explain differences in outcomes between our cases.

Instead, we have analysed the cases using the contextual factors for which we do have data, and then separately assessed whether the contradictions between the cases could be explained by our understanding of the case studies.

In Table 4.3, we present simple correlations between each individual contextual factor and the outcome of the cases.<sup>13</sup> It shows that each contextual factor is associated with a greater likelihood of being transformational, but it also shows that there are many cases without each contextual factor that were also assessed to be transformational.

*Table 4.3: Proportion of cases that led to a transformational outcome, split by whether a contextual factor was present or not*

Contextual factor	Proportion of cases that led to transformational outcome	
	WITHOUT contextual factor	WITH contextual factor
(Poor) quality existing transport access	60%	71%
Strong background economic growth	57%	70%
Latent demand for housing in wider region	57%	70%

*Source: CEPA analysis*

We show a truth table below presenting the results of our testing of Hypothesis 3. Of the combinations of contextual factors that led to contradictory outcomes, we show the proportion that were considered to have been transformational.

Although the truth table does lead to a solution, which we show below, the solution itself is not in itself particularly insightful given the presence of many contradictions:

- (Poor quality existing transport access × NOT strong background economic growth × latent demand for housing)
- + (Poor quality existing transport access × strong background economic growth × NOT latent demand for housing)
- transformational outcome

<sup>13</sup> The dataset used to populate this table includes all the changes made during earlier calibration exercises (from our analysis of hypotheses 1 and 2).

Table 4.4: Truth table testing Hypothesis 3

Cases	Transformational Outcome	Quality of existing transport access	Strong background economic growth	Latent demand for housing in region
Nottingham Express Transit - Phase 2 (Clifton) Nottingham Express Transit - Phase 2 (Beeston) Corby new station and rail service	<b>C (66%)</b>	0	0	0
High Speed 1 - Phase 2 - King's Cross area	<b>0</b>	0	0	1
Nottingham Express Transit - Phase 1 Sheffield Supertram - Line 1	<b>C (50%)</b>	0	1	0
Manchester Metrolink - Phase 3(a) Jubilee Line Extension - Waterloo / Southwark Jubilee Line Extension - Canary Wharf Jubilee Line Extension - Stratford	<b>C (75%)</b>	0	1	1
High Speed Rail Network - Spain - Phase 1 - Puertollano	<b>0</b>	1	0	0
Manchester Metrolink - Phase 3(b)	<b>1</b>	1	0	1
High Speed Rail Network - Spain - Phase 1 - Ciudad Real	<b>1</b>	1	1	0
Manchester Metrolink - Phase 1 Manchester Metrolink - Phase 2 Jubilee Line Extension - Bermondsey / Canada Water Borders Railway - Edinburgh	<b>C (75%)</b>	1	1	1

Source: CEPA analysis

Notes:

(a) A case is considered to have led to a transformational outcome if there was evidence of job creation or productivity improvements within the urban centre, or evidence of higher employment levels among residents of the satellite area.

(b) Rows highlighted blue represent cases that were assessed to have led to a transformational outcome, while those highlighted red represent cases that had different outcomes despite being subject to the same contextual factors.

The experience of the HS1 line between London and Kent provides an interesting example. The opening of the line shortly after the financial crisis has commonly been cited as a reason for why outcomes have so far been relatively poor. Comparing these outcomes to Phase 3a of Manchester Metrolink and to the Jubilee Line Extensions to Canary Wharf and Stratford, suggests that there may be some merit to this rationale.<sup>14</sup> However, this should not be overstated given the experience of the Phase 2 Nottingham Express Transit lines, which are both associated with positive employment effects despite opening without a backdrop of strong economic growth.

The diverging outcomes of Ciudad Real / Puertollano and Sheffield Supertram Line 1 / Nottingham Express Transit Line 1 also provide interesting examples. There is evidence to suggest the introduction of the Madrid-Seville line extended Madrid's labour market catchment, but the evidence suggests that this only benefitted Ciudad Real and not Puertollano. In fact, we found an element of displacement, where high productivity workers migrated from Puertollano to Ciudad Real to take advantage of the improved links to Madrid. One of the likeliest explanations for this is that this was due to Ciudad Real being closer to Madrid than Puertollano, and therefore a more attractive location for commuters. Other key differences include:

- The city council at Ciudad Real actively taking steps to promote the city as a commuter location, repurposing brownfield sites and adapting the city masterplan to account for the high-speed link to Madrid. The evidence we have reviewed suggests that city authorities at Puertollano did not take similar steps.
- Differences in the structure of the local economy at Ciudad Real and Puertollano. Puertollano's local economy was not particularly well-suited to be integrated into Madrid's labour market, being more dependent on industry and specifically, the oil and gas sector.

