Youth Mobility and Access to Economic Opportunities

Jeroen Arne Bastiaanssen

Submitted in accordance with the requirements for the degree of

Doctor of Philosophy

The University of Leeds

Institute for Transport Studies

May 2021

Publications and intellectual property

The candidate confirms that the work submitted is their own, except where work which has formed part of jointly authored publications has been included. The contribution of the candidate and the other authors to this work has been explicitly indicated below. The candidate confirms that appropriate credit has been given within the thesis where reference has been made to the work of others.

The work in chapter 4 of the thesis has been published as:

Jeroen Bastiaanssen, Daniel Johnson & Karen Lucas (2020). Does transport help people to gain employment? A systematic review and meta-analysis of the empirical evidence, Transport Reviews, 40:5, 607-628, DOI: 10.1080/01441647.2020.1747569

I was responsible for the research design, data collection, data analysis and interpretation, drafting the article, critical revision of the article, and final approval of the version to be published. The contribution of the other authors was related to the design of the work, data interpretation, and critical revision of the article.

The work in chapter 5 of the thesis has been published as:

Bastiaanssen, J., D. Johnson & K. Lucas (2021). Does better job accessibility help people gain employment? The role of public transport in Great Britain. Urban Studies, 1-21, DOI: 10.1177/00420980211012635

I was responsible for the research design, data collection, data analysis and interpretation, drafting the article, critical revision of the article, and final approval of the version to be published. The contribution of the other authors was related to the design of the work, data interpretation, and critical revision of the article.

The work in chapter 6 of the thesis has been submitted for publication as:

Bastiaanssen, J., D. Johnson & K. Lucas (2021). Does better public transport-and-bicycle job accessibility and vehicle access increase employment probabilities? A study of the Netherlands. Urban Studies

I was responsible for the research design, data collection, data analysis and interpretation, drafting the article, critical revision of the article, and final approval of the version to be published. The contribution of the other authors was related to the design of the work, data interpretation, and critical revision of the article.

The work in chapter 7 of the thesis is to be submitted for publication as:

Bastiaanssen, J., D. Johnson & K. Lucas (2021). Job accessibility and employment outcomes: a case study of the Rotterdam-The Hague Metropolitan Region. Regional Studies

I was responsible for the research design, data collection, data analysis and interpretation, drafting the article, critical revision of the article, and final approval of the version to be published. The contribution of the other authors was related to the design of the work, data interpretation, and critical revision of the article.

The work in chapter 8 of the thesis is to be submitted for publication as:

Bastiaanssen, J., D. Johnson & K. Lucas (2021). Does public transport help young people to access jobs and how can local transport authorities respond? An in-depth case study of the West Yorkshire region of the UK. Transport Policy

I was responsible for the research design, data collection, data analysis and interpretation, drafting the article, critical revision of the article, and final approval of the version to be published. The contribution of the other authors was related to the design of the work, data interpretation, and critical revision of the article.

Acknowledgements

I would firstly like to thank my supervisors Professor Karen Lucas and Daniel Johnson for this great opportunity and for their extensive support and guidance over the past four years of the PhD. The rich discussions during our monthly supervision meetings and in various workshops, conferences and pub visits provided invaluable guidance to my research and personal life, extending well beyond this thesis.

This thesis was supported by the University of Leeds and publicly funded by two regional authorities: the West Yorkshire Combined Authority (WYCA) in the UK and the City of Rotterdam in the Netherlands. I am grateful to the University of Leeds, for awarding me a 2016 Leeds Anniversary Research Scholarship (LARS). I am also very grateful for the support and research collaboration during my placement periods at the WYCA and the City of Rotterdam. Special thanks to Steve Heckley, Peter Glover and Patrick Bowes from the WYCA and to Helen Browne from the Department for Work and Pensions for facilitating the interviews with young job seekers at the local job centres in West Yorkshire.

The research collaboration with the City of Rotterdam dates back to my master thesis research in 2012 into transport poverty in Rotterdam, which was awarded the 2014 (biennial) thesis prize of the Social and Economic Council of the Netherlands (SER). In this regard, I would like to thank in particular Jan Murk, Gert Jan Polhuijs, Martin Guit and Zoë Peters for their support of my research, and Cees Stoppelenburg from the Rotterdam-The Hague Metropolitan Region authority for facilitating my research seminar in December 2018 in Rotterdam. This collaboration included a placement at research organisation SEOR in Rotterdam, for which I would like to thank Professor Jaap de Koning and Dr. Paul de Hek in particular. Special thanks further go to Professor Karst Geurs and Dr. John Pritchard from Twente University for their support with the computation of the job accessibility measures for the Netherlands, and to Dr. Manuel Ojeda Cabral from the University of Leeds for the discussions on the econometric models applied in this thesis. In this regard, I would also like to thank my colleagues at the Netherlands Environmental Assessment Agency (PBL) for their support during my final year of the PhD.

I am also grateful to the European COST Action ‘Transport Equity Analysis’ (TU 1209). The various workshops with researchers from across Europe and short scientific missions with Professor Karen Lucas at ITS Leeds and with Dr. Elisabete Arsénio at LNEC in Lisbon have provided me a unique opportunity to explore and discuss transport equity issues and expand my collaboration network. In this regard, special thanks also go to Professor Karel Martens, who supervised my master thesis research and sparked my interest into transport equity during my time as a student and researcher at the Radboud University.

My time in Leeds would not have been complete without the company of my good friend Dr. Thiago Guimarães, with whom I had the pleasure to discuss our shared research interest and enjoy the yearly masters’ European Field Trip, various workshop and conferences and many more pubs and restaurants. In this regard, I would also like to mention Taco Regensburg and Dr. Pedro Copado for contributing to the wonderful time in Leeds and my good friends Robin Roks and Ries van der Sanden for always being around when I came to the Netherlands. Special thanks go to my parents Ad and Ilse Bastiaanssen for their unconditional support and to Catarina Neves, for her love and support, and for those great trips to some of the US cities that also feature in this thesis.

Abstract

The association between transport access and employment outcomes has received considerable attention in US metropolitan areas and, more recently, in some EU cities. However, evidence for this association shows mixed empirical results. The objectives of this thesis were to enhance the understanding of the relationship between transport job accessibility and employment outcomes in the relatively unexplored contexts of Great Britain and the Netherlands, with specific attention for young people, and to provide a methodological contribution to the current assessment of this relationship. To realise these objectives, the existing empirical evidence on the linkage between transport access and employment outcomes has been reviewed and enhanced with national and regional case studies in Great Britain and the Netherlands, consisting of a quantitative phase based on the computation of transport job accessibility measures combined with national individual-level employment probability models, followed by a qualitative phase of in-depth interviews with young job seekers.

The thesis established a positive association between transport access and employment outcomes, with varying effects for four identified categories of transport measures: car ownership, public transport access, commute times, and job accessibility levels. It further established that similar patterns do hold in the UK and the Netherlands, but only in certain contexts. In particular, job seekers without access to private vehicles, such as young people, low income and lower educated groups and those residing in urban areas under-served by public transport, such as peripheral and deprived neighbourhoods could benefit from higher levels of job accessibility. This goes beyond improving door-to-door journey times and includes reliability of services, especially in off-peak hours, affordability, comfort and (perceived) safety. The findings in this thesis are important for policymakers in that they imply that job seekers may benefit from more targeted public policies to improve their transport access and thereby their social mobility.

Table of contents

List of tables

List of figures

1. Introduction

This thesis examines the role of transport in employment outcomes within the contexts of Great Britain and the Netherlands. The research is publicly funded by two regional authorities - the West Yorkshire Combined Authority in the UK and the City of Rotterdam in the Netherlands - and therefore focuses on both the national and regional levels, with specific attention for young people. In both countries, young people are overrepresented in unemployment and precarious (low-hour and low-paid) jobs (OECD, 2020), whilst often being more public transport dependent (Ministry of Infrastructure and the Environment, 2014, Chatterjee et al., 2018), which may constrain their accessibility to, and uptake of, employment. Since low-skilled and young people in particular have also been impacted through the nature of their work by the current Covid-19 pandemic (ILO, 2020), transport may be even more important in helping them into employment.

1.1 Background

At least since the 1960s, the association between transport access and employment outcomes has received considerable attention among scholars in urban economics, transport geography and sociology (e.g. (Kain, 1968, Wachs and Kumagai, 1973). Much of the early literature derives from Kain's (1968) Spatial Mismatch Hypothesis, which stated that poor access to employment opportunities was a major factor in inner-city unemployment in US metropolitan areas. Residential segregation and an increasing decentralisation of employment to the suburbs prevented in particular low-skilled minority youths from accessing employment opportunities, resulting in a spatial mismatch between potential workers and employment (Kain, 1968). For those residing far from employment opportunities, job search was often inefficient and implied long and costly commuting trips, thereby reducing job search horizons and, subsequently, employment probabilities (Wilson, 1987, Ihlanfeldt and Sjoquist, 1998). The spatial distribution of workers and employment gradually changed over time. More low-skilled minority groups also moved from the inner-cities to suburban locations, albeit often near the city boundaries (McLafferty and Preston, 1996). Deindustrialization and relocation of manufacturing jobs to the periphery further reduced low-skilled employment opportunities, while service sector jobs expanded selectively in cities and suburban locations (Fujita, 1989, Stoll, 2005, Houston, 2005, Mollenkopf and Castells, 1991a). As service jobs typically place a greater premium on higher-level skills, skills mismatches prevented low-skilled unemployed from taking advantage of close proximity to employment (Kasarda, 1988, McQuaid et al., 2001). Given the dispersed spatial structure of US metropolitan areas, this posed serious problems for low-skilled workers without cars. With public transport services increasingly concentrated on the main corridors in urban centres, most trips to suburban employment locations were often difficult to make without a car (Cervero et al., 1999, Raphael and Rice, 2002, Ong and Miller, 2005). This led to substantial differences in accessibility to employment opportunities between workers with access to a car and those who relied on public transport services (e.g. (Cervero et al., 1999, Kawabata and Shen, 2007, Grengs, 2010).

Lack of access to a private car and inadequate public transport services has since been identified as an important barrier for accessibility to, and uptake of, employment, particularly in more car dependent metropolitan areas (Taylor and Ong, 1995, Ong and Miller, 2005). In the following decades, a large body of studies in US metropolitan areas have ensued, which typically found that access to private cars and higher levels of car-based job accessibility increased employment probabilities. While public transport dependency, on the other hand, has been associated with decreased employment probabilities, higher levels of public transport job accessibility often yielded, at best, mixed results (e.g. (Taylor and Ong, 1995, Ihlanfeldt and Sjoquist, 1991, Blumenberg, 2002, Ong and Houston, 2002, Cervero and Tsai, 2003, Sanchez et al., 2004). Many of these studies, present particularly compelling evidence for car access and higher levels of job accessibility among low-skilled minority youth, as their greater reliance on public transport services makes them more exposed to the time and cost implications of longer commutes (e.g. (Ihlanfeldt and Sjoquist, 1990, O'Regan and Quigley, 1991, Bauder and Perle, 1999).

Although most of the Spatial Mismatch literature has been conducted in the specific context of US metropolitan areas, scholars have recently turned their attention to European metropolitan areas. In recent decades, European cities have also witnessed a process of decentralisation of both people and employment, affecting all countries with varying intensity and timing (Turok and Edge, 1999, Houston, 2005). While inner-city areas and peripheral neighbourhoods in many European metropolitan areas have been dominated by the social housing sector, a gradual decline in social housing stock and increasing housing prices in the inner-cities have made many low-skilled workers to relocate to neighbourhoods in the urban periphery (Lupton and Power, 2002, Houston, 2005, Korsu and Wenglenski, 2010). The inner-cities have often maintained their role as major employment areas, but mainly higher skilled service jobs are increasingly concentrated in city centres and along major transport corridors, while low-skilled jobs have gradually declined and dispersed to peripheral business and industrial parks (Dujardin et al., 2008, Houston, 2005, Korsu and Wenglenski, 2010). As public transport systems predominantly serve the city centres and intercity connections, trips between peripheral neighbourhoods and job locations are often difficult to realise without a car. For those residing outside the city centres, accessibility to employment opportunities is therefore typically much lower when relying on public transport (Houston, 2005, Korsu and Wenglenski, 2010, Matas et al., 2010, Lucas, 2012). Recent studies in EU metropolitan areas have indicated that access to cars as well as higher levels of public transport job accessibility could help to increase employment probabilities among low-skilled unemployed, in the Paris and Bordeaux metropolitan regions (Korsu and Wenglenski, 2010, Gobillon et al., 2011, Sari, 2015), in Copenhagen (Rotger and Nielsen, 2015), and in the Barcelona and Madrid metropolitan areas (Di Paolo et al., 2014, Matas et al., 2010).

In this thesis, and in an important departure from previous spatial mismatch studies, a combination of national transport and employment micro datasets and in-depth interviews with young job seekers are used, to examine the relationship between transport job accessibility and individual employment probabilities within the relatively unexplored contexts of Great Britain and the Netherlands.

As in many other western countries, the facilitation of the growing car usage in the UK has fostered a decentralisation of employment while traditional public transport services have become increasingly concentrated in the main corridors of urban centres (Turok and Edge, 1999, Houston, 2005, Lucas, 2012). Various qualitative studies in the UK have found that for young people in particular it is, therefore, often more difficult to access jobs, in particular when residing outside of the main public transport corridors and city centres (e.g. (Lucas et al., 2001, SEU, 2003, Rae et al., 2016, JRF, 2018). While the Netherlands generally has more compact cities and towns, a relatively extensive public transport and bicycle infrastructure, and less socio-economic segregation compared to the UK, many jobs have also been (re)located to peripheral business parks near motorways that are often under-served by public transport and difficult to reach by bicycle (PBL, 2012, Bastiaanssen and Martens, 2013, Jeekel, 2015). Hence, reliance on public transport among young low-skilled job seekers has been found to decrease their job uptake and job retention (Bastiaanssen and Martens, 2013, De Koning et al., 2017).

To address these accessibility problems, local transport authorities in the UK[1] have been required between 2006 and 2011 to undertake accessibility assessments as part of their Local Transport Plans (LTPs) and the UK Department for Transport (DfT) provides annually updated job accessibility indices for England[2] at the small local area geographical scale (DfT, 2018). While the accessibility assessments are no longer a statutory requirement in LTPs, recent analysis of the DfT job accessibility indices for the UK Government Office for Science (Lucas et al., 2019b) indicated large and widening disparities in accessibility to employment opportunities between people who rely on public transport and those

[1] The Department for Transport (DfT) is responsible for national transport in the UK (e.g. strategic road and rail) and for local transport in England, while for London these responsibilities have been devolved to the Greater London Authority. In other parts of the UK local transport is provided by the relevant devolved administrations of Scotland, Wales and Northern Ireland (House of Commons, 2017).

[2] For Scotland, Wales and Northern Ireland, accessibility statistics are also available for a range of services as part of their Indices of Multiple Deprivation, but these do not include job accessibility indices.

with access to private cars. In the Netherlands, the Dutch Scientific Council for Government Policy (WRR) also concluded that increasing disparities in accessibility to employment opportunities may reduce the participation of people in Dutch society and prevents the full utilization of the potential labour force, therefore advising the government to address this in public policies (WRR, 2018). More recently, the Dutch Council for the Environment and Infrastructure (Rli) also concluded that Dutch citizens increasingly experience transport-related problems when accessing employment or public services and advised the government to make 'access for all' the basic principle of transport policy (Rli, 2020). According to the Rli, this would require a fundamental change of current national, regional and local transport policies, which mainly focus on the economic utility of transport investments, towards guaranteeing that all citizens have sufficient possibilities to access key activities. Some regional authorities in the Netherlands (e.g. in the Rotterdam-The Hague Metropolitan Region) have recently started using job accessibility measures to assess socio-economic inequalities, but accessibility planning and measurements lack at the national level (see Geurs (2018), for discussion).

To date, however, the assumed relationship between higher levels of transport job accessibility and improved individual employment probabilities has not been scientifically proven in Great Britain and the Netherlands. It is important to establish this relationship, as transport policies in both countries may be increasingly motivated by the assumed employment effects of (disparities in) job accessibility.

1.2 Research gaps

In this thesis, several gaps in the knowledge on the relationship between job accessibility and employment outcomes are addressed:

The first gap concerns the nature of the relationship between transport and employment outcomes. While most studies suggest a positive association in line with the Spatial Mismatch Hypothesis (Kain, 1968), the empirical evidence is not conclusive or consistent and shows mixed results (Ihlanfeldt and Sjoquist, 1998, Gobillon et al., 2007). This may imply that transport policies targeted at improving people's employment probabilities may not be effective as a policy instrument in all cases. By exploring the existing empirical evidence on the relationship between transport and employment outcomes as measured by the probability of employment, this thesis can help to identify transport policies with the greatest effect on employment outcomes.

The second gap concerns the lack of knowledge on the relationship between transport job accessibility and individual employment probabilities within the relatively unexplored national contexts of Great Britain and the Netherlands. While a large body of studies has examined this relationship in the context of US metropolitan areas, and more recently in some EU cities, it is unclear whether the same patterns would hold in metropolitan areas in Great Britain or the Netherlands and in smaller cities and towns where travel times and distances are shorter and/or where decentralisation of employment is less pronounced (see also (Ihlanfeldt, 1992). By empirically examining the relationship between transport job accessibility and individual employment probabilities within the national contexts of Great Britain and the Netherlands, this thesis helps to enhance our understanding of the role of transport job accessibility and the extent to which certain urban and rural areas and different population groups would benefit. In turn, this could help policymakers to select more targeted transport policies to improve transport job accessibility of job seekers and thereby their social mobility.

The third gap relates to the methodology and datasets used to assess the relationship between job accessibility and employment outcomes. As previous Spatial Mismatch studies have often relied on quantitative methods and Census datasets of vulnerable groups (e.g. low-skilled or carless groups) in metropolitan areas, it remains unclear whether similar patterns would hold when using national micro datasets for the population at large. It is also uncertain if qualitative methods would indicate similar patterns, due to differences between measured and experienced job accessibility or transport-related factors not captured in accessibility measures. By combining analysis of national transport and employment micro datasets with in-depth interviews with young job seekers, this thesis aims to gain a more holistic understanding of the relationship between job accessibility and employment probabilities.

The fourth gap concerns the role of transport on young people's employment outcomes. Various Spatial Mismatch studies in US metropolitan areas have shown that low-skilled minority youth in particular would benefit from car access and higher levels of job accessibility, but the existing empirical studies on the relationship between transport and young people in Great Britain and the Netherlands is predominantly qualitative by nature (e.g. (Green et al., 2005). While these studies have often indicated that young people's dependence on public transport reduces their access to employment opportunities, it remains unclear whether higher levels of transport job accessibility would actually improve their employment outcomes. By empirically examining the role of transport job accessibility in employment probabilities of young people, this thesis provides further evidence on the extent to which (public) transport could improve young people's employment outcomes, which is particularly pertinent given increasing youth unemployment rates due to the Covid-19 pandemic.

1.3 Objectives and outline of the thesis

The overarching objectives of this thesis are twofold. The first objective is to enhance the understanding of the relationship between transport job accessibility and employment outcomes in the relatively unexplored contexts of Great Britain and the Netherlands, and among young people in particular. The poor employment outcomes of young people in both countries (see also OECD (2020) are hypothesised to partially follow from their constrained transport accessibility to job opportunities. The second objective is to provide a methodological contribution to the current assessment of this relationship. To realise these objectives, the existing evidence on the linkage between transport access and employment outcomes will be reviewed and enhanced with case studies in Great Britain and the Netherlands, consisting of a quantitative phase based on the computation of job accessibility measures combined with national employment probability models, followed by a qualitative phase of in-depth interviews with young job seekers. The comparative element of this research allows to take different urban and transport contexts into account that may affect job accessibility and, subsequently, employment outcomes. Although the focus in this thesis is on Great Britain and the Netherlands, the knowledge and methodological contribution can also be applied elsewhere. The thesis itself comprises five chapters based on academic papers (chapters 4 to 8), each of which address a particular research question. These chapters are briefly described in the next subsections, highlighting their main contributions and how they are related to each other and to the overall objective of this research. All papers have been published or submitted for publication in an international academic journal. As the papers were designed as independent publications but following one another in a sequential order, there is some unavoidable overlap in the literature reviews and methods and data sections.

The research questions addressed in sequential chapters 4-8 of this thesis are as follows:

1. *What is the nature of the relationship between transport and employment outcomes?*

   This research question is addressed in chapter 4 (Does transport help people to gain employment? A systematic review and meta-analysis of the empirical evidence). This chapter systematically reviews the existing empirical evidence of the relationship between transport access and employment outcomes as measured by the probability of employment, with a particular focus on young people in different contexts. It then synthesises this evidence through a meta-analysis to produce general effect sizes of the relationship between transport and employment probabilities and to determine the sources of variation in the mixed empirical results. This work was awarded the Moshe Givoni Prize 2021 for best paper of the year in the journal Transport Reviews.

By systematically merging the empirical evidence, a positive association between transport access and employment probabilities is established, with varying effects for four identified categories of transport measures (or combinations thereof): car ownership, public transport access, commute times, and job accessibility levels. The meta-regression models show that car ownership significantly increases individual employment probabilities, with young drivers benefitting when residing in multiple car households. The meta-regression models further show that longer mean commute times are related to decreased employment prospects, with young people in particular being more sensitive to the time and cost implications of longer commutes. The systematic review further suggests that better access to public transport and higher levels of job accessibility increase employment probabilities, but that more consistent accessibility measures would be necessary for meta-analysis.

The paper concluded that a larger evidence base for cities and towns outside the US-context and with regard to public transport was needed to establish a more robust relationship between job accessibility and employment probabilities. The next British study therefore empirically examines employment effects of public transport job accessibility.

This chapter has been published as:

Jeroen Bastiaanssen, Daniel Johnson & Karen Lucas (2020). Does transport help people to gain employment? A systematic review and meta-analysis of the empirical evidence, Transport Reviews, 40:5, 607-628, DOI: 10.1080/01441647.2020.1747569

2. *To what extent do higher levels of public transport job accessibility increase employment probabilities?*

   This research question is addressed in chapter 5 (Does better job accessibility help people gain employment? The role of public transport in Great Britain). This chapter is the first national study within the context of Great Britain to empirically examine the relationship between public transport job accessibility and individual employment probabilities. In an important departure from most standard accessibility methodologies, first a local-area public transport job accessibility measure is computed using detailed public transport timetable data and business register micro datasets. This is then combined with national individual-level employment probability models for Great Britain and for various geographical area types and population groups, with a particular focus on young people.

The paper finds that in particular individuals residing in urban areas with low car ownership rates and in low-income neighbourhoods could benefit from improved public transport job accessibility. It further shows that mainly lower educated groups and young people would benefit from better public transport job accessibility.

However, this relationship was not straightforward without controlling for individual car ownership, due to lack of available data. In light of this concern, the next Dutch study utilises a national vehicle registration dataset to examine the differential employment effects of job accessibility and vehicle ownership.

This chapter has been published as:

Bastiaanssen, J., D. Johnson & K. Lucas (2021). Does better job accessibility help people gain employment? The role of public transport in Great Britain. Urban Studies, 1-21, DOI: 10.1177/00420980211012635

3. *To what extent do higher levels of public transport and bicycle job accessibility and vehicle access increase employment probabilities?*

This research question is addressed in chapter 6 (Does better public transport-and-bicycle job accessibility and vehicle access increase employment probabilities? A study of the Netherlands). In this chapter, and in a departure from both the previous British study in chapter 5 and existing studies in some European metropolitan areas, a Dutch national employment micro dataset is combined with a detailed local-area public transport-and-bicycle job accessibility measure, national vehicle registration and household income datasets. This allowed us to empirically examine if higher job accessibility levels by public transport in combination with the bicycle would increase individual employment probabilities, while controlling for household vehicle ownership, and which geographical area types and population groups would benefit most.

The paper finds that higher levels of public transport-and-bicycle job accessibility increases individual employment probabilities in urban areas, while in rural areas vehicle ownership is a more important factor in driving employment outcomes. In particular, low-income groups as well as low-educated groups and most older age groups could benefit from higher public transport-and-bicycle job accessibility levels, whereas middle-educated groups and especially young people are sensitive to vehicle ownership.

However, it remained unclear whether the same patterns would hold in metropolitan areas in the Netherlands, where many unemployed reside in spite of having relatively high levels of job accessibility. The next Dutch study therefore focusses specifically on the Rotterdam-The Hague Metropolitan Region.

This chapter has been submitted for publication as:

Bastiaanssen, J., D. Johnson & K. Lucas (2021). Does better public transport-and-bicycle job accessibility and vehicle access increase employment probabilities? A study of the Netherlands. Urban Studies

4. *To what extent do people in metropolitan areas benefit from higher levels of public transport and bicycle job accessibility and vehicle access?*

This research question is addressed in chapter 7 (Job accessibility and employment outcomes: a case study of the Rotterdam-The Hague Metropolitan Region). Building on the previous national study for the Netherlands in chapter 6 (based on a random population sample), this chapter utilizes an administrative employment micro dataset providing a *full population sample* of the Rotterdam-The Hague metropolitan region (MRDH-region), combined with detailed urban-rural classification and household income datasets, to empirically examine the differential employment effects of job accessibility and vehicle access for different urban areas and income groups in this metropolitan region. This work was supported through a PhD Prestige Grant, awarded by the World Conference on Transport Research Society (WCTRS), on the basis of a research proposal and subsequent paper submitted to, and presented at, the 2019 WCTR Conference in Mumbai.

The paper finds that higher levels of public transport-and-bicycle job accessibility and household vehicle ownership increases individual employment probabilities, especially in the Rotterdam Metropolitan Area. People who reside in high urban areas are most sensitive to job accessibility changes, while vehicles access plays an important role in low urban areas. In contrast to the Dutch national study in chapter 6, it further found that all income groups were sensitive to higher public transport-and-bicycle job accessibility levels and household vehicle access, but that low-income groups would benefit most and that this positive effect decreases with increasing income levels.

This chapter is to be submitted for publication as:

Bastiaanssen, J., D. Johnson & K. Lucas (2021). Job accessibility and employment outcomes: a case study of the Rotterdam-The Hague Metropolitan Region. Regional Studies

5. *To what extent does potential public transport job accessibility match young people's experiences of accessing employment opportunities?*

   This research question is addressed in chapter 8 (Does public transport help young people to access jobs and how can local transport authorities respond? An in-depth case study of the West Yorkshire region of the UK). This chapter departs from the quantitative evidence for Great Britain in chapter 5 and uses a 3-pronged mixed methods approach to empirically examine the extent to which *potential* public transport job accessibility opportunity levels match young people's *experiences* in accessing employment opportunities. It therefore combines the previously developed public transport job accessibility opportunity measure with young people's reported experiences of accessing employment opportunities using micro-scale analysis of the UK National Travel Survey and in-depth interviews with young job seekers in West Yorkshire, UK.

   The paper found that variations in the coverage of the public transport and land use system resulted in substantial job accessibility disparities across the region. It further showed that young unemployed in particular had turned down jobs due to inadequate public transport or high fare costs, but that this was much less so among those with higher public transport job accessibility levels or with access to a household car. The interviews indicated that their experienced accessibility to employment opportunities included availability, reliability, connectivity and affordability of local bus services, especially in off-peak hours and in peripheral areas, which all need to be included in accessibility assessments.

   This chapter is to be submitted for publication as:

   Bastiaanssen, J., D. Johnson & K. Lucas (2021). Does public transport help young people to access jobs and how can local transport authorities respond? An in-depth case study of the West Yorkshire region of the UK. Transport Policy

1.4 Organisation of the thesis

Chapter 2 comprises the theoretical framework adopted in this thesis, followed by a description of the applied research methodology in chapter 3. The subsequent chapters 4-8 of this thesis are briefly described above. Chapter 9 synthesis the key findings and contributions of this thesis and discusses future research directions. The chapter ends with public policy recommendations.

In the next sections, the theoretical framework and research methodology are briefly discussed. The final section provides an overview of chapter-related contributions that were made during the time-span of the thesis.

1.4.1 Theoretical framework

While the Spatial Mismatch literature emphasises the role of poor transport job accessibility as a major source accounting for adverse employment outcomes, the processes that shape people's accessibility to employment opportunities remain unclear and not properly linked to theoretical concepts. This thesis therefore draws on cross-disciplinary theoretical concepts around agglomeration economies, accessibility and social exclusion to enhance the understanding of how people's accessibility to, and probability of, employment is shaped and, subsequently, their risk of social exclusion.

From the theoretical framework, both a structural dimension and an individual dimension to (in)accessibility to employment have been discerned. The structural dimension to accessibility is partially shaped by land-use patterns, in which agglomeration forces generally promote accessibility by geographically concentrating workers and firms, while processes of geographical dispersion of activities tends to counter accessibility (thereby increasing spatial mismatch). The transport system and, increasingly, technological innovations such as ICT are important determinants of agglomeration and may enhance accessibility, even when land-use patterns are fixed.

The individual dimension to accessibility, on the other hand, is shaped by people's motility, i.e. their capacity to be mobile, which determines the extent to which they can take advantage of transport accessibility to employment opportunities. Motility partially results from available transport resources, such as different forms and degrees of private and public transport services that people are able to use, and from socio-economic resources on the individual, household and neighbourhood level. In combination, these resources affect people's level of motility and, hence, their accessibility to employment.

A person's accessibility to employment opportunities and, subsequently, social inclusion, thus follows from both the transport system and land-use patterns as well as by his or her capacity to be mobile, within the context of our highly mobile societies. This implies that policy strategies aimed at improving people's accessibility to employment opportunities and, in turn, their employment outcomes, are likely to be more effective when they address both the individual and structural dimension of accessibility.

1.4.2 Methodology

In a departure from standard Spatial Mismatch methodologies, this research adopts a multi-instrument approach using different datasets to look at the relationship between transport job accessibility and employment outcomes and combines this with a case study strategy. The multi-instrument approach follows a sequential explanatory design, consisting of a quantitative phase to gain a general understanding of the relationship between transport access and employment outcomes, followed by a qualitative phase to provide further in-depth insight into experiences of accessing employment opportunities. The quantitative phase is based on a systematic review and meta-analysis of the existing quantitative evidence of the relationship between transport access and employment outcomes, followed by the computation of job accessibility measures combined with national and regional secondary employment micro datasets of Great Britain and the Netherlands, to empirically examine the relationship between transport access and individual employment probabilities within these relatively unexplored contexts. The qualitative phase consists of in-depth interviews with young job seekers in West Yorkshire into the role of public transport in their accessibility to employment opportunities, within their real-life context.