When comparing Sheffield Supertram and Nottingham Express Transit, we find two schemes that were similar in many ways but with very different outcomes. There are a number of key differences to note:

- Existing commuting patterns in Sheffield were more car dependent than Nottingham, which had access to a good quality public transport network and generally higher levels of road congestion. The development of Nottingham Express Transit reinforced existing patterns by improving public transport accessibility to parts of the city.
- There was a greater level of integration between the bus and tram networks at Nottingham, when compared to Sheffield. Although bus services in both locations were deregulated, Nottingham's major bus operator was owned by the local authority. This allowed the local authority to adapt its bus network to provide feeder services to the tram line. On the other hand, Sheffield's bus network was entirely privately run and, following the introduction of the Supertram, actively competed with its services.

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<sup>14</sup> The Jubilee Line Extension to Waterloo and Southwark was the case that was not associated with a positive effect on employment. We consider this was most likely due to the Jubilee Line only presenting a marginal improvement to public transport accessibility at Waterloo, when compared with the other Jubilee Line stations.

## 5. COMMENTARY

### Results

Through our analysis, we have found some evidence that the context surrounding a transport intervention can act as a condition for whether the scheme is transformational or not. The most definitive conclusion we have been able to draw is that a combination of latent demand for housing in a satellite area (as evidenced by high levels of housing deprivation) and action taken to facilitate housing regeneration, can work collectively to transformation the area in favour of more residential activity. In other words, transport investment can be used to unlock housing developments in an area. Whether this ultimately eases housing pressures in the area is less clear, and depends on whether housebuilding activity keeps pace with increases in demand to live in the area.

Our analyses of the other two hypotheses produces less definitive conclusions. We find that the strength of background economic growth is weakly associated with achieving a transformational outcome, suggesting that transport links help accelerate underlying economic trends. This conclusion is supported by the qualitative evidence we collected as part of our case study analysis, where we observed that the most successful schemes have been those that took place in areas that were already deemed to be growing.

We also find a weak association between taking discrete action to redevelop areas benefitting from improved transport links, and achieving a transformational outcome. We also observe that this works best when the actions are taken well in advance of scheme opening, which appears to create virtuous cycle, and also works better when regeneration actions and transport developments are fully integrated.

Finally, from a more qualitative analysis of the cases, we find a weak association between the integration of other transport modes with the transport scheme, and achieving a transformational outcome. Many of the more successful cases within our dataset have had integrated park and ride facilities. And as we note in the previous section, one of the potential reasons for Nottingham Express Transit's success relative to Sheffield Supertram, is the better integration between the bus and tram networks.

### Methodology

As far as we are aware, there are very few examples of using QCA to evaluate transport interventions. Our application of QCA to evaluate the transformational impact of transport investments has presented a number of challenges, which we discuss below.

- **Limited numbers of cases.** QCA works best where there are several of cases for each combination of contexts and outcomes, such that any difference between cases can be investigated and analysed. The cases being investigated also need to be sufficiently similar such that the same ToC applies. For example, a transport intervention that is primarily about improving freight connectivity is unlikely to be subject to the same ToC as an intervention about connecting urban centres together.

Given our Stage I analysis consisted of fifteen case studies, not all of which were relevant to each ToC, we used alternate techniques to ensure we have sufficient cases. We have wherever possible tried to split schemes into separate cases, either by region affected or by phase. However, there are diminishing returns to this approach, as there is often less variation in contexts and outcomes within schemes than there is between schemes.

This challenge is inherent to applying QCA to transport investments given the limited number of schemes available. But over time, as more schemes are evaluated, we would expect this to present less of a challenge.

- **Inconclusive or incomplete evidence around outcomes** – We have found that many of the indicators used to assess a particular outcome are imperfect in isolation, either because they do not assess causality, are only indirect indicators of a particular outcome, or are subject to uncertainty. To counter this, we have sometimes triangulated between multiple evidence sources. However, the indicators are quite often contradictory in ways that cannot easily be explained through theory. In such instances, it is challenging to

determine how to code the specific outcome. One of the most common contradictions we have observed is where outturn patronage has underperformed expectations, sometimes substantially so, but nonetheless the scheme is associated with a positive impact on other outcome metrics such as employment.

- **Incomplete evidence around contextual factors** – The selection of contextual factors and hypotheses to test were driven more by data availability, than them necessarily the most insightful. The most notable contextual factor that has been absent from our analysis, due to lack of available evidence, is any assessment of the skills context. We strongly suspect that this is a driver for some of the differential outcomes, particularly where the transmission mechanism for achieving transformation is through the impact on the labour market. However, the available evidence around this is extremely limited.