Due to the public funding of this research by the West Yorkshire Combined Authority in the UK and the City of Rotterdam in the Netherlands, the multi-instrument approach is combined with national and regional case studies of Great Britain and the Netherlands. Since the collaboration with the City of Rotterdam builds on previous qualitative master thesis research into the role of public transport among low-skilled job seekers in Rotterdam (Bastiaanssen and Martens, 2013), the regional case study focuses on a more detailed examination of the quantitative relationship between job accessibility and employment probabilities in Rotterdam and the wider MRDH-region. For West Yorkshire, employment micro datasets were not available at the local level, while youth unemployment has remained relatively unexplored in this region. This regional case study therefore consists of in-depth interviews with young job seekers, combined with analyses of national transport micro datasets, to examine young people's experiences of accessing employment opportunities.

As an integral part of this research, placement periods have been conducted at the WYCA, the City of Rotterdam and research organisation SEOR in Rotterdam (part of Erasmus School of Economics). During these placements, access was provided to various datasets and transport models used in this research and the direct collaboration with local policy makers helped to enhance the mutual understanding of how to better tailor transport and land-use policy strategies in order to improve accessibility to employment opportunities. As part of the placement periods and to further enhance the mutual understanding of the relationship between transport job accessibility and employment outcomes, a research seminar 'Transport Poverty in the Labour Market' has been organised on 19 December 2018 in Rotterdam, in which the research results were presented and discussed with local and national researchers and policymakers from ITS Leeds, the WYCA, the City of Rotterdam, SEOR and various other Dutch governmental organisations.

1.4.3 Chapter-related contributions

Various additional contributions have been made to several thesis chapters during the time-span of this research, thereby informing and/or complementing these chapters and the overall thesis.

Firstly, contributions were made to the report 'Inequalities in Mobility and Access in the UK Transport System' (Lucas et al., 2019b), commissioned as part of the UK government's Foresight Future of Mobility project. These included a desk-based review of published literatures from 2002-2018 pertaining to current transport and accessibility inequalities in the UK and analysis of public transport accessibility to key activities using the DfT Journey Time Statistics for 2015. These accessibility analyses were used as a basis for the public transport job accessibility measure developed in this research, in particular in chapters 5 and 8, while the literature review provided insights into the various aspects of accessibility that may affect people's experiences of accessing employment opportunities.

Secondly, contributions were made to two chapters of the book 'Measuring Transport Equity' (Lucas et al., 2019a), which resulted from EU COST Action 'Transport Equity Analysis' (TU 1209; http://teacost.eu/). The first chapter discusses key components, framings and metrics related to measuring transport equity (Martens et al., 2019). This book-chapter informed the overall thesis and chapters 4-7 in particular, by providing indicators for transport access and accessibility measures as well as disaggregation's for different geographical areas and population groups. The second book-chapter comprises job accessibility analysis in combination with income-level data in an index to measure accessibility poverty risk in the Rotterdam-The Hague Metropolitan Region (Martens and Bastiaanssen, 2019), which served as a basis for the case study analysis in chapter 7 and informed the income-based employment submodels in chapters 6 and 7 of this thesis.

2. Theoretical framework

At least since the 1960s, literatures in urban economics, transport geography, and sociology have examined the connections between the (in)ability of people to access employment opportunities and socioeconomic inequalities (e.g. (Kain, 1968, Wachs and Kumagai, 1973). While socioeconomic inequalities largely result from structural changes in the macroeconomic context and labour market reforms, it has long been suggested that poor accessibility to employment opportunities also adversely affects the ability of people to participate in labour markets.

Much of this literature derives from the Spatial Mismatch Hypothesis (Kain, 1968), which emphasises the role of the spatial disconnection between residential and employment locations as a major source accounting for adverse employment outcomes. It was only since the 1990s that theoretical models have been used to explain spatial mismatch as resulting from a substantial and continuing decentralisation of firms and people over the second half of the twentieth century, fostered by a rise in motorised transportation (Ihlanfeldt, 2006, Gobillon et al., 2007). Yet, firms and people are often also markedly geographically concentrated, which would partially counteract spatial mismatch. The processes that shape people's transport accessibility to employment opportunities remain unclear in the spatial mismatch literature and not properly linked to a theoretical framework.

This chapter discusses cross-disciplinary theoretical concepts around agglomeration, accessibility and social exclusion. This allows to enhance our understanding of how different types of private and public transport services influence location choices of firms and workers which, in turn, affects people's transport accessibility to, and probability of, employment and, subsequently, their risk of social exclusion.

2.1 The concept of agglomeration

Urban economic and regional science literature explains that the location choice of firms and workers in close proximity to, or at a distance from urban centres, can be understood as the result of the relative strength between centripetal forces that promote agglomeration effects and centrifugal forces that tend to geographically disperse activities (Krugman, 1998, Fujita and Thisse, 2002). The transport system and, increasingly, technological innovations such as ICT are seen as the main determinants of agglomeration, which shift the balance between centripetal and centrifugal forces (Krugman, 1991, Venables, 2007, Lafourcade and Thisse, 2011).

Centripetal forces are associated with the classic Marshallian (1890) sources of external economies, related to market-size effects, thick labour markets, and pure external economies (Fujita et al., 1997, Krugman, 1998). A large local market facilitates (more efficient) production and provides firms with larger access to consumers, while providing workers (who are also consumers) with better access to goods and services (Fujita and Thisse, 2002). Agglomeration also supports thick labour markets, in which firms have access to a larger and more diverse labour pool, while workers can more easily find good employer matches and may expect higher wages (Rosenthal and Strange, 2004, Lafourcade and Thisse, 2011). Further, agglomeration fosters innovation through knowledge spillovers, which occurs as spatially concentrated firms and people are more easily able to learn from each other (Rosenthal and Strange, 2004). According to Marshall (1890), agglomeration can result in a cumulative process, where new firms cluster to benefit from localisation and urbanisation economies (Lafourcade and Thisse, 2011). In localisation economies, firms operating in the same industry cluster to take advantage of this sharing, matching and learning (Duranton and Puga, 2004). In particular, service industries tend to concentrate in urbanised locations, induced by proximity to workers (who are also consumers) and their often localized markets (Fujita, 1989, Rosenthal and Strange, 2004). In the case of urbanisation economies, benefits accrue from close proximity to firms in other industries, in which the city scale itself facilitates sharing, matching and learning that, in turn, affects productivity and wages (Rosenthal and Strange, 2004, Graham, 2007).

Centrifugal forces, on the other hand, tend to geographically disperse firms and workers, which relates to immobile factors such as land, natural resources and labour, higher land values and wages, and pure external diseconomies (Krugman, 1998, Fujita and Thisse, 2002). Immobile factors counteract concentration of production, in which some firms need to locate where these production factors are available. As expressed by bid-rent theory (e.g. Alonso (1964), agglomeration also generates increased demand for local land, driving up land rents and housing costs, which provides a disincentive for further concentration of firms and workers. This also relates to intensified competition over market shares and local labour force (driving up wages), which drives firms away to more peripheral locations (Fujita and Thisse, 2002). Especially for the manufacturing industry, which largely exists for regional and larger markets while consuming much land, decreasing transport costs have provided peripheral locations a competitive advantage in the form of lower land rents (Glaeser and Kohlhase, 2004). Due to fragmentation of production processes, (manufacturing) firms have also taken advantage of differences in technologies and lower land rents and wages in various geographic locations (Lafourcade and Thisse, 2011). Lastly, agglomeration can generate more of less pure external diseconomies, such as increased commuting costs resulting from congestion, due to which firms and workers may relocate away from urban centres in order to consume more land or housing (Fujita, 1989, Krugman, 1991), often leaving poor households (and firms) in areas where housing prices are lowest (Mills, 1972).

As the location of firms and workers thus follows from the changing tension between centripetal and centrifugal forces, which is being fostered by transport and technological innovations, employment opportunities will continue to grow and decline unevenly in (networks of) agglomerations and more dispersed locations (Mollenkopf and Castells, 1991b, Krugman, 1998). The problem is therefore one of accessibility to employment rather than distance (spatial mismatch) *per se*. It follows that agglomeration promotes accessibility by geographically concentrating workers and firms, while geographical dispersion of activities tends to counter accessibility by enlarging the distances between workers and firms (thereby increasing spatial mismatch). There is a clear labour demand dimension to accessibility that plays out principally through better connectivity promoting agglomeration (see also Banister and Berechman (2001) for discussion), which thereby increases productivity and potential firm entries and, subsequently, the demand for labour. In terms of labour supply, improved accessibility to employment, resulting from a reduction in commute time and costs relative to the reservation wage, can then lead to adjustments in the labour supply as it enables workers to increase the geographical scale of their job search, may encourage potential workers to participate in the labour force, and enhances matching of firms and workers which reduces time spent unemployed looking for work and can maximise hours and wages (Rietveld, 1994, Duranton and Puga, 2004).

While the concept of agglomeration enhances our understanding of the structural dimension to accessibility, it remains unclear how (in)accessibility to employment opportunities is shaped within agglomerations, given that the spatial mismatch literature mainly revolves around metropolitan areas. The ways in which personal transport resources (and/or mobility) and land-use affects people's accessibility to employment opportunities has received much attention in the accessibility literature.

2.2 The concept of accessibility

In recent years, literature in transport geography and transport policy have substantially contributed to advance our understanding of the mechanisms that influence an individual's accessibility to employment and how patterns of accessibility vary between different areas and population groups. In contrast to the term mobility, which generally refers to the ease with which a person can move through space (e.g. Sager (2006), accessibility refers to the ease with which people can reach and participate in activities (Handy and Niemeier, 1997, Farrington and Farrington, 2005, Martens, 2012, Levinson et al., 2017). The notion of accessibility is rooted in the idea that transportation is a derived demand, i.e., transport is not an end in itself but a means to provide access to spatially dispersed activities and destinations (Wachs and Kumagai, 1973). Although a fluid and contested concept, Geurs and van Wee (2004) provide the following widely cited definition of accessibility:

'the extent to which land-use and transport systems enable (groups of) individuals to reach activities or destinations by means of a (combination of) transport mode(s).' (Geurs and van Wee, 2004: 128)

This definition of accessibility importantly highlights that the extent to which people have access to activities such as employment, results from both land-use patterns and transport systems. It follows that both components of accessibility, generally conceived in terms of proximity to activities (land-use) and speed (transport system), can function as levers to increase geographic accessibility to employment (Levine et al., 2012), but these exist in tension with each other: in areas with high concentrations of activities transport systems tends to provide low travel speeds (e.g. in agglomerations), whereas in areas where transport systems provide high travel speeds activities tend to be further apart (e.g. peripheral locations). In agglomerations, increasing concentrations of economic activities and people may therefore enhance accessibility, but only to the point that proximity outweighs speed-reduction effects (Levinson et al., 2017, Merlin, 2017).

This implies that an individuals' level of geographic accessibility to employment results from the dynamic relationship between residential and employment locations (land-use) and the available transport linkages between these locations (Sanchez, 2008). However, accessibility is also influenced by temporal and individual dimensions. Geurs and van Wee (2004), in particular, distinguish four components of accessibility: i) a land-use component describing the proximity or density of activities; ii) a transportation component related to the qualities of the transport system in terms of travel speed or time, cost and comfort; iii) a temporal component reflecting constraints with regard to availability of transport and activities; and iv) an individual component reflecting individual needs and abilities. Following the above definition and components of accessibility, the concept of accessibility can be used to measure the extent to which both land-use patterns and transport systems enable people to reach employment opportunities from a given location and the difficulty of reaching these opportunities in terms of travel time, cost and comfort (Foth et al., 2013, El-Geneidy et al., 2016).

A large body of empirical studies have analysed accessibility patterns related to the availability and physical access to transport, which typically show substantial disparities in accessibility to employment opportunities, most notably between people with access to cars and those who are dependent on public transport services (e.g. (Kawabata and Shen, 2007, Grengs, 2010, Foth et al., 2013, Golub and Martens, 2014). The costs of transport in terms of how much individuals need to spend in order to access and use the transport system, often referred to as affordability, has also been cited as an important dimension of accessibility. In particular, low-income groups often have to spend a relative large share of their income on transport, which may be worsened by (increasing) spatial mismatch (e.g. (Hine and Grieco, 2003, Sanchez et al., 2004, Bocarejo and Oviedo, 2012). More recently, the temporal availability of transport services and activities has been found to substantially influence accessibility to employment opportunities, referred to by Farber et al. (2016) as space-time mismatch, in particular affecting public transport-dependent groups (e.g. (Owen and Levinson, 2012, Fransen et al., 2015, Fayyaz et al., 2017).

Accessibility to employment opportunities thus results from a dynamic relationship between (personal) transport resources and land-use patterns, as well as temporal and individual constraints. Yet, there may still be issues with the appropriation of mobility that, in turn, could lead to inaccessibility of employment. This individual dimension to accessibility has received much attention in the literature around social exclusion.

2.3 The concept of social exclusion

Since the 1990s, literature in sociology and transport geography have substantially increased our understanding of the linkages between transport disadvantage, inaccessibility to key opportunities and processes of social exclusion.

The concept of social exclusion originated in France and has become an important part of the European social policy discourse during the 1990s, in order to explain how particular (groups of) people are prevented from inclusion in society (Levitas, 1998, Muddiman et al., 2000). In contrast to the more static descriptions of poverty and deprivation that focus on a lack of material resources and particular attributes to be fully included in society (Higgs and White, 2000, Atkinson and Kintrea, 2001), social exclusion is a broader concept which implies that people are not just poor or deprived, but that they have additionally lost the ability to participate in society. Despite numerous (often conflicting) definitions of social exclusion, there is wide agreement that social exclusion refers to a multi-dimensional and cumulative process that prevents individuals or groups from participating in activities considered normal in society, such as employment, education, health and social contacts (e.g. (Burchardt et al., 2002, Levitas, 2006, Levitas et al., 2007). For example, Levitas et al. (2007) define social exclusion as:

'the lack or denial of resources, rights, goods and services, and the inability to participate in the normal relationships and activities, available to the majority of people in a society, whether in economic, social, cultural or political arenas. It affects both the quality of life of individuals and the equity and cohesion of society as a whole.' (Levitas et al., 2007: 9).

This definition importantly highlights that there are barriers beyond the control of the excluded (groups of) individuals that prevent their participation in normal activities and thereby their social inclusion, with income disadvantages (as presumed root cause of poverty) arguably being the most mentioned barrier in the literature (Levitas, 1998, Burchardt et al., 2002). As work provides the potential income needed to participate in society, unemployment and (involuntary) economic inactivity, or, in the case of young people, those at risk of becoming so, increases the chance of becoming socially excluded (Levitas et al., 2007). Due to the prevalence of underemployment, however, especially among low-skilled and young people, a job may not guarantee the income needed to participate in society, while social exclusion is also not always the inevitable outcome, as people may be protected from this through other income (e.g. from other household members). Both individual and household economic (in)activity thus determine the level of poverty and related risk of social exclusion (Levitas et al., 2007).

Social exclusion often has a clear geographical dimension, causing the unemployed and low-income groups through self-reinforcing mechanisms of residential segregation to reside in poor neighbourhoods (Lupton and Power, 2002, Burchardt et al., 2002). These mechanisms relate to well-established intrinsic characteristics of poor neighbourhoods including poor economic and housing structures and adverse social effects, which tends to exacerbate employment outcomes of its residents, as it deteriorates employability, reduces the quality of social networks used in job-search activities, and may induce neighbourhood stigmatization (Wilson, 1987, Crane, 1991, Gobillon et al., 2007). This has led to the understanding that social exclusion not necessarily follows from a lack of activities to participate in, but from the inability to access those activities (Cass et al., 2005, Preston and Rajé, 2007). The spatial mismatch literature basically sought to link up this geographical dimension of exclusion, by analysing the spatial disconnections between workers and employment opportunities (Preston et al., 1998, Church et al., 2000). Thinking in this way about the linkage between geographical access and social exclusion also allowed transport to be taken into consideration.

Transport-related social exclusion

From the end of the 1990s, social exclusion has been linked to transport disadvantage, based on the understanding that inaccessibility of key opportunities can be both a cause for, and a result of, social exclusion (Church et al., 2000, Farrington and Farrington, 2005). The early, predominantly British, studies identified lack of access to transport and lack of accessibility to key opportunities - i.e. the (relative) ease with which a person can reach activities such as employment, education, healthcare and social contacts - as key components of transport disadvantage, influencing many dimensions of the social exclusion discourse (e.g. (Church et al., 2000, Lucas et al., 2001, Kenyon et al., 2002, SEU, 2003, Cass et al., 2005, Preston and Rajé, 2007). As discussed by Geurs and van Wee (2004), causes for social exclusion can relate to all four components of accessibility: lack of access or available transport, problems with affordability, or barriers such as (perceived) safety; lack of key opportunities such as (matching) employment; space-time mismatches between transport supply and demand; and changing needs and abilities of people.

This insight has resulted in the coining of the term transport poverty. In line with the distinction between poverty and social exclusion, transport poverty refers to a lack of resources, which, according to Lucas (2012), is caused by direct and indirect interactions between transport disadvantage (e.g. lack of access to a car or inadequate public transport services) and social disadvantage (e.g. low income or educational skills). Transport-related social exclusion, in turn, can result from transport poverty when (groups of) individuals systematically experience inaccessibility of key opportunities and this leads to significant social impacts, such as unemployment, deterioration of health, or social isolation (Kenyon et al., 2002, Lucas, 2012). Kenyon et al. (2002) offered the following, widely-cited definition of transport-related social exclusion, highlighting its transport and accessibility dimensions, as:

'The process by which people are prevented from participating in the economic, political and social life of the community because of reduced accessibility to opportunities, services and social networks, due in whole or part to insufficient mobility in a society and environment built around the assumption of high mobility' (Kenyon et al., 2002: 210)

This definition importantly highlights that the inaccessibility of key opportunities and, subsequently, social exclusion of those who are less mobile, follows from a society that has become increasingly organised around and dependent upon high levels of mobility (Kenyon et al., 2002, Lucas, 2012). In particular, the facilitation of the growing car usage, which fostered the decentralisation of employment, education, healthcare and, in consequence, social networks, alongside the decline in public transport services due to a combination of decreased ridership, cuts in public funding and cost-efficiency measures, has led to a widening disparity in accessibility to key activities between people with and without access to cars (Kenyon et al., 2002, SEU, 2003, Houston, 2005, Lucas, 2012).

According to Kenyon et al. (2002), it is important to recognise that the more mobile society becomes the more accessibility among less mobile groups, especially those without cars, may be reduced, which, in turn, increases their risk of social exclusion. The extent to which transport-related social exclusion can be adequately addressed, thus not only depends on those who are currently (at risk of) exclusion, but also on reducing the dynamic of *hypermobility* in which mobility is considered an important prerequisite to participate in society (Urry, 2000). This understanding of the dynamics of mobility in the social structures of society is further enhanced by the concepts of motility (Kaufmann, 2002, Kaufmann, 2004) and network capital (Urry, 2007).

Motility and Network Capital

Kaufmann (2002) has extended the notion of mobility by taking into account the potential and ability to be mobile, which he refers to as '*motility*' (Kaufmann, 2002: 37), encompassing an individuals' access to different forms and degrees of mobility, the competence to recognize and make use of access, and the appropriation of a particular choice. Each of these interdependent elements affects the motility of an individual. As mobility is an important prerequisite to participate in current societies, Kaufmann (2004) argue that motility (the potential and ability to be mobile) constitutes a form of capital on its own. The notion of motility as mobility capital also relates to the concept of *network capital* (Urry, 2007), which is described in Elliott and Urry (2010) as a combination of capacities to be mobile within our complex, networked societies. The uneven distribution of the capacities to be mobile, can be thought of as different degrees of motility (Elliott and Urry, 2010), i.e. differences in the appropriation of potential mobility by (groups of) individuals in society. Urry (2007) argues that the unequal distribution of network capital in society therefore leads to differential levels of access to key opportunities and, subsequently, risk of exclusion among (groups of) individuals who lack the capacity to be mobile.

This also links to more indirect forms of capabilities, such as relative lack of power to affect (transport) planning and policy processes (Hodgson and Turner, 2003, Lucas, 2012) and the accumulation of transport-related disadvantages, in which (groups of) individuals both lack the capacities to be mobile and may be more prone to experience the negative externalities of transport in terms of traffic accidents and pollution (Martin, 2007). The understanding of the linkages between transport disadvantage and social exclusion has more recently been extended by building on the concept of social capital (i.e. the actual or potential resources of a person), where it has been proposed that social capital mediates those linkages (Currie and Stanley, 2008, Stanley et al., 2012, Schwanen et al., 2015). In this sense, transport disadvantage may change a person's social capital that, in turn, could lead to social exclusion.

The social exclusion literature thus importantly establishes that, within the context of our highly mobile societies, it is not just a lack of adequate transport but rather a lack of the capacity to be mobile that leads to inaccessibility of employment opportunities which, in turn, may result in social exclusion. Social inclusion is therefore increasingly a matter of gaining the capacity to be mobile in order to access, and participate in, employment opportunities.

2.4 Conceptual model

A conceptual model has been derived from the theoretical framework, in which the concepts around agglomeration economies, accessibility and social exclusion have been linked and schematically presented (Figure 2.1). The purpose of this model is to illustrate the key interactions between the transport system and land-use patterns and the capacity of individuals to be mobile, which all shape a person's accessibility to employment that, in turn, can be a cause for, and a result of, social exclusion.

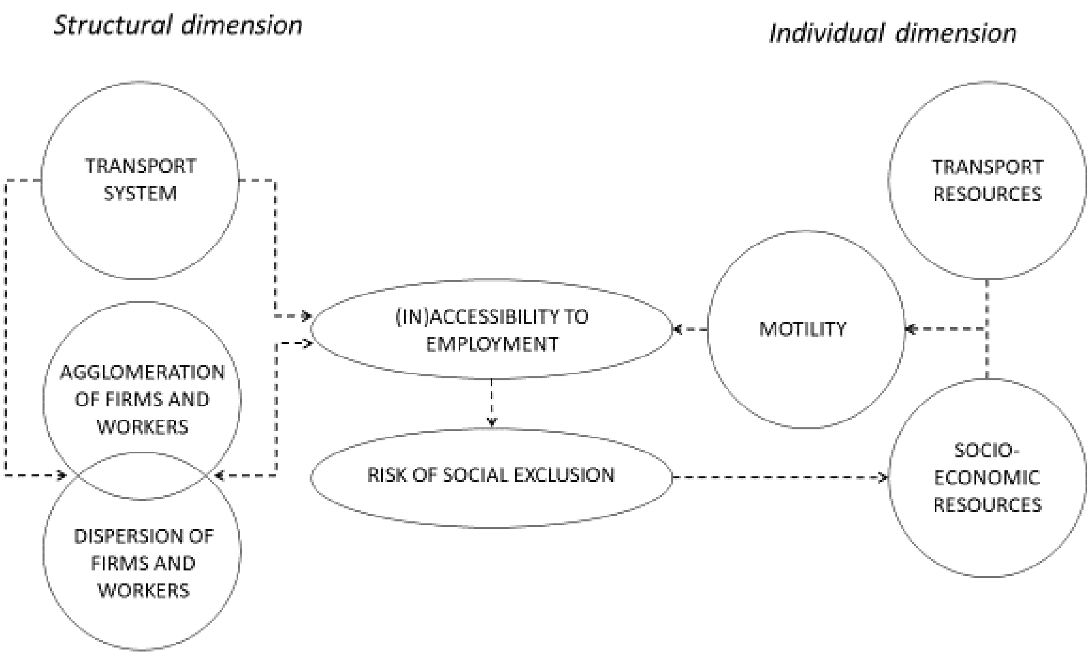


Figure 2.1 Diagram of the relationship between the concepts of agglomeration, accessibility and social exclusion

From the theoretical framework, both a structural dimension and an individual dimension to (in)accessibility to employment can be discerned.

The structural dimension to accessibility is shaped by the transport system and land-use patterns of agglomeration and dispersion of firms and workers. Agglomeration is promoted by centripetal forces through sharing, matching and learning mechanisms, which tend to geographically concentrate firms and workers and thereby enhance accessibility to employment. Increased accessibility, in turn, also promotes agglomeration through better connectivity, which can increase productivity and potential firm entries and, subsequently, the demand for labour. Geographical dispersion of activities, caused by centrifugal forces such as higher land rents and congestion, tends to counter accessibility to employment by enlarging the distances between firms and workers (increasing spatial mismatch). The transport system and, increasingly, technological innovations such as ICT are seen as the main determinants of economic agglomeration, which shift the balance between centripetal and centrifugal forces. Even when land-use patterns are fixed, however, accessibility to employment can still be enhanced by the transport system, as reductions in commute times and costs may enable workers to increase their job search horizon and reach (matching) employment opportunities.

The individual dimension to accessibility is shaped by people's motility, i.e. their capacity to be mobile, within the context of our highly mobile societies, in order to take advantage of access to employment opportunities. Motility partially results from available transport resources, which relates to the different forms and degrees of mobility that people are able to use, with less mobile groups, especially those without cars, often having a reduced capacity to be mobile and, subsequently, reduced accessibility to employment opportunities. Motility is also influenced by socio-economic resources on various levels, related to the individual (e.g. education and skills), the household (e.g. income and economic (in)activity of household members) and the neighbourhood (e.g. quality of housing stock, local economy, unemployment), which in combination affects people's access to transport resources and capacity to be mobile.

A person's accessibility to employment opportunities and, subsequently, social inclusion, thus follows from both the transport system and land-use patterns as well as by his or her capacity to be mobile, within the context of our highly mobile societies. This implies that policy strategies aimed at improving people's accessibility to employment opportunities and, in turn, their employment outcomes, are likely to be more effective when they address both the individual dimension and the structural dimension of accessibility.

3. Methodology

This thesis follows a deductive approach to examine the relationship between transport access and employment outcomes in two national and two regional case studies of Great Britain and the Netherlands. The research therefore moves from the combined insights of the more general theoretical concepts in chapter 2, to the specific and concrete cases of Great Britain and the Netherlands in chapters 5 to 8. Due to the interdisciplinary nature of the research, in which the urban economic and sociological theoretical concepts are linked and integrated to enhance the understanding of the relationship between transport job accessibility and employment outcomes, the methodology and study design also move beyond the scope of a single discipline. In an important departure from standard Spatial Mismatch methodologies, this research therefore adopts a multi-instrument approach using different datasets to look at this relationship between job accessibility and employment outcomes and combines this with a case study strategy.

3.1 Multi-instrument approach and case studies

The multi-instrument approach applied in this research uses a sequential explanatory design, consisting of a quantitative phase to gain a general understanding of the relationship between transport access and employment outcomes, followed by a qualitative phase to provide further in-depth insight into experiences of accessing employment opportunities. First, all existing quantitative empirical evidence of the association between transport access and employment outcomes is systematically reviewed and synthesised through a meta-analysis, in order to produce general effect sizes and to determine the sources of variation in the mixed empirical results (Figure 3.1). Second, nationwide transport job accessibility measures are computed at micro spatial level and combined with econometric models using cross-sectional national and regional secondary employment micro datasets of Great Britain and the Netherlands, to examine the relationship between transport job accessibility and individual employment probabilities within these relatively unexplored national contexts. These datasets consisted of secure access (anonymised) data at the level of individuals, which allowed to allocate each individual a unique job accessibility level related to his or her area of residence (further discussed in the next sections). While longitudinal data would allow to establish more robust relationships between (changes in) job accessibility levels and employment outcomes, thereby overcoming potential endogeneity (two-way causality) in the relationship between job accessibility and employment probabilities, these datasets were not available for Great Britain or the Netherlands. This research therefore applies an instrumental variable (IV) approach to control for endogeneity, which is further elaborated in chapters 5 to 7.

This is followed by a qualitative phase of in-depth interviews with young job seekers in West Yorkshire, in order to gain a deeper understanding of the role of public transport in people's experiences of accessing employment opportunities, within their real-life context. This qualitative phase thereby allowed to complement and interpret the findings from the quantitative phase (Creswell and Plano Clark, 2011, Robson and McCartan, 2016). Although survey techniques could have been applied to generate a larger evidence base, interviews with young people allowed to gain more in-depth insights into (other) factors that influence their accessibility to employment. The interviews have been complemented with analysis of national transport micro datasets, which allowed to further examine the role of public transport in young people's experiences of accessing employment opportunities throughout England (further discussed in chapter 8). The multi-instrument approach applied in this research thereby importantly permitted for triangulation of the results from the quantitative and qualitative methods and data, which is achieved through the different thesis chapters (academic papers) that build on one another in a sequential order (Johnson and Onwuegbuzie, 2004, Creswell and Plano Clark, 2011, Robson and McCartan, 2016). As a result, more valid and well-substantiated conclusions can be made about the relationship between transport access and employment outcomes.

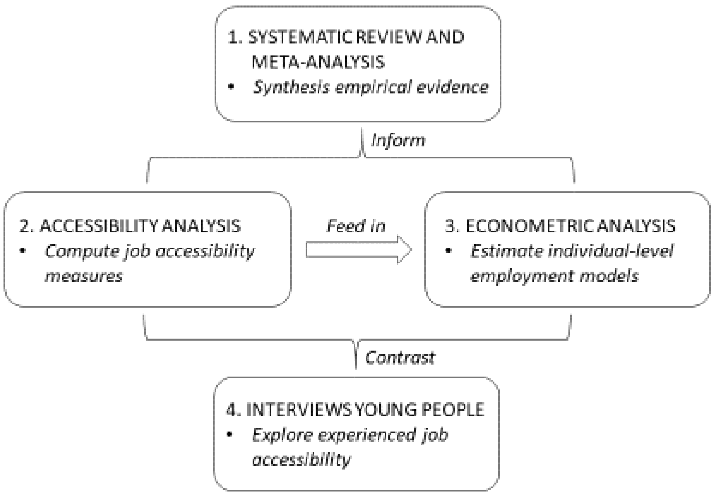


Figure 3.1 Model of key research elements

The multi-instrument approach is combined with two national case studies to empirically examine the quantitative relationship between transport job accessibility and employment probabilities, within the different transport and land use contexts of Great Britain and the Netherlands. According to Yin (2009), case study is particularly useful when the boundaries between the phenomenon and the context are not clearly evident. The comparative structure of this research implies that the same methods and data are repeated in both countries, in order to determine whether the results from one country also occurred in the other. This adds to the generalisability and validity of the research results through replication logic (Yin, 2009). The case studies therefore use comparable cross-sectional transport and employment micro datasets to develop nationwide transport job accessibility measures and combine this with national individual-level employment probability models. In order to enhance the empirical evidence base of the linkage between job accessibility and employment probabilities, the employment models for both countries are also calculated for various geographical area types and population groups (see section 3.2).

As this research is publicly funded by the West Yorkshire Combined Authority and the City of Rotterdam, case studies were also conducted at the regional level, i.e. West Yorkshire within the context of Great Britain and the Rotterdam-The Hague metropolitan region (MRDH-region) within the context of the Netherlands. As the collaboration with the City of Rotterdam builds on previous qualitative master thesis research into the role of public transport among low-skilled job seekers in Rotterdam (Bastiaanssen and Martens, 2013), the regional case study uses an administrative dataset to examine in more detail the quantitative relationship between (public) transport job accessibility and employment probabilities in Rotterdam and the wider MRDH-region (further discussed in the next sections). The case study of West Yorkshire, on the other hand, uses a 3-pronged mixed methods approach to empirically examine the role of public transport in young people's experiences in accessing employment opportunities, by combining our previously developed potential public transport job accessibility opportunity measure with micro-scale analysis of the UK National Travel Survey and in-depth interviews with young job seekers in West Yorkshire, which builds on the former qualitative research in Rotterdam (further discussed in section 3.2). This is because employment micro datasets were not available at the local level in West Yorkshire, while youth unemployment in this region remained relatively unexplored.

3.2 Methods of data analysis

The quantitative phase of this research comprises the studies in chapters 4 to 8. Chapter 4 consists of the systematic review and meta-analysis of all existing quantitative empirical evidence of the relationship between transport access and employment outcomes, as measured by the probability of employment, with a particular focus on young people in different contexts. This study helped to identify gaps in the empirical evidence (e.g. lack of evidence outside the US-context and with regard to public transport) and informed the development of the gravity-based job accessibility measures and calculation of the employment probability models (e.g. model type, variables and endogeneity controls) in the following chapters.

In chapter 5, firstly a local-area public transport job accessibility measure is computed for Great Britain using detailed public transport timetable data and business register micro datasets. Secondly, the public transport job accessibility measure is combined with a national individual-level employment micro dataset, in order to estimate the impact of public transport job accessibility on individual employment probabilities in locally specific, national employment models for Great Britain and for various geographical area types and population groups.

In chapter 6, and in a departure from the previous British study, a national employment micro dataset for the Netherlands is combined with a detailed local-area public transport-and-bicycle job accessibility measure, vehicle registration and household income datasets. This allowed us to derive individual-level employment probability models, while controlling for vehicle ownership, and to examine differential employment effects for various geographical area types and population groups. Chapter 7 builds on the national employment models for the Netherlands (based on a random population sample) and uses administrative datasets providing a full population sample of the Rotterdam-The Hague Metropolitan Region (MRDH-region) to examine the differential employment effects of job accessibility and car access for different urban areas and income groups in this metropolitan region.

The qualitative phase of this research comprises the study in chapter 8. This study departs from the quantitative evidence for Great Britain in chapter 5 and uses the public transport job accessibility measure in combination with analysis of national transport micro datasets and in-depth interviews with young job seekers in West Yorkshire. The national transport micro datasets have been used to provide general insights into the role of public transport in job search and job uptake among young job seekers. Next, in-depth interviews have been conducted with 30 young people at local job centres in West Yorkshire. In order to capture a variety of the different transport and land use contexts in the region, 10 interviews have been conducted in Leeds, in Bradford, and in Halifax, with around half of the interviews conducted at the more central job centres in each place and the other half at job centres in the urban periphery. Research of this nature is often limited to a maximum of 25-30 interviews, as after this point answers tend to become repetitive and more interviews would not contribute new information (Cebollada, 2009). To guide the interview questions, a semi-structured interview guide based on the theoretical concept of motility was used, which drew from previous master thesis research in Rotterdam (Bastiaanssen, 2012, Bastiaanssen and Martens, 2013). Access to the local job centres and interview participants was arranged through a collaboration with the Department for Work and Pensions (DWP) and the West Yorkshire Combined Authority, which is further elaborated in sections 3.3 and 3.4.

3.3 Data collection and management

Various secondary and primary data sources haven been analysed to empirically examine the relationship between transport job accessibility and employment probabilities. This section elaborates the data collection and management for each of the thesis chapters.

3.3.1 Reviewed studies

In chapter 4, all 93 identified studies that quantitatively assessed the relationship between transport access and employment outcomes were imported into EndNote and stored on the university server. These studies were systematically merged and categorised based on different (combinations of) transport measures and employment outcomes, and have been included in a citation database, which was uploaded to the research data repository of Research Data Leeds (https://doi.org/10.5518/762).

Of the 20 studies that were included in the meta-analysis, random-effects meta-regressions were computed to produce general effect sizes for the relationship between transport access and employment probabilities, while study variation was accounted for through additional random-effects GLS meta-regressions with study-specific covariates. All meta-regression models were computed in STATA and have been stored on the university server, which is backed-up regularly and password protected. Only output of the analyses has been released for the purpose of a journal article.

3.3.2 British micro datasets

In chapters 5 and 8, various British individual-level employment and transport micro datasets have been used, which are held by the Office for National Statistics (ONS) and the Economic and Social Research Council (ESRC). Access to these secure micro datasets was obtained via the UK Data Service through the Secure Lab of the UK Data Archive. The Secure Lab is a remote access facility whereby micro datasets that are stored on servers of the UK Data Archive can be accessed and analysed remotely from an organisational desktop computer.

The research project has been registered as 'ONS Project 109745: Youth Mobility and Access to Economic Opportunities' and published on the ONS website as a public record. As part of the research project application, Jeroen Bastiaanssen (PhD candidate) and Daniel Johnson (thesis supervisor) jointly applied as ONS Project Team members for an ONS Accredited Researcher (AR) training in Manchester and obtained AR status (in July 2017). Following this, project approval was obtained (in January 2018), conditional on: 1) that the research serves the public good by providing an evidence base for public policies and improves knowledge on social and/or economic trends; and 2) that the research outputs will be published.

Throughout the research project, the Secure Lab was accessed from an allocated desktop pc in the secure open plan office of the Leeds Institute for Data Analytics (LIDA). To construct the job accessibility measure and various neighbourhood variables for the econometric modelling, public transport timetable data and Census datasets (downloaded as open data from NOMIS) have been imported as external datasets by the UKDS into the project folder. All micro datasets were processed in SPSS and STATA and have been stored together with external datasets in the research project folder on the servers of the UK Data Archive. Only non-disclosive research outputs written up for publication have been exported from the Secure Lab environment, subject to UKDS statistical disclosure control checks. As access to the Secure Lab is required during the review procedure of the journal paper, which has been delayed due to the Covid19 lockdown of LIDA and the University of Leeds, the project will remain open till the end of December 2021.

3.3.3 Dutch micro datasets

In chapters 6 and 7, the equivalent Dutch individual-level employment and transport micro datasets have been used, which are held by Statistics Netherlands (Centraal Bureau voor de Statistiek, CBS). Access to these secure micro datasets was obtained via CBS through a secure internet connection (Remote Access), which allows the user to analyse the micro datasets from any secure workplace.

As the research was part of wider collaboration with the City of Rotterdam and research organisation SEOR (Stichting Economisch Onderzoek Rotterdam, SEOR, part of Erasmus School of Economics), the research was added to the existing Remote Access microdata project 8449 'Vervoersarmoede in arbeidsmarktperspectief' (Transport poverty in labour market perspective). This Remote Access project from SEOR had ensued from previous qualitative master thesis research into transport poverty in Rotterdam (Bastiaanssen, 2012, Bastiaanssen and Martens, 2013), but with a focus on spatial mismatches in the local labour market of the Rotterdam-The Hague metropolitan region (see (De Koning et al., 2017). The current research project more specifically brought the transport/job accessibility dimension into the analysis, and partially re-used the prepared regional micro datasets for the employment probability model in chapter 7. As for the British research in chapters 5 and 8, access to the microdata has been provided on condition that the research served the public good and that research outputs will be published.

Analysis of the microdata was conducted via Remote Access from an organisational desktop computer during the placement period at the municipality of Rotterdam and SEOR, and from a personal laptop during the remainder of the PhD. The job accessibility measures and other datasets have been imported and stored together with the processed microdata (in SPSS and STATA) in the research project folder on the CBS servers. All micro datasets remain in this secured CBS environment and only non-disclosive research outputs for publication have been released. As Remote Access is required during the review procedure of the journal papers, the project is anticipated to remain open till early 2021.

3.3.4 Interview data and ethical review

For chapter 8, interviews have been conducted with young people at the local job centres in West Yorkshire. Approval for the interviews with young people was obtained from the District Office of the DWP in Leeds (in November 2018), after which the local job centres have been contacted (in March 2019). Since the interviews involved human participants in a vulnerable age group, an ethical review application was submitted to the Faculty Research Ethics Committee of the University of Leeds. Ethical approval for the interviews was obtained (in March 2019) under Ethics reference: AREA 18-119.

The interviews have been conducted in April 2019 during Youth Obligation workshops at the following local job centres: Park Place (centre) and Eastgate (periphery) in Leeds; Westfield House (centre) and Eastbrook Court (periphery) in Bradford; and Crossfield House in Halifax. All interview participants were provided with an information sheet and a consent form, which informed them about the aim of the research and usage of their personal data, including anonymization and the option to withdraw at any moment (up to a week after the interview). The interviews were audio-recorded for the purpose of transcription and exclusive use within this research project, as was approved by the Faculty Research Ethics Committee. The participants' identity and related personal data were anonymized through coding, and pseudonyms have been used when quoting participants for illustrative purposes. No other disclosive data from the participants has been collected.

The audio-records and transcripts of the interviews have been stored on the university server, which is backed-up regularly and password protected. The interview transcriptions were subsequently used for cluster analysis in NVivo 12. Only output of the analyses has been released for the purpose of a journal article.

3.4 Placement periods and research seminar

As an integral part of this research, placement periods have been conducted at both the West Yorkshire Combined Authority (WYCA) and the City of Rotterdam. A placement period with the WYCA was conducted from October 2017 to March 2018, followed by a placement period from July to November 2018 with the City of Rotterdam and research organisation SEOR in Rotterdam. During these placements, access was provided to various transport and employment datasets used in this research and the direct collaboration with the local policy makers helped to enhance the mutual understanding of the linkages between the (local) transport system, the spatial distribution of job seekers and employment opportunities, and the resulting transport job accessibility levels for different geographical area types and population groups. Due to the orientation of the two regional authorities, specific attention has been paid to public transport services and the labour market position of young people, for which access to public transport time table datasets (e.g. Traveline datasets) and access to young job seekers at the local job centres in West Yorkshire was provided. During and after these placement periods, research results have been used as the basis for regular presentations and workshops at the WYCA and the city of Rotterdam, which intended to enhance the general understanding of how to better tailor transport and land-use policy strategies in order to improve accessibility to employment opportunities and, subsequently, social inclusion.

As part the placement periods and to further enhance the mutual understanding of the relationship between transport job accessibility and employment outcomes, the seminar 'Transport Poverty in the Labour Market' was organised on 19 December 2018 in Rotterdam, in collaboration with SEOR and the City of Rotterdam (see also https://kwp-stedelijkearbeidsmarkt.nl/onderzoek-en-seminar-over-transportarmoede-op-de-arbeidsmarkt/). During this seminar, the research results were presented and discussed with local and national researchers and policymakers from the WYCA, ITS Leeds, the City of Rotterdam and various other Dutch governmental organisations.

4. Does transport help people to gain employment? A systematic review and meta-analysis of the empirical evidence

Abstract

The role of transport in providing access to employment has received considerable attention. Since transport policies may be motivated by assumed effects on employment probability outcomes, it is important to establish the nature of the relationship between transport and employment outcomes. While the majority of the empirical evidence suggests a positive association, it is not conclusive or consistent and often shows mixed results. To address this confusion, our study has systematically reviewed this evidence base and synthesised it through meta-analysis.

We first identified 93 studies that quantitatively assessed the impact of transport on employment outcomes. By systematically merging the empirical evidence, this study establishes a positive association between transport and employment outcomes, with varying effects for four identified categories of transport measures (or combinations thereof): car ownership, public transport access, commute times, and job accessibility levels. This positive association persists in studies that control for endogeneity between transport and employment, but a larger evidence base is needed to establish a more robust relationship, in particular for cities and smaller (rural) areas outside the US-context and with regard to public transport.

We then selected 20 methodologically comparable studies for inclusion in the meta-analysis. Our meta-regression models clearly demonstrate that car ownership significantly increases individual employment probabilities, in particular among welfare recipients. Young drivers benefit from access to household cars when these are not in use by their parents, and they are more sensitive to the time and cost implications of longer commutes. While our systematic review suggests that better access to public transport and higher levels of job accessibility increases employment probabilities, meta-regression analysis requires more consistent transport measures. The findings in this study are important for policymakers in that they imply that job seekers may benefit from public policies targeted at improving their access to public transport, in particular for people without access to cars and in areas with fewer job opportunities.

Keywords: transport, car, commute, accessibility, meta-analysis, employment

4.1 Introduction

Transport has been associated with improved employment probability outcomes as it provides people with greater access to spatially dispersed job opportunities. Following the seminal work of Kain (1968) on the Spatial Mismatch Hypothesis, who argued that a major source accounting for inner-city unemployment in the US was to be found in poor access to job opportunities, a large body of studies in US metropolitan areas have ensued. More recently, some studies have also evaluated this relationship in EU cities (Ihlanfeldt and Sjoquist, 1998, Gobillon et al., 2007). However, while most studies largely confirm the positive effects of transport on employment probability outcomes, some find insignificant or even negative outcomes, implying that transport policies targeted at improving people's employment probabilities may not be effective as a policy instrument in all cases.

However, the mixed empirical results of previous studies may also arise from the use of different transport measures and employment outcomes, which are, thereby, difficult to compare in a meaningful and consistently measurable way. Most studies relate individual employment probabilities or employment rates to a measure of transport access – i.e. with car ownership, public transport access, commute times, or job accessibility measures typically used as the key indicator of transport supply. Disparities may further arise from limitations in the underlying datasets and methodologies (Gobillon et al., 2007). Additionally, studies typically focus on US metropolitan areas, and it is unclear whether the statistical relationships would hold in less car-dependent environments (such as European cities) or in smaller travel-to-work zones, where travel times and distances are shorter (Ihlanfeldt, 2006).

A further limitation of many studies lies in their lack of consideration of potential endogeneity (non-causality) between transport and employment probability outcomes: for example, access to a car is likely to increase people's employment probabilities, while a job also provides the financial means for a car, which may bias study results. Linking employment outcomes to transport further raises the issue of residential endogeneity because of the simultaneity between an individual's employment outcome and residential location decision (Glaeser, 1996). Studies that do not control for endogeneity, therefore, establish an association rather than causality between transport and employment probability outcomes.

It is important to establish the exact nature of the relationship between transport and employment outcomes, since transport policies may be motivated by assumed effects on employment outcomes, as well as to identify the causes underlying the mixed empirical results. The aim of this reported study has therefore been to: (i) systematically review all studies that have quantitatively assessed[3] the relationship between transport and employment probability outcomes, and (ii) synthesize the identified studies through a meta-analysis to produce general effect sizes of the relationship between transport and employment probability outcomes and to determine the sources of variation in the mixed empirical results.

Within the transport domain, meta-analyses have previously been conducted to establish the relationship between productivity gains and urban agglomeration economies, with transport being implicitly incorporated (Melo et al., 2009), the productivity effects of transport infrastructure (Melo et al., 2013), and effects of public transport infrastructure on regional growth (Elburz et al., 2017). To date, however, no meta-analysis has established the specific relationship between transport access and employment probability outcomes. In this study, we focus on the empirical evidence that quantitatively assesses this relationship using individualized employment probability metrics. This allows us to estimate the overall effect sizes of transport access on employment probability outcomes, which, in turn, can help to identify transport policies with the greatest effect on employment uptake.

In our meta-analysis, we are principally interpreting individual employment impacts as based on labour supply side effects arising from incremental changes in accessibility. Better accessibility to employment opportunities will hypothetically reduce the amount of time required to find work both in terms of expanding job search horizons and increasing the offered wage of a given job, net of transport cost (i.e. reducing their reservation wage) and, thereby, hypothetically increase the likelihood of applying for and accepting such work. The underlying data for our models are derived from cross-sectional studies, which compare employment outcomes across different areas (i.e. rather than before and after new transport interventions). These studies typically looked at the impact on individual's employment probabilities of accessibility, measured through differences in car ownership or mean neighbourhood commute times by public transport or car. There is a labour demand dimension to improving accessibility which plays out principally through better connectivity promoting agglomeration (see Banister and Berechman (2001) for discussion), which could be amplified through land use change, thus increasing productivity and the demand for labour, however, this issue is outside the scope of this paper.

4.2 Methodology

We systematically reviewed and synthesised all available evidence that has quantitatively assessed the relationship between transport access and employment probability outcomes. The review was

[3] Qualitative studies could provide important insights into perceived transport barriers to employment, however, these were outside the scope of our study because they do not quantify this relationship.

conducted up to 2019, and involved identification of all relevant studies using keyword combinations related to 'transport', 'impact' and 'employment'[4] in the publication title, abstract and keywords of studies. The search engines of Science Direct, Web of Science and Google Scholar were used. Additionally, websites of specialist institutes such as Centre for Economic Policy Research, London School of Economics and the grey literature (including reports, conference proceedings and dissertations) were searched separately. The searches were performed without restrictions on publication date, status or language of publication. In addition to the database searches, the recent synthesis report Transport Review by the What Works Centre (2015) and the reference lists of all included studies and literature in the author's databases were screened for relevant studies.

In total, 2958[5] unique studies were identified, from which 118 studies were selected that directly related transport access to individual employment outcomes. The excluded studies were found either to be unrelated to transport or employment outcomes, or used qualitative methods that did not quantify this relationship. The full text was obtained for the 118 identified studies and reviewed, after which we identified 93 studies that quantitatively assessed the impact of transport on employment outcomes. Fifteen studies were excluded for not providing quantitative model estimations for the impact of transport on employment outcomes and another ten studies were excluded as their measures did not incorporate a transport component (e.g. these studies used job ratio or job density measures).

We manually extracted data from the 93 identified studies using a predefined data template including: study sample size; characteristics and geographical location; transport and employment measures used; cross-sectional or longitudinal datasets; econometric model type and controls for endogeneity (e.g. subsamples, IV-approach); and effect sizes (coefficients, standard errors, and p-values) [6].

As hypothesised, there was considerable variation in transport measures and employment outcomes. We identified four categories of transport measures (or combinations thereof) that were used in the studies: car ownership, public transport access, commute times and job accessibility levels. The studies typically assessed individual employment probabilities or neighbourhood employment rates, as discussed in section 4.3. To gain an understanding of the extent to which transport affects

[4] Transport keywords: transport*, infrastructure, travel*, commut*, road, highway, motorway, car, transit, rail, tram, bus, metro, subway, bicycle, walk; Relationship keywords: relation*, impact, caus*, eval*, experiment, affect*, effect*, link*, case*; and Employment keywords: employment, job, labour, productivity, economic activity. Keywords 'access' and 'work' were not used as being found too general.
[5] In total 2392 studies from online searches; 189 studies from WWC report; and 377 studies from own libraries.
[6] The citation database is available through: https://doi.org/10.5518/762

employment outcomes and to determine the sources of variation in the mixed empirical results, we next synthesized the methodologically comparable empirical evidence through a meta-analysis.

4.2.1 Meta-analysis

Meta-analysis is a systematic framework that allows estimation of effect sizes of relationships, in our case between transport and employment outcomes, based on merging of common variables in datasets taken from different individual studies (Boland et al., 2014, Littell et al., 2008, Borenstein et al., 2009). As this requires us to compare 'like with like', we confined our meta-analysis to studies that assessed individual employment probabilities (being employed as opposed to being not employed) using binomial logit models. Of the 93 identified studies, 20 comparable studies were included in the meta-analysis that all used binomial logit models to explain individual employment probabilities resulting from car ownership (12) or commute time (8). These studies yielded similar effect sizes, which is a requirement for meta-analysis (Boland et al., 2014). The various public transport access and job accessibility measures used in studies were found incompatible with each other and thus were unsuitable for a meta-regression. We excluded studies using multinomial logit, probit or Tobit models due to their different functional form yielding incomparable coefficients. We also excluded studies focussing on employment rates as these cannot be directly compared with individual employment probabilities[i].

As meta-analysis typically involves a regression-based approach (Waldorf and Byun, 2005), we used the reported coefficients (i.e. log-odds ratios) and standard errors related to transport measures as effect sizes for our meta-regressions. Since the studies varied in terms of sample sizes and significance of the estimated effects, we followed the 'gold standard' in meta-analysis and calculated weights based on the 'inverse variance' of the squared standard error, which minimizes the variance of the average effect size estimates and assigns the greatest weight to the most precise estimates of individual studies (Borenstein et al., 2009, Littell et al., 2008). We then conducted a random-effects regression[7] using the inversely weighted mean effect sizes[8]. A fixed-effects model was deemed inappropriate as it assumes that all included studies share a common effect size (τ^2=0)[9], while we

[7] The random-effects model is formulated as $ES = \sum ES_i * W_i / \sum W_i$, where *ES* is the common effect size; ES_i is the reported coefficient (i.e. log-odds ratio) of individual study *i*; and W_i is the weight assigned to study *i*.
[8] Following Borenstein et al. (2009), under the random-effects model the weight assigned to each study is $W_i = 1/V_i$, where V_i is the within-study variance for study *i* plus the between-studies variance (sum squared deviations of each study from the combined mean), tau-squared.
[9] As the between-study variation of both study samples is τ^2>0 and the I^2 statistic is >75% (see forest-plots in tables 4.1 and 4.3) and thus suggest heterogeneity, we *a priori* selected a random-effect regression, which allows to control for variance within and between studies.

expect similar but not per se identical effect sizes due to different socioeconomic covariates (Borenstein et al., 2009).

To compare and interpret the estimated effects we used 'odds-ratios', which describe the ratio of the probability of an event occurring relative to the probability of the event not occurring (Boland et al., 2014). For example, if the odds of being employed relative to being not employed are higher for car owners than those without a car, the odds ratio would be higher than 1, while the opposite effect would yield an odds ratio less than one. A defining characteristic of binomial logit models is that the coefficients are log-odds ratios, which could therefore easily be transformed into odds-ratios by taking their exponential. While employment elasticities are easier to interpret, the logit functional form used by constituent papers in our meta-regression does not allow for the derivation of constant elasticities of employment and most studies did not report elasticities or the required descriptive statistics for all (sub)models by which to derive them.

Both significant and insignificant coefficients from individual studies were included in the meta-analyses, as dropping the insignificant observations could have biased the effect sizes by over- or underestimating the impact of transport on employment outcomes. This is a standard approach in meta-analysis (see e.g. (Melo et al., 2009, Ewing and Cervero, 2010)). In accordance with Ewing and Cervero (2010), we included both published and unpublished studies in our meta-analysis, as publication bias may inflate the results estimated by the meta-analysis.

Since the variation between the studies in terms of transport indicators, samples, and strategies to account for endogeneity are likely to have different impacts on employment outcomes, we also conducted random-effects generalized least squares (GLS) meta-regressions with study-specific covariates for our two meta-analyses samples (i.e. car ownership and commute time studies), based on the log odds (coefficients) of the reported individual employment models and dummy variables for four aspects of each study: (1) definition of the transport indicator (e.g. car ownership, one/multiple household cars, car commute times); (2) study samples used (e.g. youth (Black, Hispanic, white), women, welfare recipients); (3) treatment of residential endogeneity (e.g. youth living at home); or (4) treatment of transport endogeneity (e.g. an instrumental variable (IV) approach[10]). Since all studies included individual, household, and neighbourhood controls, we did not include dummy variables to control for these additional variables, as they were already inherent within the source models.

[10] An IV-approach uses a third variable (Z) correlated with employment only through the applied measure of transport access to control for endogeneity between employment probability outcomes and transport access.

4.3 Systematic review of literature on transport and employment outcomes

This section discusses the results of our systematic review, based on a categorisation of the studies by their transport measures and employment outcomes: individual or household car ownership measures in section 4.3.1, public transport measures in section 4.3.2, commute time measures in section 4.3.3, and job accessibility measures in section 4.3.4, followed by conclusions in section 4.3.5.

4.3.1 Studies using individual or household car ownership measures

We identified 42 studies that assessed the association between access to a car and individual employment probabilities, in mainly US metropolitan areas. Eight cross-sectional studies found a positive association between individual car ownership and employment probabilities among low-income and low-educated groups (Rice, 2001, Kawabata, 2002, Kawabata, 2003, Lucas and Nicholson, 2003, Garasky et al., 2006, Stoll, 2005) and (female) welfare recipients (Ong, 1996, Sanchez et al., 2004), especially in more car-dependent areas. Three studies further found that household car ownership increased employment probabilities of (low-skilled) youth (Painter et al., 2007), in particular when they had access to multiple household cars (Bauder and Perle, 1999, Perle et al., 2002). Similar associations have been found for the Czech Republic (Marada and Květoň, 2016) and among aborigines in rural Taiwan (Lin et al., 2014).

While access to a private car is associated with increased employment probabilities, Ong and Houston (2002), found no statistically significant effect on employment for welfare dependent women who were unable to borrow a car. Other studies did find that a driver's license or higher numbers of household cars increased employment probabilities (Yi, 2006, Smart and Klein, 2015), with similar associations being found in the Barcelona and Madrid metropolitan areas (Matas et al., 2010, Di Paolo et al., 2014). In France, Cavaco and Lesueur (2004) further showed that car access was related to shorter unemployment durations. These studies thus suggest that individual and household car ownership increase individual employment probabilities, however, endogeneity was not controlled for, i.e. did the car precede or follow the job?

Three US studies controlled for endogeneity by using an instrumental variable (IV) approach to predict household car ownership and also found an increase in employment probabilities of single welfare women (Ong, 2002, Bansak et al., 2010) and male and female labour force participation (Thompson, 2001). Four other US studies used longitudinal datasets, assuming an exogenous relationship if car ownership preceded employment, and typically found car ownership associated with shorter unemployment durations (Holzer et al., 1994, Sullivan, 2003, Dawkins et al., 2005, Johnson, 2006). Twelve US studies utilised longitudinal welfare data, also showing positive associations between (gained) car ownership and welfare-to-work transitions (Blumenberg, 2008, Cervero et al., 2002, Cervero and Tsai, 2003, Shen and Sanchez, 2005, Gurley and Bruce, 2005, Sandoval et al., 2011, Alam, 2009, Blumenberg and Pierce, 2017) or for having a driver's license (Bania et al., 2003), and between car access and job retention (Thakuriah and Metaxatos, 2000). Alternatively Danziger et al. (2000), showed that having no car or driver's license decreased weekly worked hours of single welfare mothers. O'Connell et al. (2012) found similar associations for male welfare recipients in Ireland. However, car ownership status between baseline and follow-up surveys is often unregistered, making it uncertain whether the car preceded the job. Four US studies combined longitudinal datasets with an IV-approach and also found that car ownership increased employment probabilities, in particular among low-skilled workers (Raphael et al., 2001, Raphael and Rice, 2002) and single welfare mothers (Baum, 2009), and increased the labour supply of low-income households (Bee, 2009). For France, Le Gallo et al. (2017) further found that randomly assigned vouchers for driving lessons among young unemployed slightly increased their long-term employment prospects, but skills-mismatches were more important.

We further identified two cross-sectional studies that established positive associations between cars per capita and employment rates in the US (Gao et al., 2008) and in the Czech Republic (Marada and Květoň, 2016). This association persists in studies by Sanchez (1999) and Ong and Miller (2005) that used an IV-approach to predict cars per capita. However, due to their reliance on zonal-level data, these studies may suffer from aggregation biases.

4.3.2 Studies using public transport access measures

Seventeen studies have assessed the association between public transport access and employment probabilities. Three US studies found small positive effects of access to a higher number of bus stops and stations within a certain radius (Ong and Houston, 2002, Yi, 2006) or higher public transport route densities (Rice, 2001), particularly among those without cars, but not for distances to bus stops (Yi, 2006). Sanchez (1999) found a positive association between hours worked and shorter distances to bus and rail stops, but not for morning service frequencies at the nearest stop. A later study by Sanchez et al. (2004) also found no association between evening service frequencies and employment probabilities of welfare recipients, which may indicate that public transport offered poor access to suitable job at the required times. This seems reconfirmed by studies that found a negative association between public transport dependence and employment probabilities among welfare recipients (Blumenberg, 2002), with labour force participation of non-white workers (Cooke, 1997), or with having paid work among non-white workers (Taylor and Ong, 1995). O'Connell et al. (2012) used longitudinal data but found no effect of residing near public transport stops among Irish welfare recipients. However, once again, these studies often have not adequately controlled for endogeneity.

Four longitudinal studies controlled for endogeneity through policy-induced rail infrastructure extensions[11], which connected disadvantaged neighbourhoods with employment locations, typically finding increased individual employment probabilities or wages in San Francisco (Holzer et al., 2003), Copenhagen (Rotger and Nielsen, 2015), Sweden (Aslund et al., 2015), and improved employment rates in the Bordeaux agglomeration (Sari, 2015). However, it remains unclear if the siting of the rail infrastructure is codetermined with economic activity, which is required to establish exogeneity (Duranton and Turner, 2012). Tyndall (2017) therefore used a 'natural shock'-based closure of a train line in New York and found increased unemployment probabilities in adjacent neighbourhoods, particularly among minority populations without cars. A later study by Tyndall (2019) used an IV-approach and showed that newly opened light rail stations had improved neighbourhood employment rates in US-metropolitan areas, while displacing low-skilled workers to isolated neighbourhoods. Group displacement effects of large public transport developments have recently gained much attention (see also (Padeiro et al., 2019).

Two further longitudinal studies found strongly increased employment probabilities in the short-run among young unemployed in urban low-wage labour markets, especially for those with poor job access, following randomly assigned fee-reducing public transport cards in Washington (Phillips, 2014) and from non-fungible public transport subsidies in Addis Ababa (Franklin, 2015). Lower public transport travel costs may thus also improve job access and, in turn, increase employment probabilities.