Many of the challenges associated with collating evidence around outcomes is also an issue for contextual factors. The coding of contextual factors is also significantly more subjective. We have tried to work around the subjectivity by using quantitative indicators wherever possible, though this can sometimes come at the expense of nuance.

- **Short term vs longer term outcomes** – Some of the cases we have used in our analysis have been assessed to have not been transformational. A challenge to this assessment is that transformation could take place over the longer term, which is not reflected in the evidence we have reviewed. We have attempted to account for this by only using cases for which at least five years have passed since scheme opening. And in many of our cases, we have many more years of evidence. Nevertheless, the outcomes we have found for a case may change if the case is revisited in future.

## **Learning for future applications of QCA and comparative evaluation**

As would be expected, comparative analytical techniques like QCA work best when the same outcome and context data is collected across several cases. We have found that this often is not the case – while at a headline level, different evaluations have assessed the evidence on the same high-level outcomes, there are subtle differences between them that make comparability difficult. For example, when looking at the effect of a transport intervention on employment, it is essential to know whether the effect observed related to where the jobs are located or where the workers are located. And when looking at the employment effect of a specific transport corridor, it is essential to clarify whether the location being investigated is considered to be a source of workers, a source of jobs, or source of both.

We have also found that certain output metrics, such as outturn patronage levels, can be as insightful as outcome and impact metrics. We have extensively used a metric indicating whether outturn patronage exceeded expected levels, to assess the impact of a scheme. We recommend such data is collected more routinely, with ex-post analyses of what is likely to be driving any differences between outturn and forecast patronage.

## Appendix A FULL LIST OF CASE STUDIES

The full list of all case studies, including the differentiation by phase and/or geographical location, is given below.

Table A.1: Full list of case studies

Name
Manchester Metrolink - Central Manchester
Manchester Metrolink – Salford
Manchester Metrolink - Satellite towns
Manchester Metrolink - Phase 1
Manchester Metrolink - Phase 2
Manchester Metrolink - Phase 3(a)
Manchester Metrolink - Phase 3(b)
Jubilee Line Extension - Waterloo / Southwark
Jubilee Line Extension - Bermondsey / Canada Water
Jubilee Line Extension - Canary Wharf
Jubilee Line Extension - Canning Town
Jubilee Line Extension - Stratford
Nottingham Express Transit - Phase 1
Nottingham Express Transit - Phase 2 (Clifton)
Nottingham Express Transit - Phase 2 (Beeston)
High Speed 1 - Phase 2 - King's Cross
High Speed 1 - Phase 2 - Kent
High Speed 1 - Phase 2 - Stratford
High Speed Rail Network - Spain - Phase 1 - Madrid
High Speed Rail Network - Spain - Phase 1 - Ciudad Real
High Speed Rail Network - Spain - Phase 1 - Puertollano
High Speed Rail Network - Spain - Phase 1 - Cordoba
High Speed Rail Network - Spain - Phase 1 - Seville
High Speed Rail Network - Spain - Phase 2 - Madrid
High Speed Rail Network - Spain - Phase 2 - Guadalajara
High Speed Rail Network - Spain - Phase 2 - Catalayud
High Speed Rail Network - Spain - Phase 2 - Zaragoza
High Speed Rail Network - Spain - Phase 2 - Lleida
High Speed Rail Network - Spain - Phase 2 - Tarragona
High Speed Rail Network - Spain - Phase 2 - Barcelona
West Coast Mainline Upgrades - Scotland
West Coast Mainline Upgrades - North West
West Coast Mainline Upgrades - Midlands



Name

West Coast Mainline Upgrades - South

West Coast Mainline Upgrades - Phase 1

West Coast Mainline Upgrades - Phase 2

West Coast Mainline Upgrades - Phase 3

Borders Railway - Edinburgh

Borders Railway - Midlothian

Borders Railway - Scottish Borders

Edinburgh-Glasgow Improvement Programme - Phase 1

Edinburgh-Glasgow Improvement Programme - Phase 2

Reading Station Redevelopment

Kirkstall Forge

Corby new station and rail service

Falmouth Rail Improvements (Penryn Loop)

Great Yorkshire Way - Phase 1

Great Yorkshire Way - Phase 2

Markham Vale (MEGZ) - Phase 1

Markham Vale (MEGZ) - Phase 2

A45 Newark to Lincoln and Newark to Widmerpool Improvements - Newark to Lincoln

A45 Newark to Lincoln and Newark to Widmerpool Improvements - Newark to Widmerpool

Sheffield Supertram - Line 1



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