4.3.3 Studies using commute time measures

We identified 22 studies in mainly US metropolitan areas that have examined the association between mean neighbourhood car or public transport commute times and employment probability outcomes. Two cross-sectional studies found higher mean commute times associated with decreased individual employment probabilities among low-wage workers (Thakuriah, 2011) and low-educated women (Thompson, 1997). Cooke (1997) further found lower commute times related to higher labour force participation, but only for married mothers. This suggests that (female) workers may adjust their labour supply when job access increases because of lower commute times. Sanchez (1999), however, found a positive association between commute times and annual weeks worked, especially when including white people; since their annual weeks worked were higher than for non-whites, this might

[11] Residential endogeneity was controlled for through pre-treatment sampling of only individuals residing in close proximity to the new stations.

indicate that commute times rise with (improved) employment. Again, these studies did not control for endogeneity.

Ten cross-sectional studies in various US metropolitan areas used samples of (low-skilled) youth residing with their parents, as their residential location is more plausibly exogenous. These studies typically found higher mean commute times associated with lower employment rates (Ellwood, 1986) and decreased individual employment probabilities, especially among public transport captives (Ihlanfeldt and Sjoquist, 1990, Ihlanfeldt and Sjoquist, 1991, Ihlanfeldt, 1992, Ihlanfeldt, 1993, Holloway, 1996, O'Regan and Quigley, 1991, O'Regan and Quigley, 1996, Bauder and Perle, 1999, Perle et al., 2002). Four studies used an IV-approach to control for endogeneity, finding that lower mean (gravity-based) commute times increased individual employment probabilities (Berechman and Paaswell, 2001, Ozbay et al., 2006), and explained interracial youth employment differences (O'Regan and Quigley, 1998). Johnson et al. (2017) also found in England that lower public transport travel times to employment centres was related to higher employment levels.

Two longitudinal studies further found lower mean commute times associated with shorter (youth) unemployment durations in the US (Holzer et al., 1994) and in France (Cavaco and Lesueur, 2004). For Great Britain, Sanchis-Guarner (2013) also found that higher mean commute times decreased (female) labour supply. Taylor and Ong (1995), on the other hand, focussed on long-term residents in various US metropolitan areas and found that workers with short commute times had more often given up their jobs, because of a dispersion of (low-skilled) jobs. Decreased job access due to longer commute times thus may reduce employment probability outcomes.

4.3.4 Studies using car or public transport job accessibility measures

We identified 33 studies that assessed the relationship between car or public transport job accessibility measures - typically based on the number of jobs reachable within 30/ 45 minutes' travel time or within a weighted travel time from each neighbourhood - and individual employment probabilities. Three studies in US metropolitan areas found positive associations for higher ratios of public transport to car job accessibility (Kawabata, 2002, Kawabata, 2003) and better bus job accessibility (Yi, 2006), particularly in car-dependent areas and among public transport captives. Parks (2004) also showed positive impacts of improved car job accessibility among some groups of low-skilled women. Three other studies found positive associations between combined measures of public transport and car job accessibility and (female) employment probabilities in the metropolitan areas of Mexico City (Quintanar, 2012) and Accra (Chen et al., 2017), and with employment stability of mainly aborigines in New Taipei City, Taiwan (Lin et al., 2014). Smart and Klein (2015), however, found a negative effect for public transport job accessibility among low-income and low-educated individuals across the US. As a higher number of household cars did increase their employment probabilities, this effect may be due to high car dependency. Yet again, endogeneity was not controlled for.

Three studies in more car-dependent US metropolitan areas that controlled for endogeneity found mixed results: Blumenberg and Pierce (2014) sampled low-income households on housing assistance but only found a positive association between public transport job accessibility and job retention, not with employment probabilities. Thompson (2001) used an IV-approach but found non-significance for male labour force participation and even a small negative association for female labour force participation. Both studies did find a positive association for car access. Hu (2016) sampled long-term residents and did find positive effects of better car job accessibility among medium- to low income groups, though not for the lowest or higher income groups.

Three European studies sampled long-term residents, finding that poor public transport and car job accessibility increased long-term unemployment probabilities in the Paris metropolitan area (Korsu and Wenglenski, 2010). More jobs were reachable per minute by public transport increased employment probabilities of low-educated women (Matas et al., 2010) and (only) female employment probabilities and youth living with their parents (Di Paolo et al., 2014) in the Barcelona and Madrid metropolitan areas. Other studies used an IV-approach and also found that better public transport and car job accessibility increased employment probabilities in Great Britain (Bastiaanssen et al., 2021a) and in The Netherlands (Bastiaanssen et al., 2021b, Bastiaanssen et al., 2021c), particularly among carless households in urban areas and low income groups.

Longitudinal studies in France found better public transport and car accessibility to jobs associated with shorter unemployment durations in the Paris metropolitan area (Gobillon et al., 2011), and with increased unemployment-to-work transitions (Détang-Dessendre and Gaigné, 2009). However, Gobillon et al. (2007) found no such association amongst public housing tenants in the Paris region. Sanchis-Guarner (2013) sampled workers affected by road construction in Great Britain, but found no effect of changes in car job accessibility on their hours worked or wages. Two US studies used longitudinal data of (involuntarily) laid-off workers, as their residential location can be considered exogenous to their employment status, and did find better public transport job accessibility associated with shorter unemployment durations (Rogers, 1997, Andersson et al., 2018). Ten other US studies utilized longitudinal welfare data but found that better car or public transport job accessibility sometimes improved welfare-to-work transitions (Alam, 2009, Sandoval et al., 2011) and job retention (Thakuriah and Metaxatos, 2000). However other studies found no significant effect (Bania et al., 2003, Cervero and Tsai, 2003, Sanchez et al., 2004, Bania et al., 2008), or even showed a negative association (Cervero et al., 2002, Shen and Sanchez, 2005, Blumenberg and Pierce, 2017). But, job accessibility between baseline and follow-up surveys is often not registered, or calculated for one year only, making longer-term employment outcomes uncertain.

Three other cross-sectional studies in US metropolitan areas found positive associations between better public transport or car job accessibility and youth employment rates (Ellwood, 1986, Raphael, 1998), and average weeks worked in (only) poor areas (Sanchez, 1999). Two studies in more car-dependent US metropolitan areas found no significant association between (changes in) public transport job accessibility and employment rates (Hu, 2015), and between car job accessibility and workers per capita at Census-level (Gao et al., 2008), while Hu and Giuliano (2017) used an IV-approach and did find positive effects of public transport job accessibility on employment rates in poor neighbourhoods. Other European studies also found positive associations between better public transport or car job accessibility and unemployment durations in the Paris metropolitan region, (Duguet et al., 2009), and with increased employment rates in central municipalities and among low-educated workers in Sweden (Norman and Borjesson, 2012, Norman et al., 2017). However, these studies could not control for personal or household characteristics, which may result in aggregation biases.

4.3.5 Discussion of main findings from systematic review

What is clear from this systematic review of these past studies is that individual or household car ownership generally increases employment probability outcomes and that this effect persists in studies that control for endogeneity. Whereas dependence on public transport generally lowers employment probabilities, the studies suggest that better access to public transport and particularly the opening of new public transport infrastructure and subsidies facilitate job search and, hence, increase employment probabilities.

The predominantly US studies that use commute time measures generally find that lower mean commute times increase employment probability outcomes, which persists in studies that control for endogeneity. However, since commute times tend to rise with income, suburban locations with higher employment rates may actually have higher mean commute times than inner-city locations with lower employment rates (see Taylor and Ong (1995). Commute measures are also flawed because they are based on mean travel patterns of employed workers rather than actual individual's commute times, and may overlook those who are unemployed due to a lack of job access. Exclusively studying young people residing with their parents is more plausibly exogenous as they would not have self-selected their residential location, but labour market participation is often highly stable across generations (Clark, 2014), suggesting that parental residential location decisions may be spatially stratifying youth by ability.

Studies that use public transport or car accessibility measures to jobs generally find a positive association with employment probability outcomes, in particular in more car-dependent metropolitan areas and among public transport captives, even when controlling for endogeneity. However, more consistent job accessibility measures and complete datasets between baseline and follow-up surveys are needed to establish robust relationships between the key variables. A larger sample of studies that adequately control for endogeneity is also required to establish more robust relationships.

A feature of our constituent studies is that they predominantly were exploring the Spatial Mismatch Hypothesis (Kain, 1968) and so are based in areas of deprivation of large cities. The linkage between accessibility and employment may well be less strong in other situations such as smaller cities where dislocation from employment areas is less pronounced (see Ihlanfeldt (1992), for discussion). Even in segregated markets, other factors influence employment; Ihlanfeldt and Sjoquist (1998) find only up to half of employment rate differentials can be explained by accessibility. Only a few studies further distinguish the type of work - Berechman and Paaswell (2001) find in occupations with a proliferation of low-skilled jobs, improvements in accessibility have little impact.

4.4 Findings from meta-analyses of transport and individual employment probabilities

This section presents the results of our random-effects meta-regressions for studies using car ownership measures in section 4.4.1 and for studies using commute time measures in section 4.4.2, followed by conclusions in section 4.4.3. To account for study variation in terms of transport indicators, samples, and strategies to control for endogeneity, we further present random-effects GLS meta-regressions with study-specific covariates for both meta-regressions.

4.4.1 Car ownership and individual employment probabilities

We identified 12 binomial logit model studies, providing 27 observations from the reported (sub)models that assessed the relationship between individual employment probabilities and individual or household car ownership (Table 4.1), with two studies by Bauder and Perle (1999) and Perle et al. (2002) using variables based on both one and multiple household cars[12]. Of these, 10 studies were conducted within the US context and two studies in Taiwan and the Czech Republic, often focussing on women, welfare recipients or young people (aged 16-25). All studies used cross-sectional employment models, of which three studies dealt with transport endogeneity between employment status and car ownership using an instrumental variable approach. Other studies dealt with residential

[12] Abbreviations are reported in Table 11.1 in the appendix

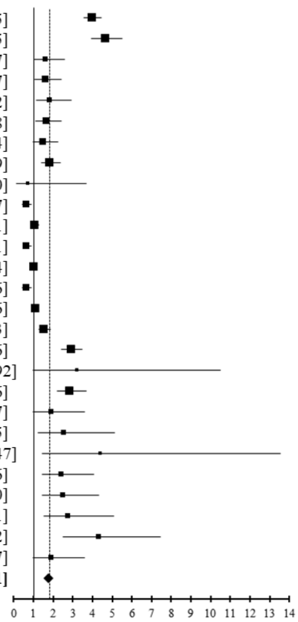
endogeneity by using samples of youth residing at home or welfare recipients, as their residential location choice is considered exogenous.

As shown in Table 4.1, the studies mainly show odds-ratios larger than 1, indicating that car ownership increases individual employment probabilities. In particular, welfare recipients and low-skilled individuals seem to benefit from car ownership, but with strong variations in precision of their odds-ratios as indicated by their 95% confidence intervals. The lower odds-ratios (< 1) provided by the studies by Bauder and Perle (1999) for youth with access to single household cars as opposed to the higher odds ratios for access to multiple household cars may be due to the usage of multiple car measures. This increases the likelihood of multi-collinearity due to potential correlation between these measures, which may have biased the regression results.

Table 4.1 Meta-regression car ownership studies

Study	Country	Sample	N	Measure	IV/S	Log Odds	SE	Weight	Odds ratio [95% CI]
1. Baum (2009)	US	W (F)	8,158	CAR (I)	S	1.380***	0.057	4.57%	3.975 [3.555, 4.445]
2. Baum (2009)	US	W (F)	8,158	CAR (I)	IV/S	1.537***	0.087	4.49%	4.651 [3.922, 5.515]
3. Baum (2009)	US	W (F)	2,768	CAR (I)	IV/S	0.480**	0.244	3.69%	1.616 [1.002, 2.607]
4. Baum (2009)	US	W (F)	2,766	CAR (I)	IV/S	0.467**	0.212	3.88%	1.595 [1.053, 2.417]
5. Ong (1996)	US	W (F)	1,110	CAR (I)	S	0.607***	0.236	3.74%	1.835 [1.156, 2.912]
6. Ong (2002)	US	W (F)	770	CAR (I)	S	0.499***	0.194	3.99%	1.647 [1.127, 2.408]
7. Ong (2002)	US	W (F)	770	CAR (I)	IV/S	0.402**	0.205	3.92%	1.495 [1.000, 2.234]
8. Sullivan (2003)	US	LS	934	CAR (I)		0.610*	0.133	4.31%	1.840 [1.417, 2.389]
9. Sullivan (2003)	US	LS (F)	459	CAR (I)		-0.320	0.830	1.17%	0.726 [0.143, 3.690]
10. Bauder and Perle (1999)	US	Y	13,048	CAR1 (HH)	S	-0.4553***	0.177	4.08%	0.634 [0.449, 0.897]
11. Bauder and Perle (1999)	US	Y	13,048	CAR2 (HH)	S	0.0751***	0.029	4.62%	1.078 [1.018, 1.141]
12. Bauder and Perle (1999)	US	Y (B)	3,464	CAR1 (HH)	S	-0.4361***	0.169	4.13%	0.647 [0.464, 0.901]
13. Bauder and Perle (1999)	US	Y (B)	3,464	CAR2 (HH)	S	0.0351***	0.014	4.63%	1.036 [1.008, 1.064]
14. Bauder and Perle (1999)	US	Y (W)	9,584	CAR1 (HH)	S	-0.4575***	0.178	4.08%	0.633 [0.477, 0.896]
15. Bauder and Perle (1999)	US	Y (W)	9,584	CAR2 (HH)	S	0.1016***	0.039	4.60%	1.107 [1.025, 1.196]
16. Perle et al. (2002)	US	Y	13,385	CAR1 (HH)	S	0.4331****	0.094	4.47%	1.542 [1.283, 1.853]
17. Perle et al. (2002)	US	Y	13,385	CAR2 (HH)	S	1.0695****	0.091	4.47%	2.914 [2.436, 3.486]
18. Lin et al. (2014)	TH	ABOR	3,504	CAR (I)		1.1753**	0.600	1.82%	3.239 [1.000, 10.492]
19. Shen and Sanchez (2005)	US	W	9,815	CAR (I)	S	1.051***	0.128	4.33%	2.861 [2.226, 3.676]
20. Yi (2006)	US		2,008	CAR (HH)		0.640**	0.327	3.18%	1.896 [1.000, 3.597]
21. Blumenberg (2008)	US	W	1,984	CAR (HH)	S	0.928***	0.360	2.97%	2.529 [1.248, 5.125]
22. Blumenberg (2008)	US	W	78	CAR (HH)	S	1.480***	0.575	1.91%	4.393 [1.425, 13.547]
23. Blumenberg (2008)	US	W	1,021	CAR (HH)	S	0.879****	0.267	3.54%	2.408 [1.427, 4.066]
24. Blumenberg (2008)	US	W	358	CAR (HH)	S	0.917****	0.279	3.47%	2.502 [1.449, 4.320]
25. Blumenberg (2008)	US	W	527	CAR (HH)	S	1.02****	0.310	3.28%	2.773 [1.510, 5.091]
26. Marada and Květoň (2016)	CZ		1,023	CAR (I)		1.466	0.277	3.48%	4.332 [2.515, 7.462]
27. Hu (2016)	US	LINC	1,284	CAR (I)	IV/S	0.64**	0.327	3.18%	1.896 [1.000, 3.597]
Overall Random Effect (I-squared 97.59%, p = 0.000)						**0.581*** **	**0.104**	**100.00%**	**1.788 [1.460, 2.191]**

Forest Plot Odds ratio [95% CI]



Heterogeneity: Tau2 = 0.232; Tau = 0.482; df = 26 (p < 0.00001)
Test for overall effect: Z = 5.608
Significance levels: *: 0.10% **: 0.05% ***: 0.01% ****: 0.001%

When we turn to the overall random effect of the meta-regression it shows a positive sign of 0.581*** with a related overall odds-ratio of 1.788, 95% CI [1.460, 2.191], p<0.001, which indicates that the odds of employment amongst individuals with access to a car are nearly 1.8 times higher than for carless individuals. Car ownership thus substantially helps people to gain employment.

To account for variation between the studies, we conducted a random-effects GLS meta-regression based on the log odds of the employment probabilities resulting from car ownership, with dummy variables for study specific covariates: i.e. 'youth' aged 16-25, 'women'[13], 'welfare recipients', 'multiple household cars', and for 'non-US studies' (Table 4.2). A dummy based on studies that used instrumental variables to control for transport endogeneity was non-significant, as individual studies reported both increased and decreased log-odds ratios, so given the small number of observations in the model it was dropped. The coefficients in the model represent the estimated adjustments to the underlying log-odds ratio of car ownership from the various study level attributes[14]. The model is significant at 0.0001%, implying that these variables help to explain variations in individual employment probabilities.

Table 4.2 Meta-regression: Car ownership odds-ratios with study specific covariates

Variables	Observations	Coefficient	Robust SE	P>|z|	Odds-ratio[15]
Youth	8	-0.644	0.352	0.068	
Women	8	-0.513	0.201	0.011	0.940
Welfare recipients	13	0.623	0.155	0.000	2.428
Multiple hh cars (youth)	4	0.549	0.036	0.000	2.164
Non-US study	2	0.786	0.140	0.000	3.755
Constant		0.534	0.072	0.000	
R^2	0.6362				
Number of observations	27				
Number of studies	12				

The non-significant log-odds ratio adjustment for youth (aged 16-25) in Table 4.2 indicates that car access for youth has no differential impact on their employment over and above that of other (age) groups. Other factors than transport may mainly influence their employment prospects, such as lack of work experience or skills mismatches.

However, the highly significant and positive log-odds ratio adjustment for multiple household cars clearly shows that if access is to more than one household car, it does improve their employment probabilities, as indicated by the odds-ratio of 2.164. Young drivers may therefore benefit from access to household cars when these are not in use by their parents. The significant negative log-odds ratio adjustment for women indicates that their employment probabilities resulting from car ownership are lower than for studies that used pooled samples of men and women, as shown by their lower odds-ratio of 0.940. However, women with access to cars will still have better employment outcomes than

[13] The comparator for 'youth' is other (age) groups and for 'women' these are studies that used pooled samples of men and women.
[14] The reported coefficients are additive effects of the study specific covariates to the overall random effect log-odds ratio.
[15] The reported odds-ratios are derived from the sum of the log-odds ratio adjustment coefficient from the meta-model and the overall random effect log-odds ratio, exclusive of the study specific covariate subsample (e.g. excluding 'youth' based studies for the youth odds-ratio derivation).

those without cars, given most of these studies involve welfare recipients who clearly benefit from car ownership, as shown by the odds-ratio of 2.428. This is likely to follow from their low car ownership rates, relative to other population groups, while public transport may offer a poor substitute in car-dependent US metropolitan areas. Studies that were conducted outside the US-context clearly show a higher impact of car ownership on employment probabilities, however, a larger evidence base is needed to establish a more robust relationship between car ownership and employment outcomes.

4.4.2 Commute time and individual employment probabilities

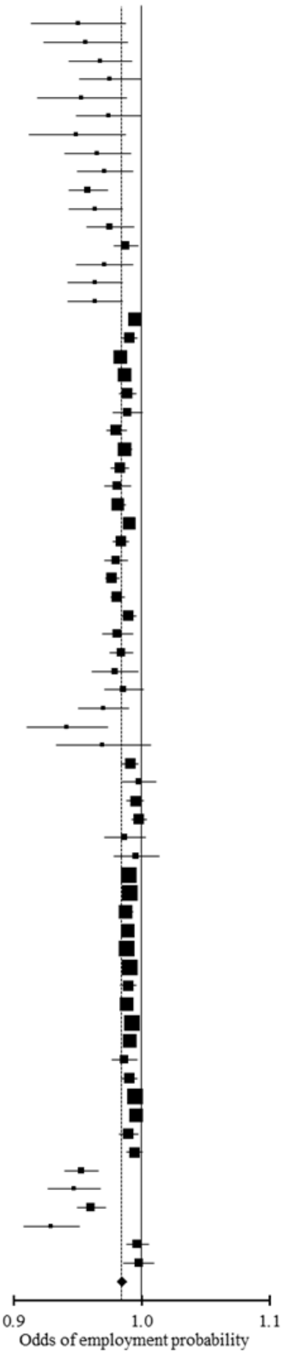
We further identified 8 studies, providing 68 observations from the reported (sub)models that assessed the relationship between individual employment probabilities and mean neighbourhood commute times in minutes (Table 4.3). All studies were conducted within the US context, often focussing on employment differentials between Black, Hispanic, and white youth (aged 16-25). Mean commute times are typically based on one-way travel time to work derived from public microdata samples by residential zone, differentiated by socioeconomic or ethnic group. The studies used cross-sectional employment models, of which most studies reduced endogeneity by sampling young people living at home and one study sampling welfare recipients.

Overall, the studies in Table 4.3 show odds-ratios less than 1 with high precision as indicated by their small 95% confidence intervals, pointing towards a robust negative relationship between mean commute times and (decreasing) individual odds of employment. The overall random effect of the meta-regression shows a small negative sign of -0.014*** with a related odds-ratio of 0.986, 95% CI [0.985, 0.988], $p<0.001$, which indicates that as the mean commute times increase, the odds of employment slightly decreases; e.g. with a ten-minute increase in commute time we would expect the relative odds of employment to decrease by a factor of 0.14.

Table 4.3 Meta-regression commute time studies

Study	Country	Sample	N	Measure	IV/S	Log Odds	SE	Weight	Odds ratio	[95% CI]
1. Holloway(1996)	US	Y (WE)	32,164	MCARCT	S	-0.051***	0.020	0.16%	0.950	[0.914, 0.988]
2. Holloway(1996)	US	Y (BNE)	2,455	MCARCT	S	-0.045***	0.017	0.20%	0.956	[0.924, 0.989]
3. Holloway(1996)	US	Y (BE)	7,350	MCARCT	S	-0.033***	0.013	0.36%	0.968	[0.944, 0.992]
4. Holloway(1996)	US	Y (WNE)	5,795	MCARCT	S	-0.025**	0.013	0.36%	0.975	[0.951, 1.000]
5. Holloway(1996)	US	Y (WE)	17,996	MCARCT	S	-0.048***	0.019	0.18%	0.953	[0.919, 0.989]
6. Holloway(1996)	US	Y (WE)	14,168	MCARCT	S	-0.026**	0.013	0.33%	0.974	[0.949, 1.000]
7. Holloway(1996)	US	Y (BNE)	1,483	MCARCT	S	-0.052***	0.020	0.15%	0.949	[0.912, 0.988]
8. Holloway(1996)	US	Y (BE)	4,114	MCARCT	S	-0.035***	0.014	0.32%	0.966	[0.940, 0.992]
9. Holloway(1996)	US	Y (BE)	3,236	MCARCT	S	-0.029***	0.011	0.44%	0.971	[0.950, 0.993]
10. Ihlanfeldt and Sjoquist (1991)	US	Y (BEH)	5,694	MCARCT	S	-0.0428***	0.008	0.77%	0.958	[0.943, 0.973]
11. Ihlanfeldt and Sjoquist (1991)	US	Y (WEH)	8,394	MCARCT	S	-0.0366***	0.011	0.46%	0.964	[0.943, 0.985]
12. Bauder and Perle (1999)	US	Y (NEH)	13,048	MCT	S	-0.0250***	0.010	0.57%	0.975	[0.957, 0.994]
13. Bauder and Perle (1999)	US	Y (BNEH)	3,464	MCT	S	-0.0124***	0.005	1.46%	0.988	[0.978, 0.997]
14. Bauder and Perle (1999)	US	Y (WNEH)	9,584	MCT	S	-0.0295***	0.011	0.43%	0.971	[0.949, 0.993]
15. Perle et al. (2002)	US	Y (EH)	13,385	MCT	S	-0.0371****	0.011	0.44%	0.964	[0.943, 0.985]
16. Perle et al. (2002)	US	Y (EH)	13,385	MCT	S	-0.0372****	0.011	0.44%	0.963	[0.942, 0.985]
17. Perle et al. (2002)	US	Y (EH)	13,385	MCT	S	-0.0049***	0.002	2.57%	0.995	[0.991, 0.999]
18. Perle et al. (2002)	US	Y (EH)	13,385	MCT	S	-0.0095****	0.003	2.17%	0.991	[0.985, 0.996]
19. Ihlanfeldt and Sjoquist (1990)	US	Y (WE)	10,418	MCARCT	S	-0.017	0.002	2.47%	0.983	[0.979, 0.987]
20. Ihlanfeldt and Sjoquist (1990)	US	Y (WE)	10,418	MCARCT	S	-0.013	0.002	2.58%	0.987	[0.983, 0.991]
21. Ihlanfeldt and Sjoquist (1990)	US	Y (BE)	2,800	MCARCT	S	-0.011	0.003	1.93%	0.989	[0.982, 0.996]
22. Ihlanfeldt and Sjoquist (1990)	US	Y (BE)	2,800	MCARCT	S	-0.011	0.006	1.18%	0.989	[0.978, 1.000]
23. Ihlanfeldt and Sjoquist (1990)	US	Y (WNE)	3,519	MCARCT	S	-0.020	0.004	1.71%	0.980	[0.972, 0.988]
24. Ihlanfeldt and Sjoquist (1990)	US	Y (WNE)	3,519	MCARCT	S	-0.013	0.003	2.22%	0.987	[0.982, 0.992]
25. Ihlanfeldt and Sjoquist (1990)	US	Y (BNE)	1,182	MCARCT	S	-0.017	0.004	1.85%	0.983	[0.976, 0.990]
26. Ihlanfeldt and Sjoquist (1990)	US	Y (BNE)	1,182	MCARCT	S	-0.019	0.005	1.31%	0.981	[0.971, 0.991]
27. Ihlanfeldt and Sjoquist (1990)	US	Y (WH)	6,615	MCARCT	S	-0.018	0.003	2.25%	0.982	[0.977, 0.987]
28. Ihlanfeldt and Sjoquist (1990)	US	Y (WH)	6,615	MCARCT	S	-0.009	0.002	2.66%	0.991	[0.988, 0.994]
29. Ihlanfeldt and Sjoquist (1990)	US	Y (BH)	2,253	MCARCT	S	-0.016	0.003	2.03%	0.984	[0.978, 0.990]
30. Ihlanfeldt and Sjoquist (1990)	US	Y (BH)	2,253	MCARCT	S	-0.020	0.005	1.48%	0.980	[0.971, 0.989]
31. Ihlanfeldt and Sjoquist (1990)	US	Y (WNH)	6,253	MCARCT	S	-0.023	0.003	2.19%	0.977	[0.972, 0.983]
32. Ihlanfeldt and Sjoquist (1990)	US	Y (WNH)	6,253	MCARCT	S	-0.019	0.003	2.19%	0.981	[0.976, 0.987]
33. Ihlanfeldt and Sjoquist (1990)	US	Y (BNH)	1,405	MCARCT	S	-0.010	0.003	2.12%	0.990	[0.984, 0.996]
34. Ihlanfeldt and Sjoquist (1990)	US	Y (BNH)	1,405	MCARCT	S	-0.019	0.006	1.11%	0.981	[0.969, 0.993]
35. Ihlanfeldt and Sjoquist (1990)	US	Y (BE)	862	MCARCT	S	-0.016**	0.005	1.45%	0.984	[0.975, 0.994]
36. Ihlanfeldt and Sjoquist (1990)	US	Y (BE)	556	MCARCT	S	-0.021**	0.009	0.60%	0.979	[0.961, 0.997]
37. Ihlanfeldt and Sjoquist (1990)	US	Y (BNEH)	835	MCARCT	S	-0.014**	0.008	0.77%	0.986	[0.971, 1.002]
38. Ihlanfeldt and Sjoquist (1990)	US	Y (BNENH)	453	MCARCT	S	-0.030**	0.010	0.51%	0.970	[0.951, 0.990]
39. Ihlanfeldt and Sjoquist (1990)	US	Y (BNEH)	484	MCARCT	S	-0.060**	0.017	0.21%	0.942	[0.911, 0.974]
40. Ihlanfeldt and Sjoquist (1990)	US	Y (BNENH)	368	MCARCT	S	-0.031	0.019	0.17%	0.969	[0.933, 1.007]
41. Ihlanfeldt and Sjoquist (1990)	US	Y (WE)	2,416	MCARCT	S	-0.009**	0.003	1.96%	0.991	[0.984, 0.998]
42. Ihlanfeldt and Sjoquist (1990)	US	Y (WE)	2,034	MCARCT	S	-0.002	0.007	0.99%	0.998	[0.985, 1.011]
43. Ihlanfeldt and Sjoquist (1990)	US	Y (WNEH)	2,131	MCARCT	S	-0.005	0.003	1.92%	0.995	[0.988, 1.002]
44. Ihlanfeldt and Sjoquist (1990)	US	Y (WNENH)	1,882	MCARCT	S	-0.002	0.003	2.18%	0.998	[0.992, 1.004]
45. Ihlanfeldt and Sjoquist (1990)	US	Y (WNEH)	1,864	MCARCT	S	-0.013	0.008	0.72%	0.987	[0.971, 1.003]
46. Ihlanfeldt and Sjoquist (1990)	US	Y (WNENH)	2,319	MCARCT	S	-0.004	0.009	0.65%	0.996	[0.979, 1.014]
47. Ihlanfeldt (1992)	US	Y (WH)	24,342	MCARCT	S	-0.0101**	0.001	2.94%	0.990	[0.989, 0.991]
48. Ihlanfeldt (1992)	US	Y (BH)	11,473	MCARCT	S	-0.0091**	0.001	2.87%	0.991	[0.989, 0.993]
49. Ihlanfeldt (1992)	US	Y (LH)	4,962	MCARCT	S	-0.0122**	0.003	2.21%	0.988	[0.983, 0.993]
50. Ihlanfeldt (1992)	US	Y (LH)	3,462	MCARCT	S	-0.0109**	0.002	2.60%	0.989	[0.986, 0.993]
51. Ihlanfeldt (1992)	US	Y (WENH)	14,136	MCARCT	S	-0.0120**	0.001	2.90%	0.988	[0.986, 0.990]
52. Ihlanfeldt (1992)	US	Y (BENH)	6,943	MCARCT	S	-0.0089**	0.001	2.85%	0.991	[0.989, 0.993]
53. Ihlanfeldt (1992)	US	Y (LENH)	2,700	MCARCT	S	-0.0106**	0.003	2.08%	0.989	[0.983, 0.996]
54. Ihlanfeldt (1992)	US	Y (LENH)	2,066	MCARCT	S	-0.0120**	0.002	2.47%	0.988	[0.984, 0.992]
55. Ihlanfeldt (1992)	US	Y (WNENH)	10,205	MCARCT	S	-0.0076**	0.001	2.88%	0.992	[0.991, 0.994]
56. Ihlanfeldt (1992)	US	Y (BNENH)	4,529	MCARCT	S	-0.0094**	0.002	2.62%	0.991	[0.987, 0.994]
57. Ihlanfeldt (1992)	US	Y (LNEH)	2,261	MCARCT	S	-0.01326**	0.005	1.39%	0.987	[0.977, 0.997]
58. Ihlanfeldt (1992)	US	Y (LNEH)	1,395	MCARCT	S	-0.0099**	0.003	2.03%	0.990	[0.984, 0.996]
59. Ihlanfeldt (1992)	US	Y (WNENH)	6,477	MCARCT	S	-0.0052**	0.001	2.87%	0.995	[0.993, 0.997]
60. Ihlanfeldt (1992)	US	Y (BNENH)	2,653	MCARCT	S	-0.0046**	0.002	2.50%	0.995	[0.991, 0.999]
61. Ihlanfeldt (1992)	US	Y (LNENH)	2,338	MCARCT	S	-0.0101**	0.004	1.88%	0.990	[0.983, 0.997]
62. Ihlanfeldt (1992)	US	Y (LNENH)	1,183	MCARCT	S	-0.0057**	0.003	2.06%	0.994	[0.988, 1.001]
63. Ihlanfeldt (1993)	US	Y (HEH)	4,327	MCARCT	S	-0.048**	0.007	0.93%	0.953	[0.940, 0.966]
64. Ihlanfeldt (1993)	US	Y (HNEH)	4,327	MCARCT	S	-0.054**	0.011	0.46%	0.947	[0.927, 0.968]
65. Ihlanfeldt (1993)	US	Y (WEH)	4,506	MCARCT	S	-0.040***	0.006	1.14%	0.961	[0.950, 0.972]
66. Ihlanfeldt (1993)	US	Y (WNEH)	4,506	MCARCT	S	-0.073***	0.012	0.40%	0.930	[0.908, 0.952]
67. Bania et al. (2008)	US	W	605	WMPTCT	S	–0.0031	0.004	1.59%	0.997	[0.988, 1.006]
68. Bania et al. (2008)	US	W	634	WMCARCT	S	–0.0022	0.006	1.09%	0.998	[0.986, 1.010]
Overall Random Effect (I-squared 79.98%, p = 0.000)						**-0.014*** **	**0.001**	**100.00%**	**0.986**	**[0.985, 0.988]**

Forest Plot Odds Ratio [95% CI]



Heterogeneity: Tau2 = 0.000; Tau = 0.005; df = 67 (p < 0.00001)
Test for overall effect: Z = -16.968
Significance levels: *: 0.10% **: 0.05% ***: 0.01% ****: 0.001%

To account for between study variation, we conducted a random-effects GLS meta-regression based on the log odds of the employment probabilities resulting from mean commute times, with dummy variables for study specific covariates: i.e. 'youth', 'Black' or 'Hispanic', and for studies that sampled youth 'living at home' to account for residential endogeneity (Table 4.4). The coefficients in the model represent the estimated adjustments to the underlying log-odds ratio of commute time from the various study level attributes. Since all studies were conducted within the US context and did not use an IV approach, we excluded these two dummies from the meta-regression. The model is significant at 0.0001%.

Table 4.4 Meta-regression: Commute time odds-ratios with study specific covariates

Variables	Observations	Coefficient	Robust SE	P>|z|	Odds-ratio
Youth	66	-0.021	0.006	0.000	0.976
Black youth	27	-0.003	0.004	0.355	
Hispanic youth	10	-0.002	0.002	0.354	
Youth living with parents	33	-0.003	0.001	0.000	0.973
Car commute	60	0.004	0.005	0.446	
Constant		-0.001	0.003	0.781	
R^2	0.0489				
Number of observations	71				
Number of studies	8				

Within the model, the significant negative adjustment to the log-odds ratio for commute times in the youth subgroup (aged 16-25) suggests more rapidly decreasing employment probabilities resulting from increased mean commute times as compared to other groups, as indicated by their lower odds-ratio of 0.976. With a ten-minute increase in commute time, the odds of employment amongst youth would decrease by a factor 0.24, which may imply that young people are more sensitive to the time and cost implications of longer commutes than other groups. In line with the seminal work of Kain (1968), all studies of young people assessed the differential employment impacts of longer mean commute times amongst Black and Hispanic youth, who typically live in poor inner-city neighbourhood, as compared to white youth, who tend to reside in suburban neighbourhoods. However, coefficients on being Hispanic or Black youth both show non-significance, which stresses that a given commute time for those being young and part of an ethnic minority does not have differential impacts on their employment probabilities over and above other groups. The variable 'youth living with parents' shows a significant but small negative log-odds ratio adjustment, indicating that the employment prospects of this group are slightly more sensitive to mean commute times than for other groups, as shown by the odds-ratio of 0.973.

Further, car commute shows a non-significant sign, from which we may infer that the different mode-based commute time measures used in the individual studies do not explain differences in employment prospects. Since the studies did not adequately address transport endogeneity (i.e. using an IV approach) the results must be carefully interpreted.

4.4.3 Discussion of findings from the meta-analysis

In summary, the meta-regression models clearly demonstrate that car ownership significantly increases individual employment probabilities, in particular among groups with low levels of car access, such as welfare recipients. While car access for youth has no differential impact on employment over and above that of other (age) groups, access to multiple household cars does. The meta-regressions further showed that longer mean commute times are related to decreased individual employment probabilities. While young people in particular are more sensitive to the time and cost implications of longer commutes, our meta-regression models found no statistically significant variation between ethnic minority and white youth, as suggested in the literatures. The various job accessibility measures used in studies were found incompatible with each other and thus were unsuitable for a meta-regression.

While most studies were conducted in US metropolitan areas, evidence based on a limited number of studies suggests that similar patterns do hold in non-US metropolitan areas, but a larger evidence base is needed to establish a more robust relationship. It remains unclear, however, whether the same patterns would hold in smaller cities and towns outside the US-context where travel times and distances are shorter and/or where there has been less peripheral urbanization and decentralization. Furthermore, endogeneity could be a possible problem with the featured studies given they are all based on cross-sectional models, which are interpreted as estimating long run relationships involving potential land use change. Few studies adequately controlled for endogeneity; although longitudinal studies can help to tease out endogeneity these were necessarily excluded because the interpretation of coefficients from these models is incompatible with those used in our meta-regression models.

4.5 Concluding remarks: public policy implications

By systematically merging 93 empirical studies of the relationship between transport access and employment probability outcomes in different geographical context and synthesising the data through meta-analysis, this study establishes a positive association between transport access and employment probability outcomes. It identifies varying effects for four identified categories of transport measures (or combinations thereof): car ownership, public transport access, commute times, and job accessibility levels. While most studies have focused only on metropolitan areas, often within the US context, evidence based on a limited number of studies in the systematic review suggests that similar patterns *do hold* in less car-dependent European metropolitan environments. This association persists in studies that have controlled for endogeneity by using, for example, an instrumental variable approach (see e.g. (Raphael and Rice, 2002, Bastiaanssen et al., 2021a). Longitudinal datasets have also been used to tease out endogeneity (see e.g. (Gurley and Bruce, 2005, Blumenberg, 2008), thereby overcoming the difficulties of finding appropriate instruments, but many studies lack complete datasets between baseline and follow-up surveys to fully establish an exogenous relationship. A larger evidence base is further needed to establish a more robust relationship between transport access and employment outcomes, in particular for smaller cities and towns outside the US-context and with regard to public transport.

Based on 20 methodologically comparable studies included in our meta-analysis, our meta-regression models clearly demonstrate that car ownership significantly increases individual employment probabilities, in particular among welfare recipients. While car access for young people has no differential impact on their employment over and above that of other (age) groups, residing in multiple car household does. The meta-regressions also show that longer mean commute times are related to decreased employment prospects, with young people in particular being more sensitive to the time and cost implications of longer commutes. However, there is apparent contradiction with the Spatial Mismatch literature (Kain, 1968), because young ethnic minority populations as compared with young people do not demonstrate differential employment effects with respect to a given commute time. Our systematic review further suggests that higher levels of public transport and car accessibility to jobs increases employment probabilities, but more consistent job accessibility measures are needed to establish a robust relationship through meta-regression.

Since the employment outcomes of job seekers could hypothetically thus be improved by better access to transport resources overall, it is suggested from our study results that *targeted policy interventions* would be needed to achieve this outcome. This is particularly important for people without access to private vehicles, such as low-income households, younger and older non-drivers and in areas under-served by public transport, such as rural areas and peripheral and deprived urban areas (Cervero et al., 2002, Blumenberg and Pierce, 2014). Most notably non-car owners often cannot afford to personally improve their transport alternatives by purchasing cars, but small-scale vehicle donation initiatives in the US (e.g. (Lucas and Nicholson, 2003)) and 'Wheels to Work' programs in the UK (Lucas et al., 2009) have been demonstrated to help people gain employment. This also implies that job seekers may benefit from public transport strategies targeted at improving their access to jobs.

On the other hand, bringing new employment opportunities closer to unemployed people might also help over the longer term, but this is notoriously difficult to achieve, as many failed regeneration initiatives over the years have demonstrated. Increasing private or public transport supply also does not necessarily mean a direct and associated increase in employment probability outcomes. There are many other factors to consider outside of transport supply such as education and skills and type of employment opportunities that are largely absent from aggregate models. What is clearer from our analysis, however, is that certain categories of individuals who are without private transport and who also currently have poor levels of access to public transport will have their employment opportunities significantly constrained.

Acknowledgements

The authors thank the anonymous reviewers for their useful comments and suggestions.

5. Does better job accessibility help people gain employment? The role of public transport in Great Britain

Abstract

The combined decentralisation of many firms and services and increasing concentration of traditional public transport services in the main corridors of urban centres has made it more difficult for people to access jobs, in particular when residing outside these prime accessibility areas. This is the first national study within the context of Great Britain to examine whether better public transport job accessibility, modelled at the micro level of individuals, improves employment probabilities for people living in Great Britain. While previous studies have typically concentrated on US metropolitan areas, our study uses British national employment micro datasets to assess which urban and rural areas and population groups would benefit from better public transport services. In an important departure from most standard accessibility methodologies, we computed a public transport job accessibility measure applied nation-wide and combined this with individual-level employment probability models for Great Britain. The models were corrected for endogeneity by applying an instrumental variable approach. The study finds that better public transport job accessibility improves individual employment probabilities, in particular in metropolitan areas and smaller cities and towns with lower car ownership rates and in low-income neighbourhoods. It further shows that mainly lower educated groups and young people would benefit most from better public transport job accessibility. The findings in this study are important for policymakers in that they imply that, in particular, job seekers who rely on public transport services may benefit from more targeted public policies to improve their accessibility to employment and thereby their social mobility.

Keywords: public transport, accessibility, employment, job seekers, Great Britain

5.1 Introduction

In recent decades, the need to travel in Great Britain[16], as in many other western countries, has increased as many firms and public services became organised in larger units in decentralised locations, partly in response to a society that has become increasingly organised around and dependent upon privately-owned motor vehicles (Turok and Edge, 1999, Houston, 2005). Alongside the decentralisation of employment and individualisation of the passenger transport domain, traditional public transport services have been increasingly concentrated along the main corridors of urban centres due to a combination of cost-efficiency measures to increase the profitability of their delivery and economic austerity measures that have reduced their public subsidy in many cities (CompetitionCommission, 2011, Lucas, 2012).

At least since the 1960s, scholars in urban economics and sociology have discussed the economic consequences of poor job accessibility for workers without access to private cars (e.g. (Kain, 1968, Wachs and Kumagai, 1973). A large body of studies in US metropolitan areas and, more recently, in some EU cities have since identified lack of car access and inadequate public transport services as an important barrier for accessibility to, and uptake of, employment, particularly in more car-dependent metropolitan areas (e.g. (Cervero et al., 2002, Sanchez et al., 2004, Korsu and Wenglenski, 2010, Kawabata, 2003, Matas et al., 2010).

Since the early 2000s, various studies in Great Britain have also shown that for job many seekers who do not have access to private cars, their reliance on public transport makes it more difficult to access jobs, in particular when residing outside of the main public transport corridors and city centres (e.g. (McQuaid et al., 2001, Patacchini and Zenou, 2005, SEU, 2003, JRF, 2018). Unlike most European countries, where public transport provision is organized through competitively tendered networks, outside of London, all public transport has been deregulated based on commercially operated routes. It receives only partial public subsidy for some socially necessary routes, which has resulted in large variations in public transport service delivery and ridership levels across different parts of the UK. For example, over half of London’s commuters use public transport, while this is only 10%-15% in other British metropolitan areas (DfT, 2017). Both low and high income groups use these public transport services, but low income groups rely 2.5 times more on local buses (for 83% of their trips) than on rail services, which are mostly used by middle- and higher income groups. Especially in rural areas and the poorest neighbourhoods on the periphery of British towns and cities people who rely on local public

[16] The paper refers to Great Britain throughout because the study is of England, Wales and Scotland and does not include Northern Ireland due to an absence of comparable data.

transport services are sometimes cut-off from job opportunities (Dobbs, 2005, Rae et al., 2016, Curl et al., 2017).

To address these accessibility problems, between 2006 and 2011 local transport authorities were required to undertake accessibility assessments as part of their Local Transport Plans (LTPs). The UK Department for Transport (DfT) publishes annually updated indices of reachable employment centres (and other key activity destinations), by various modes and journey times, and at the small local area geographical scale (DfT, 2018). These accessibility assessments are no longer statutory requirement for LTPs, however, our own analyses of these job accessibility indices (Lucas et al., 2019b) found that only half of the employment centres could be reached within 45 minutes by public transport as compared to the same trips by car, which is likely to decrease the job prospects of those reliant on public transport services. A recent study by (Johnson et al., 2017) further showed positive effects of shorter bus travel times to employment areas on aggregate employment levels in England.

To date, however, the assumed relationship between better public transport job accessibility and individual employment probabilities has not been established for Great Britain. This is the first micro-based study at the national level in Great Britain to examine whether better access to jobs by public transport helps people to secure a job, and it identifies which urban and rural areas and population groups would benefit from this.

Previous studies in US metropolitan areas and in some EU cities, have found that better job accessibility improved employment outcomes, within the context of an increasing spatial mismatch between jobs and workers in areas of deprivation of large cities (see Bastiaanssen et al., 2020 for discussion). It is unclear whether the same patterns would hold in the context of British metropolitan areas or in smaller cities and towns where travel times and distances are shorter and/or where dislocation from employment areas is less pronounced (see Ihlanfeldt (1992) for a further discussion of this).

In this study, we have developed a public transport job accessibility measure based on the widely used gravity model that can be applied nationwide and at the very micro spatial level of Lower Layer Super Output Areas (Census administrative areas, each with approximately 600 households), using detailed public transport timetable data and employment micro datasets. We then combined our public transport job accessibility measure with a national individual-level employment dataset, so that each individual in the dataset is allocated a unique job accessibility level from his or her area of residence. Next, we corrected for potential endogeneity between public transport job accessibility and employment outcomes by applying an instrumental variable approach (see third section). We then estimated the impact of public transport job accessibility on individual employment probabilities in a locally specific, national employment model for Great Britain and for various geographical area types and population groups. These findings add to the empirical evidence base of the linkage between public transport job accessibility and employment outcomes, which help to inform more targeted transport strategies.

5.2 Literature review: public transport job accessibility and individual employment outcomes

Much of the early literature on the relationship between job accessibility and individual employment Much of the early literature on the relationship between job accessibility and individual employment outcomes was linked to the Spatial Mismatch Hypothesis, which stated that poor access to job opportunities was a major factor in inner-city unemployment in US metropolitan areas ((Kain, 1968). This accessibility problem emerged because of the decentralization of jobs from these inner city areas as a result of changing industrial structures (Wilson, 1987), combined with processes of residential segregation, partly due to discrimination in the housing markets.

While a limited supply of public transport has been found to decrease job chances in US metropolitan areas and more recently in some EU cities (Ihlanfeldt and Sjoquist, 1998, Gobillon et al., 2007), this relationship is not conclusive or consistently proven in various studies. In their meta-analysis of existing empirical studies, Bastiaanssen et al. (2020) established that these mixed empirical results mainly resulted from differences in datasets, metrics and methodologies across the different studies. It also potentially resulted from endogeneity between job accessibility and employment outcomes in the models used, whereby high levels of job accessibility are likely to increase employment probabilities, but employment may also facilitate residing in neighbourhoods with good job accessibility, which is often not controlled for in earlier studies (Dujardin et al., 2008, Aslund, 2009). Some recent studies have also focused on job accessibility in the Global South (e.g. (Quintanar, 2012, Chen et al., 2017), but this is outside the scope of this paper because of the considerable contextual differences in the public transport operating systems of these countries. As such, we consider below only the empirical evidence from research undertaken in the Global North context to inform our own study strategy.

In two US studies in the car-dominated metropolitan areas of Los Angeles and San Francisco (Kawabata, 2002, Kawabata, 2003), a positive association was found between higher ratios of public transport-to-car job accessibility and the individual employment probabilities of carless workers, while higher poverty rates decreased job probabilities. However, these effects were less significant in the more public transport-oriented Boston Metropolitan Area. A study in Houston, Texas, (Yi (2006) also found a positive association between better bus job accessibility and increased individual employment probabilities, especially among public transport captives, but residential segregation was not controlled for. Smart and Klein (2015), on the other hand, found that both a higher public transport job accessibility and a higher poverty rate increased unemployment probabilities of poor and low-skilled groups across the US, while a higher number of household cars related to decreased unemployment. However, none of these studies controlled for endogeneity.

Blumenberg and Pierce (2014) sampled low-income households on housing assistance to control for endogeneity but only found a positive association between public transport job accessibility and job retention, not with employment probabilities, while the poverty rate was non-significant. A study by Thompson (2001) in Dade County, Florida, used various instrumental variables for public transport job accessibility but found non-significance for male labour force participation and even a small negative association for female labour force participation. Both studies did find a positive effect for car access on employment.

Two further US studies used longitudinal data of (involuntarily) laid-off workers, as their residential location can be considered exogenous to their employment status, and did find that better public transport job accessibility was associated with shorter unemployment durations while a higher poverty rate decreased job uptake (Rogers, 1997, Andersson et al., 2018). Other studies utilizing longitudinal welfare data found that higher public transport job accessibility sometimes increased welfare-to-work transitions and decreased welfare usage (Alam, 2009, Sandoval et al., 2011), or increased job retention (Thakuriah and Metaxatos, 2000). On the other hand, some studies found no significant effect (Bania et al., 2003, Cervero and Tsai, 2003, Sanchez et al., 2004), or even showed a negative association (Cervero et al., 2002, Shen and Sanchez, 2005, Blumenberg and Pierce, 2017). However, the models often did not register job accessibility levels between baseline and follow-up surveys, or calculated them for one year only, and residential segregation was often not controlled for, which makes the employment effects uncertain.

More recently, some studies have turned their attention to the European urban context, which generally has less peripheral urbanization and greater reliance on public transport services compared to US metropolitan areas. Three studies reduced endogeneity by sampling only long-term residents (>10 years), thereby overcoming the difficulties of finding appropriate instrumental variables. Korsu and Wenglenski (2010) found that both poor public transport job accessibility and living in poor neighbourhoods with many unemployed increased the long-term unemployment probabilities of low-skilled workers in the Paris metropolitan area, but found no effects for residing in medium or high accessibility neighbourhoods. Two studies in the Barcelona and Madrid metropolitan areas also found that more jobs reachable per minute by public transport and a higher number of cars in the household was associated with increased employment probabilities. In particular, low-educated women (Matas et al., 2010) and young women living with their parents were most significantly affected (Di Paolo et al., 2014), while a higher degree of residential segregation tended to decrease their job probability. Other longitudinal studies in the Paris metropolitan area found that neighbourhood segregation prevented unemployed workers from finding a job, while better public transport job accessibility only yielded a small association with shorter unemployment durations (Gobillon et al., 2011), or had no association with yearly unemployment-to-work transitions of public housing tenants (Gobillon and Selod (2007).

While residential segregation, thus, tends to decrease job probabilities, better public transport job accessibility mainly has differential employment effects in car-dominated metropolitan areas and among non-car owners. However, studies have often not adequately controlled for endogeneity in the relationship between public transport job accessibility and individual employment probabilities, which may bias the results and/or reduce the significance of the relationship. While most studies have concentrated on mainly US metropolitan areas, it also remains unclear whether this relationship would hold in metropolitan areas in Great Britain and in smaller cities and towns. In our current study, we therefore use national individual-level employment datasets to assess the effect of public transport job accessibility in different area types and for various population groups, while controlling for endogeneity by applying an instrumental variable approach.

5.3 Data and methods

In this section of the paper, we first present in section 5.3.1 the calculation of our public transport job accessibility model. In section 5.3.2, we next describe the combination of our job accessibility measure with a cross-sectional employment micro dataset for Great Britain, including controls for endogeneity in section 5.3.3.

5.3.1 Public transport job accessibility model

We first calculated a bespoke location-based public transport job accessibility measure for Great Britain that could be consistently applied nation-wide, based on the widely used gravity model (Hansen, 1959) in order to discount jobs through an impedance function based on travel time. Although such job accessibility indices abound in the literature, our study used employment micro datasets accessed by special permission from the Office for National Statistics. We subsequently matched this dataset with public transport travel time datasets under Secure Lab conditions to calculate a detailed public transport job accessibility model for each 2011 Census Lower Super Output Area (LSOA), which are small area Census tracts of about 600 households (ONS, 2011) in England, Wales and Scotland (in total 41,729 LSOAs in Great Britain). We excluded Northern Ireland from our analysis, as public transport datasets were not available.

Although the DfT (2018) annually provides readily available accessibility indices for England these are not available for Wales and Scotland. Since the DfT indices are based on reachable employment centres (ranking from 1-10) within certain travel time thresholds, they lack information about individual jobs outside these thresholds and neglect the decreasing attractiveness of jobs with increasing travel time and costs.

The standard gravity-based accessibility formula is implemented, which consists of three elements: the number of employment opportunities (jobs) at any location (postcode area), the travel time between every origin-destination (employment) location, and the associated distance decay function for public transport by region in Great Britain and urban/rural area. The gravity-based accessibility measure is expressed as follows:

$$(1)\ A_i = \sum_j E_j f(t_{ij})$$

Where A_i is the level of public transport job accessibility in LSOA area *i*; E_j reflects the number of employment opportunities (jobs) in destination LSOAs *j* reachable from LSOA *i*; t_{ij} is the travel time by public transport between *i* and *j*; and $f(t_{ij})$ represents the distance decay function of travel time between area *i* and area *j*.

Public transport job accessibility was estimated using a general transit feed specification (GTFS) dataset in the TRACC© software package to compute optimal routing algorithms for journeys between population-weighted centroids of LSOAs in the morning peak hours (6:00 – 9:00 am) when most people in Britain travel to work. The metric includes walking access time to a bus stop/ rail station through the road network, waiting time at the stop or station, in-vehicle travel time, transfer time, and walking egress times to the final destination (employment location).

The General Transit Feed Specification (GTFS) data were derived from Traveline National Dataset (TNDS) for the first quarter of 2017, which provided a quarterly snapshot of timetable-based public transport journey times from all National Public Transport Access Nodes (NaPTAN) in Great Britain. The Edina Integrated Transport Network (ITN) and Urban Paths layer 2018 further provided a fully topologically structured link-and-node network representing the roads network and pedestrianised streets and paths of Great Britain. Since we did not have access to congestion data to represent travel times on the road network, a car job accessibility measure could not be estimated in our study.

Employment opportunities were calculated at LSOA level based on microdata from the UK Business Structure Database (BSD) 2016 (ONS, 2019), which contains a yearly updated register of businesses in the UK covering approximately 99% of all economic activity including temporary work (Statistics, 2018). The BSD provides information on each business' employment and postcodes, which we aggregated to LSOA-level. The availability of this micro dataset for all Great Britain is essential to avoid administrative boundary effects (Grengs et al., 2010). While job vacancies by occupational classes would best reflect actual job openings available to job seekers, this data is not available for the UK. Instead, we used the number of jobs as a proxy for vacancies, since areas with a higher number of jobs also tend to generate a larger number of vacancies (Rogers, 1997).

In the accessibility literature, various distance decay functions of travel time are used, such as exponential and power specifications, inverse-potential and logistic functions (Geurs and van Wee, 2004, Merlin, 2017). While this yields different impacts on the job accessibility measure, the generated spatial patterns can be very similar (Kwan, 1998). We applied and estimated the model fit of the negative-exponential and logistic decay functions using observed banded trip travel times of public transport commuters in Great Britain for the period 2006 through 2016 from the UK National Travel Survey (DfT, 2019). A log-normal formulation was empirically derived as the best-fit solution with the observed data, which is expressed as follows:

$$(2)\ f(t_{ij}) = \frac{exp\left(-\frac{1}{2}(\frac{ln\,x-\mu}{\sigma})^2\right)}{x\sigma\sqrt{2\pi}}$$

where t_{ij} is the travel time between *i* and *j*, and *ln x* is the natural log of the mid-point of the banded public transport travel times, and μ and σ are parameters to be estimated. We estimated the decay functions for each of the seven English regions and for Wales and Scotland. People residing in less densely populated peripheral and rural regions typically commute over longer distances due to the paucity of nearby jobs, while trips made in urban regions are relatively short. To account for this, we further distinguished the decay functions between commute times in London boroughs, urban areas (major and minor conurbations to median urban areas), and rural areas (small/ medium urban to rural areas), based on the 2011 Urban Rural Classification for England and Wales (DEFRA, 2011) and for Scotland (SG, 2011).

5.3.2 Employment probability model

In the second stage of the methodology, and in an important departure from most standard accessibility methodologies, we combined our public transport job accessibility measure with a cross-sectional national employment micro dataset for Great Britain, to examine whether better public transport job accessibility increases *individual* employment probabilities, and which urban and rural areas and population groups would benefit from this. The usage of individual-level employment microdata allowed us to allocate each individual in the dataset a measure of public transport accessibility to employment opportunities from their area of residence, while controlling for personal and local characteristics that may contribute to employment differentials.

Following previous studies (e.g. (Matas et al., 2010, Di Paolo et al., 2014) we employed binomial probit models to explain the relationship between public transport job accessibility and individual employment probabilities, which is expressed as follows:

$$(3)\ EP_i = f(A_i, I_i, N_i)$$

where EP_i represents the employment probability for individual *i* (1 = employed, 0 = unemployed) as a function of: A_i representing the local accessibility levels for individual *i*; I_i are individual and household characteristics for individual *i*; and N_i represent neighbourhood characteristics for individual *i*.

The dependent variable and all individual and household explanatory variables were constructed from the first quarter of the UK Labour Force Survey (LFS) of 2016 (ONS, 2018), which was accessed by special permission from the Office for National Statistics. These were subsequently matched to each local area accessibility measures records using STATA 15 under Secure Lab conditions (as described in 5.3.1). The LFS micro dataset consists of a quarterly sample survey that covers approximately 80,000 individuals aged 16 and over and provides information on current employment and detailed personal and household characteristics, including the LSOA code of residence of each individual, but exclusive of information on individual vehicle ownership. Since we are interested in the employment status of individuals, we excluded students and individuals outside the labour force (i.e. economically inactive individuals) from our dataset, resulting in a total of 44,351 individual records. This is a clear distinction from prior studies that typically used samples of employed versus not employed (as opposed to unemployed) from Census datasets: as a large proportion of economically inactive individuals are out of employment for other reasons other than employment availability, they would not be in a position to respond to changes in job accessibility, whereas those classed as unemployed are registered as willing and able to enter employment. As the LFS includes population weights, our employment model further allows estimates of employment rates for Great Britain.

Table 5.1 shows the individual and household variables that were included as dummy or continuous variables in all models. Age is expected to increase individual employment probabilities, as youth unemployment is relatively high in Great Britain. This age effect is assumed to diminish with each additional year as reflected by the age-squared variable, which we divided by 100 to normalise coefficients. The employment prospects of women are typically lower than men, due to a larger share of part-time work and domestic tasks within the female population, whilst being lower educated or part of an ethnic minority is attached to less marketable employment skills and higher overall job competition. The number of dependent children (aged < 15) in the household is further expected to reduce employment prospects due to increased caring responsibilities and we assess the differential effects of being a single household or single parent household, which are likely to increase household responsibilities and financial constraints whilst limiting the social network that can be used for job search.

As a measure of residential segregation, we further constructed a neighbourhood variable based on the percent unemployed (excluding students) in each LSOA area, as adverse social effects and increased job competition are expected to decrease employment prospects, while public transport services in these areas may be limited. We further included our public transport job accessibility measure, which was matched to each individuals' LSOA code of residence and divided by 1,000,000 to normalise the coefficients. Both the neighbourhood and accessibility variables are included as continuous variables in the model.

Table 5.1 Descriptive statistics and expected effects of employment models

Variables	Continuous or dummy measure	Mean (SD)		Expected effects
		Base model	>30%non-vehicle households	
Dependent variable				
Employed (1); unemployed (0)	*(dummy)*	0.950 (0.219)	0.922 (0.269)	
Individual & Household variables				
Age	*(continuous)*	41.002 (13.624)	38.209 (12.953)	**+**
Age squared /100	*(continuous)*	18.667 (11.632)	16.277 (10.732)	**-**
Female	*(dummy)*	0.467 (0.499)	0.459 (0.498)	**-**
Low educated	*(dummy)*	0.140 (0.347)	0.188 (0.391)	**-**
Non-white ethnicity	*(dummy)*	0.117 (0.324)	0.212 (0.409)	**-**
Young children < age 15	*(continuous)*	0.613 (0.936)	0.601 (0.964)	**-**
Single household	*(dummy)*	0.103 (0.304)	0.138 (0.345)	**-**
Single parent household	*(dummy)*	0.103 (0.304)	0.137 (0.343)	**-**
Neighbourhood & accessibility variables				
Percent unemployed (excl. students)	*(continuous)*	0.066 (0.041)	0.105 (0.046)	**-**
Public transport job accessibility/ 1,000,000	*(continuous)*	0.385 (0.804)	0.853 (1.209)	**+**
N		44,351	13,578	

Source: 2016 QLFS, ONS

While the LFS does not register individual vehicle ownership, which is endogenous to employment status, analysis of the English National Travel Survey (Mackie et al., 2012) found that 70% of the people with no car available use the bus or other public transport frequently, compared with 20% of those with a car[17]. We therefore also estimate models based on a sub-sample of individuals residing in neighbourhoods (LSOAs) with ≥ 15% and ≥ 30% non-vehicle households to assess the differential employment effects of public transport job accessibility.

5.3.3 Endogeneity and instrumental variables

As noted earlier in the literature review, we needed to ensure that we had adequately controlled for endogeneity in the model in terms of the relationship between public transport job accessibility and individual employment probabilities. The recommended ways to control for endogeneity are to use random natural shocks (Tyndall, 2017) or policy induced 'quasi-random' changes in job accessibility (Blumenberg and Pierce, 2017). Since both these approaches are not possible due to the cross-sectional nature of our datasets, we applied an instrumental variable (IV) approach.

The application of an IV-approach requires the use of an instrument (i.e. another variable) highly correlated with the endogenous explanatory variable it is instrumenting (i.e. public transport job accessibility) but that has a very low correlation with the residual error from the second stage regression (on employment probabilities). Our instrument is thus to be correlated with employment only through its correlation with job accessibility.

Following previous studies (Thompson, 2001, Hu and Giuliano, 2017), we created an instrumental variable based on population densities (population per hectare) in all LSOAs: the Pearson correlation coefficient between population densities and public transport job accessibility levels is statistically significant and strong at 0.61 while the correlation between population densities and individual employment status is weak and insignificant. We also experimented with instruments used by Hu (2016) based on the percentage of non-vehicle owners in each LSOA, as this may be higher in urban areas with more extensive public transport systems, but these proved insignificant.

To assess the impact of public transport job accessibility on individual employment probabilities, the employment models with IV-approach were estimated in two stages (see Supplemental Appendix Table I for the base model). In the first stage model, accessibility Ai was estimated as a function of all individual and household variables Ii and the neighbourhood variable Ni plus our instrumental variable population density. The first-stage results demonstrate that our instrument population density was a strong and highly significant predictor of public transport job accessibility (Table 11.2 for the base-model).

[17] On average 26% of all households on LSOA level in Great Britain have no access to a car or van.

To test for weak instruments, we report the Kleibergen-Paap under-identification test, which tests the null hypothesis that our instrument has insufficient explanatory power to predict our endogenous variable (i.e. public transport job accessibility) in the model for identification of the parameters.

In the second stage model, employment is estimated as a function of all I_i and N_i variables plus the predicted value of accessibility, A_i, from the first stage regression. In this way, the impact of job accessibility is purged of endogeneity bias. The Wald Chi-Squared statistics for each model indicated whether we could reject the null hypothesis of exogeneity (P value <0.05) and reported the estimates from the two-stage model, which use the estimated job accessibility from the first-stage model.

For the models with insignificant Wald Chi-Squared statistics, we did not reject the null hypothesis of exogeneity for explanatory variables and thus reported the estimates from the single stage model without instrumental variable. Since the latter does not imply that job accessibility is exogenous in these areas, but rather that there is not enough evidence in the samples against the hypothesis, we estimated all equations under the null hypothesis (single-stage model) and the alternative hypothesis (IV model) in order to compare the results (see Table 11.3).

5.4 Results and discussion

In this section of the paper, we report and discuss the results of our models and their implications for employment probabilities. We compare the base-models for Great Britain with and without IV-approach in the appendix (Table 11.2), which show that the job accessibility coefficients increased in absolute value when using the IV-approach, suggesting that they are biased downwards in the single-stage probit model, i.e. that job accessibility is lower in higher areas of unemployment. In the first-stage regression, our instrument yields a significant Kleibergen-Paap F-statistic of 4552.66***, which is larger than the critical values in the Weak Identification F test, and so we reject the null-hypothesis that our instrument is weak.

Where the predicted values of accessibility in the second stage (i.e. our instrument) are insignificant, the Wald Chi-Squared statistics always indicated that we could not reject exogeneity, i.e. that there is enough evidence in the samples against the hypothesis. However, wherever we have a significant instrumented accessibility measure (e.g. for the base model and sub-models of urban areas, low-income neighbourhoods, young people and low educated people), we find consistent evidence of endogeneity. In the models where the predicted accessibility coefficients were not significant, the single-stage probit model coefficients on accessibility (i.e. without instrumental variable) were also insignificant. It thus seems to be consistent that where accessibility is an important determinant of employment, it is also endogenous. It makes sense to find no evidence of endogeneity if accessibility was not significant in the single-stage model.

As most previous accessibility studies have focused solely on metropolitan areas, and most often in the US context, we first examine whether the same probability patterns hold for a range of different area types in Great Britain. We follow a strategy applied by Johnson et al. (2017) and present in Table 5.2 employment models based on the official 2011 Rural-Urban Classification for England and Wales (DEFRA, 2011) and for Scotland (SG, 2011): London; Urban areas (≥10,000 residents); and Rural areas (<10,000 residents).

We reported all equations under the null hypothesis (Probit model) and the alternative hypothesis (IV Probit model) in order to compare the results, which clearly show that similar patterns between the different equations hold. From the resulting Wald Chi-Squared statistics for the model for Urban Areas, we reject the null hypothesis of exogeneity and use the estimates from the two-stage model which use the predicted value of accessibility from the first stage model. For the models for London and Rural Areas we did not reject the null hypothesis of exogeneity for explanatory variables and thus use the estimates from the single stage probit model without instrumental variable. We expect smaller issues with exogeneity in London as people are generally more dependent on public transport (for 53% of their commutes, (DfT, 2017), while job accessibility in rural areas may simply be too low to yield differential employment effects.

Among the individual variables, a higher age improves individual employment probabilities, which may be explained by the larger share of young people that are unemployed: on average, the employed are aged well over 41 while the unemployed are aged just below 35. Their relative lack of work experience in comparison with other age groups, in combination with competition from other more experienced job seekers, may make it more difficult for young people to find employment. This age effect diminishes with each additional year of age, as indicated by the negative coefficient for age squared.

Being female is only a significant factor for Urban Areas and slightly increases employment probabilities, which seems to follow from their higher inclusion in the labour market (53% of unemployed are men). Being low educated decreases employment prospects, which is typically attached to less marketable employment skills and higher overall job competition, while the non-white population often have lower employment prospects due to discrimination or residential segregation.

Table 5.2 Individual employment probabilities by Rural-Urban Classification

Variables	**Coefficients (SE)**						**Elasticities: +10% accessibility**
	London		**Urban areas**		**Rural areas**		
	Probit	IVprobit	Probit	IVprobit	Probit	IVprobit	
Dependent variable							
Employed (1); unemployed (0)							
Individual & Household variables							
Age	0.109*** (0.014)	0.109*** (0.014)	0.085*** (0.006)	0.082*** (0.006)	0.063*** (0.009)	0.061*** (0.009)	
Age squared/100	-0.118*** (0.016)	-0.118*** (0.016)	-0.086*** (0.007)	-0.083*** (0.007)	-0.053*** (0.010)	-0.053*** (0.010)	
Female	-0.047 (0.066)	-0.046 (0.066)	0.089*** (0.027)	0.088*** (0.027)	-0.175 (0.053)	-0.021 (0.052)	
Low educated	-0.090 (0.085)	-0.087 (0.085)	-0.342*** (0.033)	-0.328*** (0.034)	-0.184* (0.077)	-0.192* (0.076)	
Non-white	-0.447*** (0.068)	-0.445*** (0.068)	-0.219*** (0.042)	-0.310*** (0.054)	0.042 (0.214)	0.128 (0.219)	
Young children (< age 15)	-0.088** (0.034)	-0.086* (0.034)	-0.041** (0.015)	-0.032* (0.015)	0.018 (0.034)	0.024 (0.033)	
Single household	-0.286** (0.105)	-0.292** (0.105)	-0.413*** (0.041)	-0.414*** (0.041)	-0.388*** (0.083)	-0.359*** (0.083)	
Single parent household	-0.345*** (0.084)	-0.345*** (0.084)	-0.440*** (0.037)	-0.423*** (0.038)	-0.492*** (0.078)	-0.461*** (0.079)	

Neighbourhood & Accessibility variables							
Percent unemployed (excl. students)	-2.003* (0.807)	-2.079* (0.813)	-3.683*** (0.272)	-4.134*** (0.308)	-3.156*** (0.910)	-3.064*** (0.909)	
Public transport job accessibility/ 1,000,000	-0.057* (0.024)		0.773 (0.086)		0.206 (0.367)		**-0.005**
Estimated public transport job accessibility/1,000,000		-0.042 (0.037)		1.154** (0.430)		-3.418 (2.082)	**0.013**
Constant	0.109 (0.277)	0.012 (0.281)	0.269* (0.108)	0.147 (0.118)	0.487** (0.183)	0.617*** (0.193)	
Wald Chi-Squared statistic	175.97***	175.24***	1080.91***	1137.96***	251.76***	235.73***	
Wald Chi-Squared statistic of exogeneity		0.22		6.35*		3.04	
Pseudo R2	0.1025		0.1022		0.0826		
N	5,111		29,963		9,277		
Mean public transport accessibility	*1,850,749*		*158,552.6*		*38,980.7*		
25th percentile	*591,868*		*70,803*		*5,911*		
75th percentile	*3,031,557*		*215,517*		*49,890*		
Mean employment rate %	*94.4%*		*94.7%*		*96.2%*		
Mean hh vehicle ownership %	*58.9%*		*75.2%*		*87.5%*		

Significance levels: *: 0.05%, **: 0.01%, ***: 0.001%

Of the household variables, having dependent children decreases employment prospects, in which case child-caring responsibilities and/or lack of suitable child-care may constrain access to employment. A more influential variable is whether a person is single or especially being a single parent household, which significantly decreases their employment prospects. Having a partner may relieve some household responsibilities and financial constraints, while potentially also providing a social network through which employment can be sought. The percentage unemployed in each neighbourhood (excluding students) further significantly decreases employment prospects, in particular in areas outside of London. Studies in other European cities (e.g. (Gobillon and Selod, 2007) suggest that this may result from higher job competition and adverse social effects.

Public transport job accessibility yields a significant and positive coefficient for Urban Areas, while there is a negative coefficient for London. We derived employment elasticities to show changes in individual employment probabilities based on a 10% increase in public transport job accessibility levels[18]. For Urban Areas a 10% increase in public transport job accessibility yields an employment elasticity of 0.013, which relates to a 0.13% increase in the employment rate. Whilst these employment elasticities seem relatively small, they imply that 29,000 people in Urban Areas move into employment based on this increases. The significant negative coefficient in the London model indicates that individual employment probabilities would decrease with increasing public transport job accessibility levels. While Londoners are more dependent on public transport, as also indicated by their lower neighbourhood household vehicle ownership rate (58.9%), their significantly higher mean job accessibility level in combination with the flat fare rate structure for public transport services in London may simply imply that there is no straightforward relationship between travel costs, job accessibility and employment prospects.

The higher levels of public transport job accessibility amongst the unemployed (2.1 million jobs) as compared to the employed (1.8 million jobs), resulting from the concentration of social housing in and around the centre of London, might also imply that residential heterogeneity is not adequately controlled for in these groups. In rural areas, the relatively high vehicle ownership rates (87.5%) seem to indicate that individuals are less dependent on public transport services, while job accessibility levels may be too low to yield differential effects to the relatively high employment rate of 96.2%).

While we lack information on individual vehicle ownership in this study, which is endogenous to employment status (see Bastiaanssen et al. 2020 for discussion), we may expect that people residing

[18] Employment elasticities were calculated for significant job accessibility coefficients using the model coefficients for the average individual, in which we increased the (estimated) public transport job accessibility levels by 10% while keeping all other variables constant.

in neighbourhoods where many households lack access to vehicles are more sensitive to changes in public transport job accessibility. We therefore narrowed our employment models to individuals residing in neighbourhoods with ≥ 15% and ≥ 30% non-vehicle households. For Great Britain as a whole, we find increasing employment elasticities of 0.003 and 0.006 for individuals residing in neighbourhoods with respectively over 15% and over 30% non-vehicle households, in response to a 10% increase in public transport job accessibility (Table 11.2 appendix).

When we narrow the area type models to ≥ 30% non-vehicle households, the employment elasticity for Urban Areas increases to 0.038, while this is now non-significant for London and for Rural Areas (Table 11.4 appendix). These results clearly show that individuals residing in urban areas with low car ownership rates could benefit from better public transport job accessibility, while this relationship is not straightforward in London without controlling for vehicle ownership.

5.4.1 The impact of public transport job accessibility by neighbourhood income level

Since individuals in poor neighbourhoods are typically more dependent on public transport, while these areas are often poorly served by traditional public transport services due to a combination of profitability and economic austerity measures, we conducted separate employment models using median neighbourhood (LSOA) household income levels as reported in the 2011 UK Experian Income dataset. In Table 5.3, we present our employment models in which we grouped our individuals based on their median neighbourhood income levels: low income (≤ £31,833) and high income (≥ £31,834).

From the resulting Wald Chi-Squared statistics of exogeneity we reject the null hypothesis of exogeneity for the low-income group and report the estimates from the two stage model which use the estimated job accessibility as an instrument from the first-stage model. For the high-income group, we were not able to reject the null hypothesis of exogeneity and thus report the estimates from the single-stage probit model[19]. Again, we find that the job accessibility coefficients increased in absolute value when using the IV-approach, implying that they are biased downwards in the single stage model.

The variables in all employment models demonstrate a significance in line with the findings in our previous models, with a positive association between increasing age and being employed, while all other variables show the expected negative impact on employment probabilities.

[19] We experimented with excluding London and rural areas from these models, but this yielded similar results with a slightly stronger impact of public transport job accessibility for the low income model.

Table 5.3 Individual employment probabilities by neighbourhood income level

Variables	**Coefficients (SE)**				**Elasticities: +10% accessibility**
	≤ £31,833		**≥ £31,834**		
	Probit	IVprobit	Probit	IVprobit	
Dependent variable					
Employed (1); unemployed (0)					
Individual & Household variables					
Age	0.078*** (0.007)	0.077*** (0.007)	0.087*** (0.006)	0.087*** (0.006)	
Age squared/100	-0.076*** (0.008)	-0.076*** (0.008)	-0.088*** (0.007)	-0.088*** (0.007)	
Female	0.091** (0.032)	0.089** (0.032)	0.010 (0.033)	0.011 (0.033)	
Low educated	-0.353*** (0.037)	-0.348*** (0.037)	-0.175*** (0.047)	-0.173*** (0.047)	
Non-white	-0.189*** (0.046)	-0.239*** (0.051)	-0.319*** (0.045)	-0.335*** (0.047)	
Young children (< age 15)	-0.040* (0.017)	-0.036* (0.018)	-0.042* (0.019)	-0.040* (0.019)	
Single household	-0.372*** (0.050)	-0.375*** (0.050)	-0.401*** (0.050)	-0.405*** (0.050)	
Single parent household	-0.472*** (0.040)	-0.477*** (0.040)	-0.390*** (0.049)	-0.389*** (0.049)	
Neighbourhood & Accessibility variables					
Percent unemployed (excl. students)	-2.927*** (0.344)	-3.252*** (0.362)	-3.973*** (0.449)	-4.140*** (0.464)	
Public transport job accessibility/ 1,000,000	0.052 (0.033)		-0.002 (0.018)		
Estimated public transport job accessibility/1,000,000		0.190** (0.066)		0.025 (0.027)	**0.004**
Constant	0.296* (0.128)	0.305* (0.128)	0.285* (0.123)	0.282* (0.123)	
Wald Chi-Squared statistic	687.45***	669.10***	626.91***	628.98***	
Wald Chi-Squared statistic of exogeneity		5.89*		1.74	

Pseudo R2	0.0894		0.0926		
N	18,553		25,798		
Mean public transport accessibility	*229,738.4*		*492,784.0*		
25th percentile	*38,682*		*48,154*		
75th percentile	*210,132*		*414,768*		
Mean employment rate %	*93.4%*		*96.4%*		
Mean hh vehicle ownership %	*68.4%*		*81.1%*		

Significance levels: *: 0.05%, **: 0.01%, ***: 0.001%

Public transport job accessibility levels again vary significantly for individuals residing in different neighbourhoods, with those in low income neighbourhoods more often residing in peripheral urban areas that are under-served by public transport services and therefore having much lower job access, while the lower mean vehicle ownership rates indicate that they are more reliant on public transport.

Public transport job accessibility is only significant for the low income group, with a 10% increase in public transport job accessibility yielding an employment elasticity of 0.004, which amounts to a 0.04% increase in the employment rate. Our accessibility measure is non-significant for individuals residing in high-income neighbourhoods, where public transport job accessibility levels and car ownership rates are much higher, while they are more often employed, so that variations in job accessibility may be less important for their employment prospects.

5.4.2 The impact of public transport job accessibility by age group and educational level

To further scrutinize the impact of public transport job accessibility on individual employment probabilities, we conducted subgroup analyses based on age groups (16-24, 25-34, 35-49, 50-64) and educational levels (low-, middle-, high educated), based on standard definitions in the LFS. In terms of age, public transport job accessibility is significant for young people aged 25-34 and for people aged 50-64, yielding employment elasticities of respectively 0.004 and 0.002 following a 10% increase in job accessibility (see Table 11.5 in the appendix).

The lower employment rates of both groups seem to be more sensitive to job accessibility changes, while the relatively low car ownership rate of 70.8% amongst young people may also indicate a higher dependency on public transport services. Public transport job accessibility is not significant for youth aged 16-24, for whom other factors such as lack of work experience or skills-mismatches may be more important than job accessibility, while they may also rely more on family and friends to drive them to jobs (see e.g. (Chatterjee et al., 2018). Rather than travel time, the British Youth Council (2012) further found that the costs of transport had a significant effect on job uptake, in particular amongst young people. For those aged 35-49, their higher employment rates may simply be less sensitive to job accessibility changes, while other factors such as skills-mismatches may be more important in their employment uptake.

When looking at education levels, public transport job accessibility only shows a significant positive impact for low-educated individuals, with a related employment elasticity of 0.006 based on a 10% increase in public transport job accessibility (see Table 11.6 in the appendix). Due to their lower employment rate of 91.5%, combined with a relatively strong negative effect of the percentage unemployed in their neighbourhood, low-educated individuals are likely to be more sensitive to changes in job accessibility levels. Public transport job accessibility is not significant for the middle- and highly-educated groups, for whom the higher car ownership levels may simply make them less dependent on public transport services.

5.5 Concluding remarks: public policy implications

In this first national British study to model public transport job accessibility at the micro-level of individuals, we empirically assessed whether better public transport access helps people to get a job and which urban and rural areas and population groups would benefit from this. To do this, we developed a bespoke, local-area public transport job accessibility measure using employment micro datasets, which could be applied nationwide. We combined this measure with a national individual-level employment dataset, which allowed us to allocate each individual with a unique measure of public transport job accessibility from their area of residence. Our employment models were further corrected for endogeneity by applying an instrumental variable approach, which showed that wherever accessibility was a significant determinant of employment, it was also endogenous.

Previously most of the spatial mismatch literature has been concentrated on the US and in the context of metropolitan areas. However, British cities and towns have also experienced the combined decentralisation of employment and concentration of traditional public transport services in the main corridors of urban centres over the past decades, making these employment locations increasingly difficult to access without a car. Our study supports recent evidence of the negative effect of poor job accessibility on employment outcomes in European metropolitan areas and smaller cities and towns (e.g. (Korsu and Wenglenski, 2010, Matas et al., 2010, Di Paolo et al., 2014), especially among people who rely on public transport.

Our empirical findings imply that providing better public transport job accessibility increases individual employment probabilities in Great Britain, but only in certain contexts. In particular, individuals residing in urban areas with low car ownership rates are found to benefit from higher levels of public transport job accessibility. However, our study could not control for individual car ownership and is, therefore, not a straightforward relationship, particularly for London, which may relate to the very high levels of public transit provision throughout the City and the flat fare structure for public transport services. In rural areas, higher employment and vehicle ownership rates make individuals less sensitive to public transport, while average public transport job accessibility levels were too low to yield differential employment effects. Our study further shows that public transport job accessibility levels are far lower in low income neighbourhoods, where an improvement would increase individual employment probabilities most. We further find that mainly low educated individuals and young people benefit from better public transport job accessibility, while other factors such as lack of work experience or skills-mismatches may be more important for other age groups and higher educated.

Our study findings are particularly important from a public policy and service operation point of view because they underline the need for public transport delivery strategies to be better targeted towards improving public transport services and subsidies in under-served neighbourhoods, such as peripheral and deprived urban areas, and among disadvantaged population groups without access to private vehicles, such as low-income households and younger people (see also (Cervero et al., 2002, Blumenberg and Pierce, 2014). From a social welfare policy perspective, our findings clearly imply that job seekers would benefit from tailored public transport services fitting with their demographic profiles and residential location, as discussed in Lucas et al. (2009). The importance of tailoring of policies in this way is also highlighted by the fact that we find public transport job accessibility is actually lower for those in low-income neighbourhoods.

When employment prospects of job seekers are influenced by public transport accessibility, as shown by the findings of this study, it can be argued that public intervention is necessary, as those who are dependent on public transport services often cannot personally increase their accessibility by purchasing cars, while ‘Wheels to Work’ programs in the UK (Lucas et al., 2009) have been demonstrated to help people gain employment. This also relates to the costs of (public) transport that can be a significant barrier for job uptake, in particular among lower income groups (Lucas, 2012) and youth (British Youth Council, 2012).

Acknowledgements

The authors would like to thank the UK West Yorkshire Combined Authority for their support of this research and the anonymous reviewers for their useful comments and suggestions. This work was based on micro datasets produced by the UK Office for National Statistics (ONS) and the ESRC and supplied by the Secure Data Service at the UK Data Archive.

6. Does better public transport-and-bicycle job accessibility and vehicle access increase employment probabilities? A study of the Netherlands

Abstract

This study examines if higher levels of job accessibility and vehicle access increase individual-level employment probabilities in the context of the Netherlands, as a follow-on study from Great Britain. While many jobs have been located to peripheral business parks near motorways, these locations are often under-served by traditional public transport services and difficult to reach by bicycle, thereby reducing job accessibility for people without private vehicles. The study combines a national individual-level employment micro dataset with a local-area public transport-and-bicycle job accessibility measure, national vehicle registration and household income datasets, which were missing in our previous British study. This allows us to examine the employment effects of job accessibility by public transport in combination with the bicycle, while controlling for vehicle ownership, for the population at large and for different geographical areas and population groups. The study finds that higher levels of public transport-and-bicycle job accessibility could improve individual employment probabilities in urban areas, while in rural areas vehicle ownership is a more important factor in driving employment outcomes. The study further identifies that, in the Dutch context, low-income groups as well as low-educated groups and most older age groups could benefit from higher public transport-and-bicycle job accessibility levels, whereas middle-educated groups and especially young people are sensitive to vehicle ownership. These findings are important for policymakers in that they imply that more tailored transport strategies may increase both the participation of people in society and the full utilization of the potential labour force.

Keywords: accessibility, employment, public transport-and-bicycle, car, the Netherlands

6.1 Introduction

This is the third in a trilogy of papers that examines the relationship between transport and employment probabilities. In a first paper (Bastiaanssen et al., 2020), we systematically reviewed the empirical evidence of the relationship between transport access and employment outcomes in different geographical context and synthesised this evidence through meta-analysis. It established a positive association between transport access and individual employment probabilities, but concluded that a larger evidence base for cities and towns outside the US-context and with regard to public transport was needed to establish a more robust relationship.

The second paper (Bastiaanssen et al., 2021a) was the first national study within the context of Great Britain to examine whether higher levels of public transport accessibility to jobs would improve individual employment probabilities. It found that in particular individuals residing in urban areas with low car ownership rates and in low-income neighbourhoods could benefit from improved public transport job accessibility. However, this relationship was not straightforward as the study lacked information on individual car ownership. It is in light of this concern, that this third paper examines the employment effects of public transport-and-bicycle job accessibility by public transport, while controlling for vehicle ownership.

In this study, and in a departure from our previous British research, we have combined a Dutch national employment micro dataset with a local-area public transport-and-bicycle job accessibility measure, national vehicle registration and household income datasets. Our job accessibility measure incorporates cycling to the train stations, as the bicycle is often used in combination with train commutes (KiM, 2016), and uses cycling travel times when these are shorter than public transport travel times. This allowed us to examine the employment effects of job accessibility by public transport in combination with the bicycle, while controlling for vehicle ownership, for the population at large and for different geographical area types and sociodemographic groups.

A Dutch focused study is particularly pertinent because the Netherlands has witnessed a strong decentralisation of employment in recent decades. The Netherlands Environmental Assessment Agency (PBL), found that between 2000 and 2010, nearly 60% of the employment growth in the Netherlands has taken place in peripheral business parks near motorways, especially for new office developments, while urban locations with good public transport access have experienced little or no job growth (PBL, 2014). As a result, access to jobs for vehicle owners is typically much higher than for those who rely on public transport or bicycles. This is not only due to higher door-to-door travel times but also because many of these peripheral job locations are located in places that are less well-served by traditional public transport services and difficult to access by bicycle; only 16% of all jobs in the Netherlands are located within close proximity of public transport stops (PBL, 2012).

The Dutch Scientific Council for Government Policy (WRR) and the Council for the Environment and Infrastructure (Rli) recently concluded that these inequalities in job accessibility may reduce both the economic and social participation of people in Dutch society and prevent the full utilization of the potential labour force (WRR, 2018, Rli, 2020). The Rli therefore advised the government to make 'access for all' the basic principle of transport policy, in which "the focus should be on ensuring that people have sufficient possibilities to reach key destinations" (Rli, 2020: 37).

To date, however, the assumed relationship between higher levels of job accessibility and increased employment probabilities has not been scientifically proven in the Netherlands. It is also uncertain whether the same patterns from our British study would hold in the Netherlands, as urban land uses are typically concentrated in compact cities and towns (Geurs and Ritsema van Eck, 2003), which typically have well-developed public transport and bicycle networks.

On average, 21% of all commutes in the Netherlands are made by bicycle (KiM, 2016), as compared to only 3% in Britain (DfT, 2017), and the bicycle is also used for 40% of all train journeys as an access mode to the main train stations in the Netherlands (KiM, 2016). Both low- and high-income groups cycle to work, for approximately 25% and 20% of their respective commutes. As in the British context, both groups also use public transport for commuting (just over 22% among high income and 20% for low income), but the low income typically rely on local buses and trams, whereas high income tend to rely more on train services. Unlike Britain or the US context, however, socio-economic segregation is generally much lower due to extensive income- and social housing policies, so that differences in access to jobs and amenities between poor and rich neighbourhoods are less substantive (PBL, 2010).

As such, this current study is the first to examine the relationship between job accessibility and individual employment probabilities in this rather different Dutch land use and transport context, using new micro datasets and an expanded modelling approach to our previous study for Great Britain (Bastiaanssen et al., 2021a). The combination of national employment microdata with a detailed public transport-and-bicycle job accessibility measure, national vehicle registration and household income datasets is unique to this study. While previous studies in mainly US metropolitan areas and in some EU cities (e.g. (Cervero et al., 2002, Sanchez et al., 2004, Matas et al., 2010) do provide information on individual car ownership in specific localised case studies, this is the first time to our knowledge that a national vehicle dataset is used in this way. In a departure from our previous GB study, which used neighbourhood income level data, we also use a matching national household income dataset to examine differential employment effects of job accessibility and vehicle ownership for low and high income groups. The study further uses an instrumental variable approach to control for potential endogeneity between job accessibility, vehicle ownership and individual employment probabilities.

6.2 Related literature on the role of public transport job accessibility and car access

The association between job accessibility and employment outcomes has received considerable attention in the academic literatures. As we have already reviewed the empirical evidence of the relationship between transport and employment outcomes more generally (see Bastiaanssen et al. (2020), here we focus more precisely on the findings of these previous studies in relation to the differential employment effects of public transport or car job accessibility and vehicle ownership.

A study by Parks (2004) in the car-oriented Los Angeles metropolitan area found that higher levels of car job accessibility decreased unemployment probabilities among some groups of low-skilled immigrant women, but car access often had a stronger employment effect. Smart and Klein (2015), however, found a negative association between public transport job accessibility levels and employment outcomes of low-income and low-educated individuals across the US, while car access improved employment probabilities. Yet, these studies did not control for endogeneity.

Other studies controlled for endogeneity through sampling low-income households in several US metropolitan areas (Blumenberg and Pierce, 2014, Blumenberg and Pierce, 2017) and showed that car access increased individual employment probabilities, while better public transport job accessibility was only positively related to maintaining employment, but not with employment probabilities. Thompson (2001) used an instrumental variable approach, finding that public transport job accessibility was non-significant for male employment outcomes and yielded a small negative association for female employment prospects, while household car ownership had a positive effect.

A large body of US studies further used longitudinal welfare data to control for endogeneity in the relationship between public transport job accessibility, car access and individual employment probabilities. A study by Alam (2009) in Broward County, Florida, found that higher levels of public transport job accessibility and car ownership decreased welfare duration, while Cervero et al. (2002) and Sandoval et al. (2011) found that higher levels of public transport job accessibility increased employment probabilities of welfare recipients in Alameda County, California, while this was non-significant in the car-dominated Los Angeles metropolitan area and in rural San Joaquin. Yet, (gaining) car access increased employment prospects in all areas. Other studies by Sanchez et al. (2004) and Shen and Sanchez (2005) in various US metropolitan areas found mixed employment effects of public transport job accessibility, while car access typically increased employment probabilities. Other studies among welfare recipients in California (Cervero and Tsai, 2003) and Cuyahoga County, Ohio (Bania et al., 2003, Bania et al., 2008) found no significant employment effects of public transport job accessibility, while car access did. What is clearer from these US studies is that car ownership tends to improve employment probabilities, whereas higher levels of public transport job accessibility are probably more important for those without cars.

More recent studies have turned their attention to less car-dependent European metropolitan contexts. Studies in the Barcelona and Madrid metropolitan areas found that higher levels of public transport job accessibility and especially a higher number of households cars increased employment probabilities of low-educated women (Matas et al., 2010) and youth living with their parents (Di Paolo et al., 2014). In our previous study in Great Britain (Bastiaanssen et al., 2021a), we used an IV approach to control for endogeneity and found that improved public transport job accessibility levels increased employment probabilities, in particular in urban areas with low car ownership rates and in low-income neighbourhoods, but car ownership was not controlled for due to an absence of data in this respect.

The empirical evidence from previous studies thus clearly indicates that better public transport or car job accessibility and especially car access can increase individual employment probabilities, particularly in more car-oriented metropolitan areas and among disadvantaged groups. It remains unclear, however, if similar patterns would hold in the Dutch national context with relatively compact cities and towns and an extensive use of the bicycle and public transport for daily commutes. In this study, we build on our previous GB study and combine a national individual-level employment micro dataset with a novel local-area public transport-and-bicycle job accessibility measure, national vehicle registration and household income datasets, which were missing in our previous study. This allows us to assess the employment effects of job accessibility by public transport in combination with the bicycle, while controlling for vehicle ownership, for the Dutch population at large and for different geographical areas and populations groups.

6.3 Data and methods

In this section of the paper, we describe in section 6.3.1 the calculation of our public transport-and-bicycle job accessibility measure. Section 6.3.2 discusses the combination of our job accessibility measure with an individual employment probability model for the Netherlands, national vehicle registration and household income datasets, followed by the datasets that we used (section 6.3.3), and how controls for endogeneity were included in the model (section 6.3.4).

6.3.1 Public transport-and-bicycle job accessibility measure

This study applies a bespoke local-area public transport-and-bicycle job accessibility measure, for which we follow a strategy similar to our previous GB study (see Bastiaanssen et al. (2021a) for a more detailed description). In brief, the standard gravity-based accessibility function was implemented, which can be expressed in equation 1 as follows:

$$(1)\ A_i = \sum_j E_j f(T_{ij})$$

where A_i is the level of job accessibility in PC4 neighbourhood *i*, for the morning peak hours (6:00-9:00 am); E_j reflects the number of employment opportunities (jobs) available in destination PC4 areas *j*, and $f(T_{ij})$ represents the distance decay function of travel time between area *i* and area *j*.

Different from our previous GB-study, our public transport-and-bicycle job accessibility measure incorporates cycling as a potential access mode to the main train stations if this is faster than walking or public transport, which is used for 40% of all train journeys from main train stations according to the Netherlands Institute for Transport Policy Analysis (KiM, 2016), and it uses cycling as an alternative for public transport when destinations up to 30 minutes away can be reached in less travel time. The travel time datasets were developed by Pritchard et al. (2019), based on a public transport general transit feed specification (GTFS) dataset in ArcGIS to compute optimal routing algorithms for journeys between all population weighted PC4s, including access and waiting time to and at a public transport stop/ station, in-vehicle travel time, transfer time, and egress times to the destination PC4 (jobs). The cycling speeds were calculated based on network geometry and variable average speeds for each segment of the Dutch cycling network.

We combined the travel time datasets with a national employment micro dataset for 2016 from the Landelijk Informatiesysteem Arbeidsplaatsen (LISA) database, which provided the total number of jobs in each PC4[20]. As in our GB study, data on job vacancies by occupational classes were not available so we used the total number of jobs as a proxy for employment opportunities.

In order to account for the decreasing attractiveness of distant jobs, the job accessibility measure was calculated based on the widely used gravity model (Hansen, 1959), in which employment opportunities are discounted through an impedance function based on travel time. The impedance function was estimated separately for urban and rural areas, based on a (best fit) log-logistic function

[20] Note that our job accessibility measures do not include employment opportunities in neighbouring countries as very few people work across the border: in 2012 only 17,000 workers living in the Netherlands had a job in Belgium or Germany, which is less than 0.3% of the Dutch working age population.

using observed trip travel times of commuters in the Dutch National Travel Survey (see Pritchard et al. (2019) for a more detailed description).

6.3.2 Employment probability models

In an important departure from our previous GB study (Bastiaanssen et al., 2021a), we combine a national cross-sectional employment micro dataset for the Netherlands with a national vehicle registration dataset to identify individuals with access to a household vehicle. We further allocated each individual in the dataset a unique measure of their level of public transport-and-bicycle job accessibility from their area of residence. This allowed us to examine the employment effects of job accessibility by public transport in combination with the bicycle, while controlling for vehicle ownership, for the population at large and for different geographical area types and population groups.

Following our previous study, we employed binomial probit models to explain the relationship between job accessibility levels and individual employment probabilities, which can be expressed in equation 2 as follows:

$$(2)\ EP_i = f(A_i, I_i, N_i, V_i)$$

where EP_i represents the employment probability for individual *i* (1 = employed, 0 = unemployed) as a function of: A_i representing the local job accessibility levels for individual *i*; I_i are individual and household characteristics for individual *i*; N_i are the neighbourhood characteristics for individual *i*; and v_i is household vehicle ownership by individual *i*.

The dependent variable and all individual and household explanatory variables were constructed from the Dutch Labour Force Survey (Enquête Beroepsbevolking, EBB) of 2016 (CBS, 2019), which was accessed remotely through a secure internet connection by special permission from Statistics Netherlands (CBS). The EBB micro dataset consists of a sample survey that annually covers approximately 395,000 individuals aged 15 and over and provides detailed information on current or past employment together along with detailed personal and household information. Since we are interested in the employment status of individuals, we excluded students and individuals outside the labour force (i.e. economically inactive individuals) from our dataset, resulting in a total of 176,876 individuals. As the EBB includes annual population weights, our employment model allows us to provide estimates of employment rates for the Netherlands.

Similar to our GB study, we constructed neighbourhood variables for all 4,071 four-digit postcode areas (PC4s) in the Netherlands (administrative areas with on average 1,900 households). As a measure of residential segregation, we constructed a neighbourhood variable based on the percent unemployed (excluding students) in each PC4 area, as increased job competition and adverse social effects are expected to decrease employment prospects.

We subsequently matched our public transport-and-bicycle job accessibility measure under Secure Lab conditions to each individuals' PC4 code of residence in our EBB dataset and divided these by 1,000,000 to normalise coefficients. Since the EBB does not provide information on the actual mode use for commutes by individuals, we assigned our job accessibility measure to all individuals in our sample. We further matched the EBB with a national vehicle registration dataset of 2016 from the Netherlands Vehicle Authority (RDW) to identify individuals with household access to a car or motorcycle. As this dataset only registers legal ownership of a vehicle, regardless of which household member uses the vehicle, we assigned each individual a dummy variable based on their access to a household vehicle.

6.3.3 Descriptive statistics

Table 6.1 shows the explanatory variables that are included as dummy or continuous variables in our employment models. In line with the Dutch labour force statistics (CBS, 2016), we expected age to increase individual employment probabilities as the unemployment rate in 2016 was highest (10.8%) among young people aged 15-29 and gradually decreases with increasing age (the average unemployment rate in The Netherlands was 6.6% in 2016). This age effect is assumed to diminish with each additional year as reflected by the age squared variable, which we divided by 100 to normalise coefficients.

Consistent with our GB study, employment prospects of women are likely to be lower than men, which follows from their relatively higher unemployment rates; in 2016 this was 6.5% for women compared to 5.6 % for men (CBS, 2016). Being lower educated or a non-Western migrant is also related to higher unemployment rates of respectively 9.8% and 13.2% (compared to 6.0% and 3.6% for middle- and higher educated, and 7.2% for Western migrants and 4.9% for Dutch-born), which is typically attached to less marketable employment skills and higher overall job competition.

The number of dependent children (aged < 12) in the household is further expected to reduce employment prospects due to increased caring responsibilities and we assess the differential effects of being a single household or single parent household, which are likely to increase financial constraints and decrease the size of the social networks that can be used for job search.

In contrast with our GB study, we also included a dummy variable for unemployment history (ever been unemployed since age 15), which is likely to lower employment prospects as it may make individuals less attractive for employers. We further hypothesise that higher levels of public transport-and-bicycle job accessibility and household vehicle access are related to increased individual employment probabilities.

Table 6.1 Descriptive statistics and expected effects of employment models

Variables	Continuous or dummy measure	Mean (SD)	Expected effects
Dependent variable			
Employed (1); unemployed (0)		0.934 (0.357)	
Individual & Household variables			
Age	*(continuous)*	41.159 (12.275)	+
Age squared/100	*(continuous)*	18.40 (10.081)	-
Female	*(dummy)*	0.460 (0.498)	-
Low educated	*(dummy)*	0.132 (0.338)	-
Non-Western migrant	*(dummy)*	0.084 (0.310)	-
Unemployment history	*(dummy)*	0.173 (0.381)	-
Young children < age 12	*(continuous)*	0.467 (0.821)	-
Single household	*(dummy)*	0.166 (0.370)	-
Single parent household	*(dummy)*	0.049 (0.216)	-
Neighbourhood & accessibility variables			
Percent unemployed (excl. students)	*(continuous)*	7.190 (5.735)	-
Public transport-and-bicycle job accessibility/1000000	*(continuous)*	0.206 (0.186)	+
Household vehicle	*(dummy)*	0.805 (0.402)	+
N		176.876	

Source: EBB 2016, CBS

6.3.4 Controlling for endogeneity

We applied an instrumental variable (IV) approach to control for endogeneity between job accessibility levels, vehicle ownership and individual employment probabilities (see Bastiaanssen et al. (2021a) for more on this). Following our previous GB study, we created an instrumental variable based on the population density in each PC4 (people/km2) as an instrument for public transport-and-bicycle job accessibility, of which the Pearson correlation coefficient was statistically significant and strong at 0.75 while this was weak and insignificant for individual employment status. As an instrument for household vehicle ownership we followed a previous study by Hu (2016) and created a variable based on the share of households without vehicles in each PC4. The Pearson correlation coefficient between household vehicle ownership and the share of households with vehicle access in each PC4 is 0.32 and significant, while the correlation coefficient between the share of households with vehicle access and individuals' employment status is insignificant. We also experimented with instruments based on car insurance premiums as applied by Raphael and Rice (2002) and with road infrastructure density, but these proved insignificant (see Table 11.7 in appendix).

To assess the impact of job accessibility and vehicle ownership on individual employment probabilities, each employment model estimated with the IV-approach was estimated in two stages. In the first stage model accessibility A_i and household vehicle access V_i were estimated as a function of all individual and household variables I_i and the neighbourhood variable N_i, plus our instrumental variables. In the second stage model, employment is estimated as a function of all I_i and N_i variables plus the predicted accessibility and vehicle ownership values, A_i and V_i, from the first stage regressions. The Wald Chi-Squared statistics of exogeneity for each employment model indicated whether we could reject the null hypothesis of exogeneity (P value <0.05) and report the estimates from the two-stage model, which uses the estimated public transport-and-bicycle job accessibility measure and household vehicle ownership from the first stage model. For the models with insignificant Wald Chi-Squared statistics, we did not reject the null hypothesis of exogeneity for explanatory variables and reported the estimates from the single stage model without instrumental variable. As before, we estimated all equations under the null hypothesis (single-stage model) and the alternative hypothesis (IV model) in order to compare the results (see Table 11.8 in appendix).

6.4 Results and discussion

In this section of the paper, we report the results of our employment models and compare these with the results of our previous GB study (Bastiaanssen et al., 2021a). While our GB study found that only individuals residing in urban areas would benefit from higher levels of public transport job accessibility, this relationship was not straightforward in London without controlling for individual car ownership. We therefore first examine whether similar patterns hold in urban and rural areas in the Netherlands. The base models with and without IV-approach for the Netherlands are provided in the Supplemental Appendix (Table 11.7), which again showed that our job accessibility and vehicle ownership coefficients increased in absolute value when applying the IV-approach, i.e. they are biased downwards in the single-stage probit model. In the first-stage regression, our instruments yielded a significant Kleibergen-Paap F-statistic of 64.11***, which is larger than the critical values in the Weak Identification F test, and so we reject the null-hypothesis that our instruments are weak. We also reported the Anderson-Rubin Wald F-statistic of 54.88***, which is >10 and therefore we can infer weak instrument robustness.

We follow the strategy applied in our previous GB study and present in Table 6.2 our employment models based on the Urban-Rural classification as distinguished by Statistics Netherlands: urban areas (≥1000 addresses per km2) and rural areas (≤999 addresses per km2). As before, we reported all equations under the null hypothesis of exogeneity (Probit model) and the alternative hypothesis (IV Probit model) in order to compare the results. From the resulting Wald Chi-Squared statistics for the employment model for urban areas, we reject the null hypothesis of exogeneity (i.e. job accessibility is found endogenous with employment) and use the estimates from the two-stage model which use the predicted values of accessibility from the first stage model. For the rural area model we did not reject the null hypothesis of exogeneity for explanatory variables and therefore use the estimates from the single stage probit model without instrumental variables. We expect smaller issues with endogeneity in rural areas, where job accessibility may simply be too low to yield differential effects on the relatively high employment rate.

In line with the Dutch labour force statistics reported above (CBS, 2016), among the individual variables, a higher age slightly improves individual employment probabilities, which may be explained by the larger share of young people that are unemployed. This effect diminishes with each additional year of age, as indicated by the negative coefficient for age squared/100. Being female also decreases employment probabilities, which seems to follow from their relatively higher unemployment rate (92.3%) as compared with men (94.4%).

Being lower educated or a non-Western immigrant also lowers individual employment probabilities, but particularly unemployment history decreases employment prospects. Having been unemployed in the past may make individuals less attractive for employers and is also related to lower levels of education amongst this group.

Of the household variables, having more dependent children is only significant in the urban area model, where it indicates to decrease employment prospects, in which case caring responsibilities tasks may constrain access to employment. In line with our GB study findings, being single or a single parent household decreases individual employment probabilities. Having a partner may relieve some financial constraints and potentially provides a social network through which employment opportunities can be sought, while single parent households are clearly more constrained in their job uptake.

The percentage unemployed in each neighbourhood also significantly decreases employment prospects in Urban and Rural areas, which may relate to higher levels of job competition and adverse social effects related to deprived neighbourhoods (see e.g. (Gobillon and Selod, 2007).

Table 6.2 Individual employment probabilities by urbanisation level

Variables	**Coefficients (SE)**				**Elasticities: +10% accessibility / Margin. effect veh**
	Urban areas		Rural areas		
	Probit	IV Probit	Probit	IV Probit	
Dependent variable					
Emp. (1); unemp. (0)					
Individual & Household variables					
Age	0.172*** (0.004)	0.165*** (0.012)	0.130*** (0.005)	0.128*** (0.048)	
Age squared/100	-0.203*** (0.004)	-0.196*** (0.013)	-0.154*** (0.006)	-0.150* (0.059)	
Female	-0.490*** (0.011)	-0.490*** (0.012)	-0.844*** (0.016)	-0.716 (0.511)	
Low educated	-0.242*** (0.017)	-0.221*** (0.031)	-0.312*** (0.020)	-0.336*** (0.055)	
Non-Western migrant	-0.220*** (0.019)	-0.226*** (0.021)	-0.186** (0.060)	-0.182* (0.083)	
Unemployment history	-0.340*** (0.014)	-0.331*** (0.023)	-0.321*** (0.020)	-0.297 (0.153)	
Young children (< age 12)	-0.041*** (0.008)	-0.044*** (0.011)	-0.007 (0.011)	-0.013 (0.013)	
Single household	-0.097*** (0.017)	-0.042* (0.102)	-0.023* (0.033)	-0.301* (0.599)	
Single parent household	-0.086*** (0.024)	-0.045* (0.075)	-0.034* (0.041)	-0.207* (0.307)	
Neighbourhood & accessibility variables					
Percent unemployed (excl. students)	-0.033*** (0.001)	-0.033*** (0.002)	-0.037*** (0.001)	-0.033 (0.021)	
Public transport-and-bicycle job accessibility/1,000,000	0.322*** (0.034)		**0.298** (0.112)**		**0.002**
Estimated public transport-and-bicycle job accessibility/ 1,000,000		**0.606* (0.256)**		-0.736 (1.561)	**0.017**
Household vehicle	0.310*** (0.014)		**0.166*** (0.026)**		**0.012**
Estimated Household vehicle		**0.553 (0.392)**		-1.617 (0.624)	
Constant	-1.821*** (0.068)	-1.967*** (0.186)	-0.711*** (0.093)	0.740 (2.844)	
Wald Chi-Squared statistic	7349.78***	7269.36***	4753.16***	6784.63***	
Wald Chi-Squared statistic of exogeneity		16.31***		1.27	
Pseudo R2	0.1229		0.1381		
N	112,217		62,440		
Mean PT-and-bicycle job accessibility	270,928		71,564		
Mean Household vehicle rate	76.2%		89.3%		
Mean employment rate	93.3%		95.0%		

*Significance levels: *: 0.05% **: 0.01% ***: 0.001%.*

Our public transport-and-bicycle job accessibility measure yields a significant and positive coefficient for urban areas and, while public transport job accessibility was non-significant in rural areas in Britain, we do find that our job accessibility measure is also significant in rural areas in the Netherlands. We derived employment elasticities to show changes in individual employment probabilities based on a 10% increase in job accessibility levels[21]. For urban areas, a 10% increase in public transport-and-bicycle job accessibility yields an employment elasticity of 0.017, which relates to a 0.17% increase in the employment rate. For rural areas, the employment elasticity is with 0.002 much lower, as their higher employment rates may make them less sensitive to job accessibility changes.

Household vehicle ownership in non-significant in urban areas, while it is significant in rural areas in the Netherlands. We derived marginal effects of vehicle ownership on employment[22], which showed that the uplift on employment probability from having access to a vehicle is 0.012. While traditional public transport services may not be a viable option to access jobs in these areas, having access to a vehicle could therefore increase employment prospects.

Following the Spatial Mismatch literature, we may assume that employment prospects for low income and lower educated groups as well as young people are more sensitive to job accessibility differences, due to their generally lower employment rates and greater reliance on public transport services, which we examine in the next sections of this study.

6.4.1 The impact of job accessibility and vehicle access by household income level

We next assessed the effect of job accessibility by household income level, as people from low-income households typically have lower access to transport while being more often unemployed, which may make them more sensitive to job accessibility changes. In a departure from our previous GB study, which was based on neighbourhood income level data, we used a matching income dataset from Statistics Netherlands to group each individual based on the median annual disposable household income level: low income (≤ €44,912) and high income (≥ € 44,913), as shown in Table 6.3.

From the resulting Wald Chi-Squared statistics of exogeneity we reject the null hypothesis of exogeneity for both the low and high income group and report the estimates from the two stage model which use the estimated job accessibility as an instrument from the first stage model. The variables in the models demonstrate a significance in line with the findings in the GB employment

[21] Employment elasticities were calculated in STATA 15 using the model coefficients for the average individual in the models, in which we increased the estimated public transport-and-bicycle and car job accessibility levels by 10% while keeping all other variables constant.

[22] Marginal effects of vehicle ownership on employment were calculated in STATA 15 using the model coefficients for the average individual in the models, in which we increased vehicle ownership from 0 to 1, i.e. the percentage uplift on employment expected from vehicle ownership.

models, though with a non-significant association between having children and individual employment probabilities for the low income group and a non-significant association between a person being single or from a single parent household and employment for the high income group.

The job accessibility levels again vary substantially between both income groups, with the lower income groups having slightly higher public transport-and-bicycle job accessibility levels. This may follow from their residence in low-income housing that historically has been concentrated in the urban periphery, as compared to high-income groups who tend to reside more often in low-urban residential areas. In line with our GB study, our estimated public transport-and-bicycle job accessibility measure is only a significant determinant of employment for the low income group, for whom a 10% accessibility increase yields an employment elasticity of 0.017, which amounts to a 0.17% increase in the employment rate. Household vehicle ownership is also significant for low-income groups only, which showed that the uplift on employment probability from having access to a vehicle is 0.055.

Both job accessibility and household vehicle ownership are non-significant for the high-income group, who are more often employed so that variations in job accessibility may be less important as compared to personal skills for their employment prospects.

Table 6.3 Individual employment probabilities by household income level

Variables	**Coefficients (SE)**				**Elasticities: +10% accessibility/ Margin. effect veh.**
	≤ €44,912		**≥ €44,913**		
	Probit	IV Probit	Probit	IV Probit	
Dependent variable					
Emp. (1); unemp. (0)					
Individual & Household variables					
Age	0.139*** (0.004)	0.126*** (0.010)	0.172*** (0.004)	0.150 (0.094)	
Age squared/100	-0.169*** (0.005)	-0.155*** (0.012)	-0.200*** (0.005)	-0.175 (0.001)	
Female	-0.525*** (0.014)	-0.528*** (0.014)	-0.710*** (0.013)	-0.665* (0.253)	
Low educated	-0.189*** (0.018)	-0.154*** (0.027)	-0.262*** (0.019)	-0.211* (0.185)	
Non-Western migrant	-0.221*** (0.025)	-0.230*** (0.026)	-0.166*** (0.028)	-0.157* (0.089)	
Unemployment history	-0.333*** (0.016)	-0.313*** (0.022)	-0.295*** (0.017)	-0.273* (0.118)	
Young children (< age 12)	-0.067*** (0.010)	-0.072*** (0.010)	0.012 (0.009)	0.002 (0.034)	
Single household	-0.036* (0.017)	-0.112 (0.052)	-0.029 (0.046)	-0.279 (0.775)	
Single parent household	0.005 (0.024)	-0.064 (0.045)	0.254*** (0.057)	-0.341 (0.234)	

Neighbourhood & accessibility variables					
Percent unemployed (excl. students)	-0.037*** (0.001)	-0.036*** (0.002)	-0.027*** (0.001)	-0.025* (0.012)	
Public transport-and-bicycle job accessibility /1,000,000	0.155*** (0.040)		0.510*** (0.042)		
Estimated public transport-and-bicycle job accessibility /1,000,000		**0.604*** (0.189)**		**1.021 (1.161)**	**0.017**
Household vehicle	0.326*** (0.016)		0.188*** (0.019)		
Estimated Household vehicle		**0.760** (0.249)**		**1.182 (2.924)**	**0.055**
Constant	-1.171*** (0.084)	-1.365*** (0.115)	-1.723*** (0.072)	-2.348 (1.1551)	
Wald Chi-Squared statistic	4863.39***	5006.60***	6978.50***	8367.19***	
Wald Chi-Squared statistic of exogeneity		19.65***		10.02***	
Pseudo R2	0.1102		0.1353		
N	70,758		103,899		
Mean PT-and-bicycle job accessibility	212,864		200,341		
Mean Household vehicle rate	72.9%		87.1%		
Mean employment rate	90.2%		94.7%		

*Significance levels: *: 0.05% **: 0.01% ***: 0.001%.*

6.4.2 The impact of job accessibility and vehicle access by age groups and educational level

While our previous GB study found that mainly young and older people and low-educated individuals would benefit from improved public transport job accessibility, this was non-significant for middle-aged and middle- and higher educated groups. We therefore examine differential employment sensitivities to job accessibility changes and household vehicle ownership for population subgroups, based on different age groups (15-24, 25-34, 35-49, 50-63) and three educational levels (low-, middle-, high educated), following the labour market categorisation by Statistics Netherlands (CBS, 2016).

As shown in Supplemental Appendix Table 11.9, for the age groups, public transport-and-bicycle job accessibility is again non-significant for young people aged 15-24. In contrast to our GB study, however, we do find that job accessibility is significant for all other age groups. A 10% increase in public transport-and-bicycle job accessibility, yields employment elasticities of 0.021 and 0.023 for the age groups 25-34 and 35-49, which then decreases to 0.006 for the highest age group. Yet, household vehicle ownership is significant for the youngest age group, which showed a substantial 0.127 uplift on employment probability from having access to a vehicle. The employment effect of vehicle access reduces to 0.034 and 0.015 for those aged 25-34 and 50-63 respectively, for whom their higher employment rates are likely to be less sensitive to vehicle access changes (see also (Bastiaanssen et al., 2020) for a discussion).

When looking at the results by education levels, we also find a different pattern as compared to our previous GB study (see Supplemental Appendix Table 11.10). Our public transport-and-bicycle job accessibility measure is significant for both low-educated and high-educated individuals, for whom a 10% job accessibility increase yields an employment elasticity of 0.008 and 0.004 respectively. The higher vehicle ownership rates among middle-educated groups, is likely to make them less sensitive to job accessibility changes. This seems confirmed by our vehicle ownership variable, which showed that the uplift on employment probability from having access to a vehicle is 0.052 for middle-educated groups, while this is with 0.032 and 0.016 somewhat lower for low-educated and high-educated groups. Their greater reliance on public transport services thus seems to make these groups less sensitive to vehicle access.

6.5 Conclusions

The aim of this paper has been to assess and compare the relationship between job accessibility and employment probabilities, using new Dutch datasets and an expanded modelling approach to our previous study for Great Britain (Bastiaanssen et al., 2021a). The usage of national employment microdata in combination with a local-area public transport-and-bicycle job accessibility measure, national vehicle registration and household income datasets of The Netherlands is unique to this study. It empirically assesses whether higher job accessibility levels and household vehicle access would increase individual employment probabilities in this rather different land use and transport context, and which geographical areas and population groups would benefit most. The study controls for endogeneity in the relationship between both job accessibility, vehicle access and employment probabilities by applying an instrumental variable approach, which again showed that accessibility was a significant but endogenous determinant of employment. The accessibility coefficients were also consistently lower in the probit models as compared to our IV-probit models, which indicates that not adequately controlling for endogeneity underestimates the effect of job accessibility.

While the association between job accessibility and employment outcomes has mainly been studied in relation to the Spatial Mismatch Hypothesis (Kain, 1968) in US metropolitan areas and, more recently, in some European cities and within our national GB study, The Netherlands, as many other western countries, has also experienced a strong decentralization of employment to peripheral locations near motorways, which are often poorly served by traditional public transport services and difficult to reach by bicycle.

The empirical findings of our study demonstrate that higher levels of public transport-and-bicycle job accessibility levels could increase the employment probabilities of the population at large: a 10% increase in public transport-and-bicycle job accessibility, keeping all other variables constant, yielded an employment elasticity of 0.014, which is higher than the elasticity of 0.003 for Great Britain. The greater reliance on cycling in combination with public transport for commuting and lower overall employment rates in the Netherlands (93.4% as compared to 95.0% in Britain) is likely to make Dutch workers more sensitive to changes in their public transport-and-bicycle job accessibility levels. While our previous GB study could not control for individual car ownership, we further found an uplift on employment probability from having access to a household vehicle of 0.038, which indicates that job seekers may benefit from vehicle access. We also find that these sensitivities vary substantially for different geographical areas and population groups.

In line with the empirical evidence for Great Britain (Bastiaanssen et al., 2021a), our Dutch study found that individuals who reside in urban areas could benefit most from higher levels of public transport-and-bicycle job accessibility. However, we also found that people in rural areas could benefit from better job accessibility, but vehicle access appeared to be the more important factor driving their employment outcomes. As the relatively household high vehicle ownership rates of 92% and 89,3% in Dutch and British rural areas seem to indicate that individuals are less dependent on public transport services, vehicle access may therefore yield similar employment effects in British rural areas.

Our empirical analysis also showed that low-income groups could benefit from both improved public transport-and-bicycle job accessibility and household vehicle access, while we also do not find a significant relationship for high income groups in the Netherlands.

In contrast to our British study, however, we found no effect of public transport-and-bicycle job accessibility on youth employment probabilities, while this was significant for all other age groups. Yet, household vehicle ownership was significant for the youngest age group, while this yielded lower employment effects for older age groups. Our study further showed that both lower- and higher-educated groups could benefit from higher levels of public transport-and-bicycle job accessibility, while middle-educated groups were found to be most sensitive to household vehicle ownership.

The empirical results of our study imply that employment outcomes of Dutch job seekers could be improved with higher levels of job accessibility and vehicle access, but targeted policy interventions in mainly urban areas and among low income groups without access to private vehicles would be needed to achieve this outcome. In turn, this could increase both the participation of people in society and the full utilization of the potential labour force, as previously referred to by the Dutch Scientific

Council for Government Policy (WRR, 2018) and the Council for the Environment and Infrastructure (Rli, 2020).

As our job accessibility measure reflect the quality of the transport and land use system, an increase in job accessibility levels could potentially be achieved through improvements in availability, reliability, routing, speeds and frequencies of transport services, especially in off-peak hours, but also through the affordability of public transport fares and vehicle-related costs. The combined use of the bicycle and train in the Dutch context, substantially increases the geographical range by bicycle and door-to-door accessibility by train (Kager et al., 2016). Yet, the bicycle is mainly used as feeder mode to intercity train stations (for 40% of the train trip) and so accessibility could be enhanced when cycling gains a more important role in trips from the main train stations to the actual destination, which is currently only at 15% (KiM, 2016), and to and from other train stations and metro and tram stops. This would require targeted investments in bicycle infrastructure and facilities such as bicycle storage and shared-bicycle schemes provided at stations (see also Martens (2004), Geurs et al. (2016). This also implies that in Great Britain, enhancing bicycle use could substantially increase job accessibility levels, in particular when this is well integrated into the public transport system.

While vehicle access can also clearly improve employment probabilities of job seekers, their limited financial resources may not allow them to purchase or maintain vehicles. However, vehicle donation programs in the US (e.g. Lucas & Nicholson, 2003) and 'Wheels to Work' schemes in the UK (Lucas, Tyler, & Christodoulou, 2009) have shown to improve people's access to, and probability of, employment.

As the decentralisation of both employment and housing over the past decades to car-based locations in the urban periphery has often made it more difficult for people without private vehicles to access jobs, planning housing and employment developments in closer proximity to each other could also help over the longer term to improve their accessibility to, and probability of, employment. It would require further case study research to look into the regional and local dimension that allows for geographically contextualised employment models to establish for which specific areas and population groups such transport and land use interventions would derive the greatest benefit.

Acknowledgements

The authors would like to thank the City of Rotterdam and SEOR for their support of this research and Dr. John Pritchard for calculating the accessibility measures used in the study. This work was based on micro datasets produced by Statistics Netherlands.

7. Job accessibility and employment outcomes: a case study of the Rotterdam-The Hague Metropolitan Region

Abstract

This study examines whether better job accessibility would increase individual employment probabilities within a case study of the Rotterdam-The Hague Metropolitan Region. It combines employment microdata of the full regional population with a local-area public transport-and-bicycle job accessibility measure and vehicle registration data, while controlling for endogeneity through an instrumental variable approach. We find that better job accessibility and vehicle access increase individual employment probabilities, especially in dense urban areas. Low income groups would further benefit most and this effect decreases with increasing income levels. They may therefore benefit from targeted public policies to improve their access to employment opportunities.

Keywords: accessibility, employment, public transport, bicycle, The Netherlands

7.1 Introduction

This paper is the second study within the context of the Netherlands to examine the relationship between job accessibility, modelled at the micro-level of individuals, and individual employment outcomes for Dutch workers. In our first national study of the Netherlands (Bastiaanssen et al. (2021b), under review), we found that in particular individuals residing in urban areas as well as low income and low educated groups could benefit from higher job accessibility levels by public transport and bicycle, while people in rural areas and higher educated groups were more sensitive to higher car job accessibility levels.

However, as the study was based on a small random population sample it could not establish whether this effect holds in metropolitan areas in the Netherlands, where travel times and distances are shorter and many people typically rely for their commuting on the bicycle and public transport services. It also remained unclear which urban areas and income groups could benefit most from improved job accessibility.

In this follow-up study, and in a departure from our previous national study, we use administrative employment micro datasets providing a *full population sample* of the Rotterdam-The Hague Metropolitan Region (MRDH-region), to empirically examine the relationship between job accessibility and individual employment probabilities. By combining these administrative micro datasets with detailed urban-rural classification and household income datasets, we are able to examine the differential employment effects of job accessibility and car access for different urban areas and income groups in this metropolitan region.

A study of the MRDH-region is particularly relevant as recent studies by De Koning et al. (2017) and Martens and Bastiaanssen (2019) found vast disparities in job accessibility levels between people with and without access to a car in the region, despite its extensive public transport and bicycle system: average public transport job accessibility levels in peak hours are just 40% of those by car and this drops to only 20% in off-peak hours. As a result, job seekers who rely on public transport services have been found to experience greater difficulties in getting access to jobs, which constrained their job uptake (Bastiaanssen and Martens, 2013).

According to De Koning et al. (2017), these job accessibility disparities in the MRDH-region largely resulted from a spatial mismatch between the unemployed, who are mainly concentrated in social housing in the urban periphery of Rotterdam and The Hague, and an increasing decentralisation of employment to business parks in peripheral locations and near motorways, which are often poorly served by traditional public transport services and difficult to reach by bicycle. The MRDH Regional

Transport Authority has recently resolved that these accessibility disparities need to be reduced by increasing regional job accessibility by public transport and bicycle (MRDH, 2019). Yet, the extent to which increased job accessibility levels would also improve individual employment probabilities has not been examined in the region.

The relationship between job accessibility and employment outcomes has been the subject of an increasing body of studies (see Bastiaanssen et al. (2020) for a recent literature review). Much of the early research is linked to the seminal work of Kain (1968) on the Spatial Mismatch Hypothesis, who argued that a major source accounting for inner-city unemployment in the US was to be found in poor access to job opportunities. Various studies in mainly US metropolitan areas have since shown that (gaining) car access and better car-based job accessibility generally improves individual employment probabilities, particularly in more car-dependent metropolitan areas, while the effect of public transport job accessibility tends to be mixed and strongly dependent on the suitability of public transport services to connect job seekers with employment locations (e.g. (Sanchez et al., 2004, Hu, 2016, Cervero et al., 2002).

More recently, some studies have focussed on less car-dependent European metropolitan areas, which typically found that both car access and higher levels of public transport job accessibility were associated with increased employment prospects, in the Paris metropolitan area (Korsu and Wenglenski, 2010, Gobillon et al., 2011), and in the Barcelona and Madrid metropolitan areas (Matas et al., 2010, Di Paolo et al., 2014). By choosing a Dutch metropolitan case study we aim to test whether the same relationship holds in this rather different land use and transport context, with relatively compact urban areas and an extensive public transport and bicycle network. For example, over 25% of all commutes in the MRDH-region are made by public transport and up to 30% by bicycle, as compared to respectively 8% and 21% at the national level, and the bicycle is further used for 25% of all metro- and train journeys in the region as an access mode to the stations (KiM, 2016, Rotterdam, 2018, Rotterdam, 2016). This implies a much higher dependence on cycling and public transport services in the MRDH-region and so improved job accessibility may therefore yield larger employment effects.

While our previous national study of the Netherlands, as well as prior studies in various US and EU metropolitan areas, have relied on small (Census-based) populations samples, this is the first time to our knowledge that administrative micro datasets of the *full population* have been used to examine the relationship between job accessibility and individual employment probabilities. By combining these datasets with our previously developed local area-based public transport-and-bicycle job accessibility measure and vehicle registration and household income datasets, we were able to examine the differential employment effects for different urban areas and income groups in the region. We further control for endogeneity in the relationship between job accessibility, vehicle access and employment probabilities, by applying an instrument variable approach.

7.2 Data and methods

In this section we present in section 7.2.1 our Dutch case study area of the Rotterdam-The Hague Metropolitan Region, followed by the estimation of our employment probability models in section 7.2.2, including controls for endogeneity in section 7.2.3.

7.2.1 Case study area

The case study of this paper is the Rotterdam-The Hague metropolitan region (MRDH) in the Netherlands, which entails the Rotterdam Metropolitan Area and The Hague Metropolitan Area (Figure 7.1). It has approximately 2.3 million residents and is part of the Southern Randstad area, which constitutes the most densely populated area of the Netherlands with approximately half of the population and jobs in just a quarter of the country's area (Geurs and Ritsema van Eck, 2003). The MRDH-region constitutes a labour market area with firmly established daily commute patterns between Rotterdam and The Hague and has a dense road network and as well as an extensive public transport and bicycle infrastructure.

Rotterdam is the second largest metropolitan area of the Netherlands (after the Amsterdam metropolitan area) with a population of nearly 1.2 million residents. It is also notorious for its high unemployment levels of around 8.2% (up to 11% in the city of Rotterdam), while this is around 6.0% for the Netherlands (CBS, 2016). The city itself is divided by the river 'Nieuwe Maas', with the city centre and most jobs located on the northern river-bank while the unemployed are largely concentrated in social housing in Rotterdam-South. Bastiaanssen and Martens (2013) have previously pointed at a spatial mismatch between the public transport network, with mainly radial connections provided by tram, metro and train services to the city centre, and (low-skilled) employment opportunities that have been increasingly located on industrial parks in the urban periphery.

The Hague comprises the fourth largest Metropolitan Area of the Netherlands, with a population of 1.1 million residents. The unemployment level is with 7.7% the second highest of the Netherlands. The city also has the highest socioeconomic segregation of the Netherlands (PBL, 2010), with pockets of unemployment in deprived neighbourhoods in and around the city centre. The Hague further has an extensive bus, tram and train network connecting all neighbourhoods to the city centre.

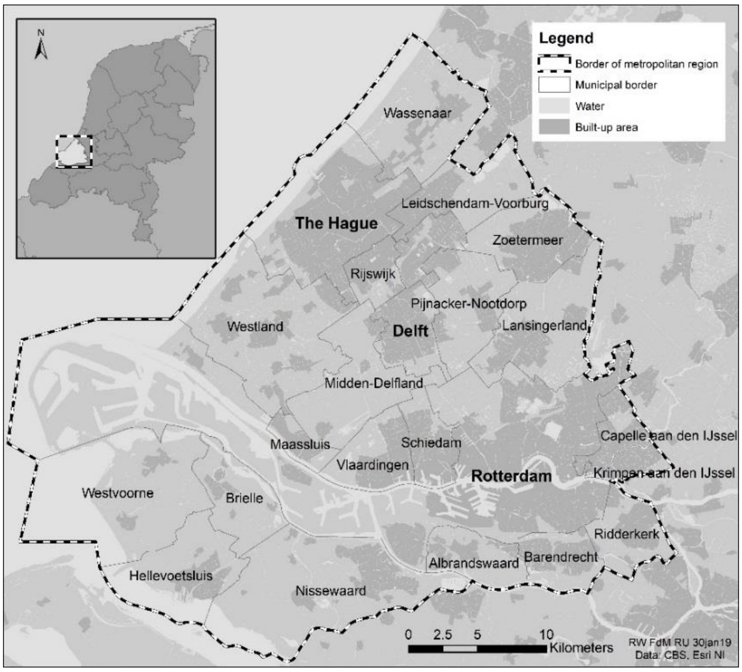


Figure 7.1 Map of the Rotterdam-The Hague Metropolitan Region

7.2.2 Employment probability models

Where our previous Dutch national study and other prior metropolitan area studies have typically relied on small sample-based datasets, this current study uses a cross-sectional administrative employment micro dataset that provides *a full population sample* of the Rotterdam-The Hague metropolitan region (MRDH-region). This allowed us to allocate each individual in the region a unique measure of their level of public transport-and-bicycle job accessibility from their area of residence and their access to a household vehicle.

Following our previous study (Bastiaanssen et al., 2021b) we employed binomial probit models to explain the relationship between job accessibility and individual employment probabilities, which can be expressed in equation 1 as follows:

$$(1)\ EP_i = f(A_i, I_i, N_i, V_i)$$

where EP_i represents the employment probability for individual *i* (1 = employed, 0 = unemployed) as a function of: I_i are individual and household characteristics for individual *i*; N_i are the neighbourhood characteristics for individual *i*; A_i representing the local accessibility levels for individual *i;* and V_i indicating household vehicle access by individual *i*.

All variables were constructed from administrative datasets of the MRDH-region, based on the national Social Statistical Datasets for 2015 (Sociaal Statistische Bestanden, SSB), and were accessed under Secure Lab conditions by special permission from Statistics Netherlands (CBS). The Social Statistical Datasets consist of microdata covering all individuals residing in the MRDH region, including detailed individual and household characteristics, employment status, and the four-digit postcode (PC4) of the residence location of each individual. Since unemployment status was not registered, we identified those in the labour force but not in work by excluding people outside the potential labour force (aged other than 15-65), those registered as students, and those receiving pensions or benefits due to work-impeding illnesses or incapacity to work. This indirect method for classifying individuals as unemployed therefore includes those who are able but not willing to enter employment (i.e. the non-active) and thus overestimates the number of unemployed. Since non-active people are unlikely to respond to accessibility changes, our employment models may underestimate the potential response of the actual unemployed to job accessibility changes.

Table 7.1 shows the explanatory variables included in our employment models for the Rotterdam and The Hague Metropolitan Areas, in which we followed our previous study (Bastiaanssen et al., 2021b), under review) for reasons of comparability. We expected age to increase individual employment probabilities as youth unemployment is relatively high in Rotterdam and The Hague. This is assumed to diminish with increasing age, for which we included an age squared variable, divided by 100 to normalise coefficients. Employment probabilities among women are expected to be lower than among men, following their lower employment rates (71.5% among women as compared to 82.5% among men) in part due to constraints from domestic commitments. Being low educated or non-Dutch is generally attached to lower employment skills and higher overall job competition, which is clearly more present among people in Rotterdam and thus likely to decrease their employment probabilities. We also included a dummy variable for unemployment history (having been unemployed in the past 5 years), which is likely to lower employment prospects as it may make individuals less attractive for employers. The number of dependent children (aged < 12) in the household is further expected to reduce employment prospects due to increased caring responsibilities and we assess the differential effects of being a single household or single parent household, which may increase financial constraints and decrease the size of the social networks that can be used for job search.

Similar to our previous Dutch study, we constructed neighbourhood variables for all 296 four-digit postcode areas (PC4s) in the MRDH-region (PC4s are administrative areas with approximately 3,500 households in each). As a measure of residential segregation, we included a variable based on the percent unemployed in each PC4, as increased job competition and adverse social effects are expected to decrease employment prospects. We next included our previously developed gravity-based public transport-and-bicycle job accessibility measure (see Bastiaanssen et al., 2021, under review), which provides the number of reachable jobs by public transport in combination with the bicycle from each

PC4 areas in the morning peak hours (6:00 – 9:00 am). In brief, this measure combined a national employment micro dataset for 2016 from the Landelijk Informatiesysteem Arbeidsplaatsen (LISA) database with public transport travel time datasets developed by Pritchard et al. (2019) for all PC4s in the MRDH-region, which incorporates cycling as a feeder mode to the main train stations if this is faster than walking or public transport (i.e. bus, tram or metro) and uses cycling as an alternative for public transport when destinations up to 30 minutes away can be reached in less travel time. It further accounts for accounts for decreasing attractiveness of distant jobs through an impedance function on travel time based on a (best fit) log-logistic function using detailed empirical public transport commute time data from the Dutch national travel survey (OViN). We matched our public transport-and-bicycle job accessibility measure under Secure Lab conditions to each individuals' PC4 code of residence in our administrative dataset and divided these by 1,000,000 to normalise coefficients. Higher levels of public transport-and-bicycle job accessibility are hypothesised to increase employment prospects.

As access to jobs for individuals with access to private vehicles is typically much higher than for people who rely on public transport services, which is likely to increase their employment prospects, we used a national vehicle registration dataset (RDW, 2015) to identify individuals with access to a household car, van or motorcycle. Note that this dataset only registers legal ownership of a vehicle, regardless of which household member uses the vehicle, and so we assigned a dummy variable to each individual with access to a household vehicle.

Table 7.1 Descriptive statistics of employment models for Rotterdam and The Hague

Variables		**Rotterdam Metropolitan Area**	**The Hague Metropolitan Area**	**Expected effects**
	Continuous or dummy measure	Mean (SD)	Mean (SD)	
Dependent variable				
Employed (1); Unempl. (0)		0.766 (0.423)	0.776 (0.417)	
Individual & Household variables				
Age	*(continuous)*	42.186 (12.123)	42.103 (12.061)	**+**
Age squared/100	*(continuous)*	19.267 (10.306)	19.181 (10.241)	**-**
Female	*(dummy)*	0.499 (0.500)	0.497 (0.500)	**-**
Low educated	*(dummy)*	0.150 (0.357)	0.123 (0.328)	**-**
Non-Dutch ethnicity	*(dummy)*	0.275 (0.447)	0.306 (0.461)	**-**
Unemployment history past 5 years	*(dummy)*	0.242 (0.428)	0.222 (0.416)	**-**
Young children < age 12	*(continuous)*	0.327 (0.734)	0.358 (0.768)	**-**
Single household	*(dummy)*	0.206 (0.404)	0.214 (0.410)	**-**
Single parent household	*(dummy)*	0.097 (0.296)	0.087 (0.282)	**-**
Neighbourhood & Accessibility variables				
Percent unemployed (excl. students)	*(continuous)*	0.111 (0.079)	0.089 (0.062)	**-**
Public transport-and-bicycle job accessibility/1,000,000	*(continuous)*	0.373 (0.167)	0.398 (0.122)	**+**

Household vehicle ownership	*(dummy)*	0.707 (0.455)	0.690 (0.463)	+
N		652,199	561,867	

Source: SSB datasets CBS, 2015

7.2.3 Controlling for endogeneity

To control for endogeneity in the relationship between public transport-and-bicycle job accessibility, vehicle access and individual employment probabilities, we followed a strategy used in our previous study (Bastiaanssen et al., 2021b) by applying an instrumental variable (IV) approach. In this study, and in a departure from prior studies in metropolitan areas (e.g. (Korsu and Wenglenski, 2010, Matas et al., 2010), we deal with endogeneity of both public transport-and-bicycle job accessibility and vehicle access.

Following our previous study, we created an instrumental variable based on population densities in each PC4 to estimate public transport-and-bicycle job accessibility: the Pearson correlation coefficient between population densities and public transport-and-bicycle job accessibility levels is significant at 0.65 while the correlation between population densities and individual employment status is insignificant. Since vehicle ownership is also clearly endogenous to employment status, we followed a strategy applied by Hu (2016) and created an instrumental variable for individual vehicle ownership based on the share of households with vehicles in each PC4. The Pearson correlation coefficient between the share of households with vehicle access in each PC4 and individual households' vehicle ownership is significant at 0.43, but the correlation coefficient between the share of households with vehicle access and individuals' employment status is insignificant.

To assess the impact of our public transport-and-bicycle job accessibility measure and household vehicle access on individual employment probabilities, each employment model estimated with the IV-approach was estimated in two stages. In the first stage model accessibility A_i and household vehicle access V_i were estimated as a function of all individual and household variables I_i and the neighbourhood variable N_i plus our instrumental variables. In the second stage model, employment is estimated as a function of all I_i and N_i variables plus the predicted values of accessibility A_i, and household vehicle access V_i from the first stage regression. The Wald Chi-Squared statistics for each model indicated whether we could reject the null hypothesis of exogeneity (P value <0.05) and report the estimates from the two-stage model, which uses the predicted value of accessibility from the first stage model.

7.3 Results and discussion

In this section of the paper, we first present in section 7.3.1 the public transport and car job accessibility patterns in the MRDH-region. We then report and discuss the results of our employment models for the Rotterdam and The Hague Metropolitan Areas in section 7.3.2, including sub-models by urbanisation level in section 7.3.3 and by household income level in section 7.3.4.

7.3.1 Public transport and car job accessibility pattern in the MRDH-region

The spatial patterns of the public transport and car job accessibility measures for the MRDH-region are visualized on four-digit postcode level (PC4) using ArcGIS. Figure 7.2a shows the spatial distribution of public transport-and-bicycle job accessibility in morning peak time in the MRDH-region, as classified on the basis of 5 breaks in the data. The darker PC4 areas represent higher levels of accessibility to employment, and vice versa. This implies that job seekers residing in accessibility-rich PC4s have greater access to jobs and, therefore, will be more likely to gain and retain employment than job seekers living in accessibility-poor PC4s, all else equal. The figure shows that the areas with the highest levels of public transport accessibility are mainly concentrated in and around the city centres of Rotterdam and The Hague, with lower levels of accessibility outwards to the periphery. This accessibility pattern reflects the radial nature of the public transport network, which is characterized by a concentration of public transport services on the main corridors in the urban centres, with often poor connections to peripheral employment locations. Car job accessibility in morning peak time is presented in Figure 7.2b, for which we multiplied our breaks in the data by five to show the spatial pattern of accessibility. Apart from the more sparsely populated south-western periphery, all PC4s in the MRDH-region can be considered accessibility-rich due to the dense road infrastructure, which even increases when congestion levels are lower in off-peak hours. This clearly shows the substantial advantage vehicle owners have in terms of job accessibility and suggests that the relevant variable to approximate their job accessibility is not commuting time, but rather the availability of a vehicle within the household, as indicated by the household vehicle dummy in our employment models.

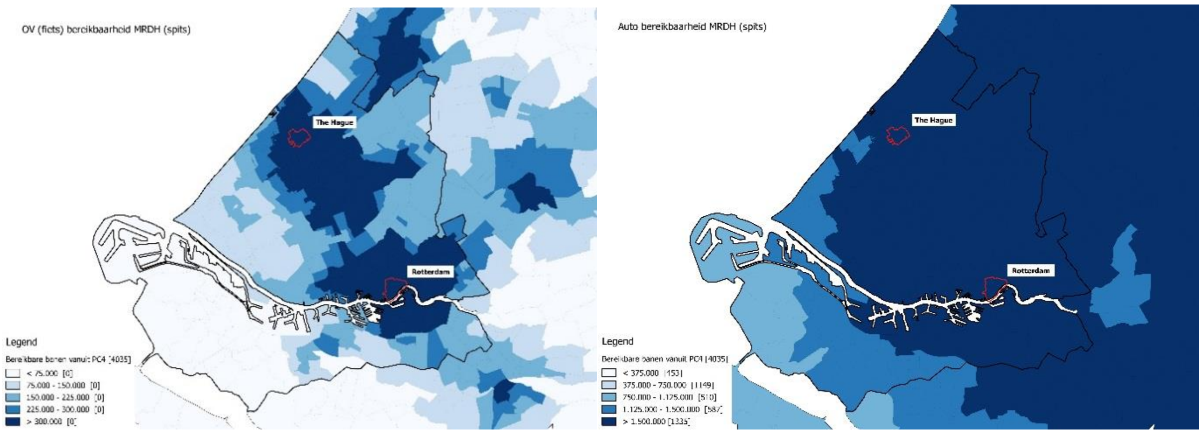


Figure 7.2 (a) Public transport-and-bicycle job accessibility; (b) Car job accessibility

7.3.2 Employment models for Rotterdam and the MRDH-region

In this section we report and discuss the results of our employment models for the Rotterdam and The Hague Metropolitan Areas, in order to examine the differential employment effects of public transport-and-bicycle job accessibility and vehicles access in both areas (see Table 7.2). We report the employment model for the MRDH-region in the appendix (Table 11.11). The first stage results from our employment models demonstrated that our instruments were significant and strong predictors of job accessibility and vehicle access. The Wald Chi-Squared statistics of exogeneity for each employment model in Table 7.2 indicated that we could reject the null hypothesis of exogeneity (P value <0.05) and report the estimates from the two-stage model, which uses the predicted values of job accessibility and vehicle access from the first stage model.

Among the individual and household variables, a higher age only slightly improves individual employment probabilities in The Hague, which can be explained by its relatively low youth employment rate (70,5% for those up to age 25), while in Rotterdam especially older age groups have lower employment rates (73.8% for youth as compared to 69.5% for those over age 55). This age effect diminishes with each additional year of age, as indicated by the negative coefficient for age squared/100. Females clearly have lower employment prospects, which seems to follow from their lower employment rates as compared to males. Being low-educated also lowers individual employment probabilities, but particularly unemployment history decreases the employment prospects. Having been unemployed in the past 5 years may make individuals less attractive for employers and is related to lower levels of education. While being non-Dutch by birth also decreases employment prospects in The Hague it yields a positive coefficient in Rotterdam, which may follow from the higher employment rate among Western migrants (67.7%), as compared to non-Western migrants (56.2%).

Of the household variables, having more dependent children also decreases the employment prospects, which may indicate that caring tasks and/or lack of suitable childcare constrains their access to employment. On the other hand, being a single household or a single parent household is, after controlling for other individual and household characteristics, related to higher employment prospects in both employment models. This seems to imply that having a partner does not relieve financial constraints and/or provide a social network through which employment can be sought.

Higher percentages unemployed in each neighbourhood further significantly decreases employment prospects in the The Hague Metropolitan Area, as people are likely to experience higher job competition by other job seekers for relatively fewer employment opportunities. For the Rotterdam Metropolitan Area this variable is not significant, which may follow from the greater dispersion of unemployment across Rotterdam.

Table 7.2 Individual employment probabilities for Rotterdam and The Hague

Variables	**Rotterdam Metropolitan Area Coefficients (SE)**	**The Hague Metropolitan Area Coefficients (SE)**	**Elasticities: +10% accessibility/ +1 HHVehicle**
Dependent variable			
Employed (1); Not employed (0)			
Individual & Household variables			
Age	0.004 (0.004)	0.041*** (0.002)	
Age squared/100	-0.011* (0.005)	-0.070*** (0.003)	
Female	-0.154*** (0.019)	-0.269*** (0.007)	
Low educated	-0.062*** (0.018)	-0.211*** (0.007)	
Non-Dutch ethnicity	0.085*** (0.026)	-0.228*** (0.016)	
Unemployment history	-0.205*** (0.042)	-0.582*** (0.017)	
Young children (< age 12)	-0.038*** (0.002)	-0.050*** (0.003)	
Single household	0.758*** (0.014)	0.541*** (0.014)	
Single parent household	0.506*** (0.013)	0.237*** (0.011)	
Neighbourhood & accessibility variables			
Percent unemployed (excl. students)	-0.036 (0.025)	-0.928*** (0.033)	
Estimated public transport-and-bicycle job accessibility/1,000,000	1.148*** (0.037)	1.356*** (0.054)	**0.125 | 0.069**
Estimated household vehicle ownership	2.487*** 0.019	2.002*** 0.031	**0.199 | 0.068**
Constant	-1.565*** (0.046)	-1.325*** (0.041)	
Wald Chi-Squared statistic	900540.79***	258427.99***	

Wald Chi-Squared statistic of exogeneity	271.20***	855.41***	
Pseudo R2			
N	652,199	561,867	
Mean job accessibility level	372,957	397,597	
Mean hhvehicle rate	70.7%	69.0%	
Mean employment rate	76.3%	77.6%	

*Significance levels: *: 0.05% **: 0.01% ***: 0.001%.*

The estimated public transport-and-bicycle job accessibility variables yield a significant and positive coefficient in both models, indicating that higher levels of job accessibility would increase individual employment probabilities. We derived employment elasticities to illustrate changes in individual employment probabilities based on a 10% increase in public transport-and-bicycle job accessibility levels[23]. For the Rotterdam Metropolitan Area, a 10% increase in public transport-and-bicycle job accessibility yields an employment elasticity of 0.125, which would imply a 1.25% increase in the employment rate. For the The Hague Metropolitan Area, a corresponding employment elasticity of 0.069 was estimated based on a 10% increase in public transport-and-bicycle job accessibility, which would relate to a 0.69% increase in the employment rate. The larger employment sensitivity in the Rotterdam Metropolitan Area is likely to follow from their lower employment levels and relatively low public transport-and-bicycle job accessibility levels.

When we turn to the estimated household vehicle access variable, we also find a significant and positive coefficient. The uplift on employment probability from having access to a vehicle is 0.199 for the Rotterdam Metropolitan Area and with 0.068 somewhat lower for the The Hague Metropolitan Area. Again, the larger employment sensitivity in the Rotterdam Metropolitan Area likely follows from the lower unemployment levels and higher car-dependence.

Following the Spatial Mismatch literature, we may assume that disadvantaged populations groups and areas would be most sensitive to public transport-and-bicycle job accessibility and vehicle access, which we examine in the next sections.

7.3.3 The impact of job accessibility and vehicle access by urbanisation level

Since traditional public transport services have been increasingly concentrated along the main corridors of urban centres, while many unemployed reside in social housing in the urban periphery, we may assume that higher levels of public transport-and-bicycle job accessibility and car access

[23] We calculated employment elasticities using the model coefficients of the whole sample, using the means for the average individual, in which we increased the estimated job accessibility levels by 10%, while keeping all other variables constant.

would yield the largest effects in dense urban areas. In our previous Dutch study, we found a significant and positive effect for urban areas, however, we were not able to assess which urban areas would benefit most. In this section we therefore examine the differential employment effects of public transport-and-bicycle job accessibility and vehicle access for different urban areas, based on the detailed Urban-Rural classification as distinguished by Statistics Netherlands (Table 7.3): very high urban areas (≥ 2.500 addresses per km2), high urban areas (2.499 to 1.500 addresses per km2), moderate urban areas (1.499 to 1.000 addresses per km2), low urban areas (≤ 999 addresses per km2).

For all employment models we reject the null hypothesis of exogeneity and report the estimates from the two stage model which use the estimated job accessibility and vehicle access from the first stage model. The variables in all employment models demonstrate a significance in line with the findings in our previous models, with a positive association between increasing age, being single or a single parent and being employed, while most other variables show the expected negative impacts on employment probabilities.

Table 7.3 Individual employment probabilities by urbanisation level

Variables	**Coefficients (SE)**				**Elasticities: +10% accessibility/ +1 HHVehicle**
	Very high urban	High urban	Moderate urban	Low urban	
Dependent variable					
Empl. (1); Not empl. (0)					
Individual & Household variables					
Age	-0.000 (0.002)	0.039*** (0.003)	0.093*** (0.004)	0.027*** (0.006)	
Age squared/100	-0.018*** (0.003)	-0.063*** (0.004)	-0.134*** (0.004)	-0.048*** (0.008)	
Female	-0.146*** (0.009)	-0.318*** (0.017)	-0.602*** (0.010)	-0.285*** (0.039)	
Low educated	-0.149*** (0.010)	-0.081*** (0.016)	-0.364*** (0.022)	-0.088*** (0.026)	
Non-Dutch ethnicity	-0.009 (0.018)	-0.060* (0.024)	-0.535*** (0.074)	0.304*** (0.060)	
Unemployment history	-0.305*** (0.023)	-0.478*** (0.037)	-1.154*** (0.036)	-0.364*** (0.070)	
Young children (< age 12)	-0.065*** (0.002)	-0.015*** (0.003)	-0.027*** (0.007)	-0.006 (0.007)	
Single household	0.639*** (0.011)	0.729*** (0.020)	0.096 (0.166)	0.996*** (0.025)	
Single parent household	0.369*** (0.011)	0.458*** (0.016)	0.017 (0.100)	0.451*** (0.023)	
Neighbourhood & accessibility variables					
Percent unemployed (excl. students)	-0.386*** (0.022)	-0.177*** (0.040)	-0.048 (0.171)	-0.169* (0.069)	
Estimated PT job accessibility/1,000,000	1.438*** (0.043)	0.933*** (0.086)	0.556*** (0.085)	1.120*** (0.091)	**0.140 | 0.086 0.023 | 0.057**

Estimated household vehicle ownership	2.196*** (0.017)	2.515*** (0.044)	0.497 (0.053)	3.025*** (0.069)	**0.127 | 0.205** **0.194**
Constant	-1.252*** (0.034)	-1.913*** (0.072)	-0.004 (0.434)	-2.435*** (0.105)	
Wald Chi-Squared statistic	703631.04 ***	222983.58 ***	19964.30* **	62542.72* **	
Wald Chi-Squared statistic of exogeneity	768.13***	393.12***	12.79**	365.35**	
N	679,061	334,522	134,469	66,014	
Mean job accessibility level	470,763	307,158	243,511	173,700	
Mean hhvehicle rate	59.7%	81.0%	86.1%	86.2%	
Mean employment rate	72.4%	81.5%	85.9%	84.9%	

*Significance levels: *: 0.05% **: 0.01% ***: 0.001%.*

The estimated public transport-and-bicycle job accessibility variables show a significant positive sign for all urban areas, in line with the findings in our previous Dutch study, but with the strongest effects in very high urban areas that gradually decreases towards low urban areas. A 10% increase in public transport-and-bicycle job accessibility yields an employment elasticity of 0.140 for very high urban areas, where the relatively low employment rates will be more sensitive to job accessibility changes, which then decreases to 0.086 in high urban areas. In medium and low urban areas, the employment elasticities drop to 0.023 and 0.057 respectively, where the relatively high employment rates and higher vehicle ownership levels may make people less dependent on public transport services.

The estimated household vehicle access yields the highest coefficients in high and low urban areas. The uplift on employment probability from having access to a household vehicle is 0.127 in very high urban areas, which then increases to 0.205 in high urban areas where public transport-and-bicycle job accessibility levels are lower. While vehicle access is non-significant in moderate urban areas, it yields an elasticity of 0.194 in low urban areas, where people are likely to be more dependent on private transport.

7.3.4 The impact of job accessibility and vehicle access by household income quartile

Since lower income groups are more likely to be unemployed, we may assume that they would benefit most from higher levels of public transport-and-bicycle job accessibility and household vehicle access. Our previous Dutch study found a significant and positive effect for individuals classified as low income based on the national median disposable household income level, but it could not establish differential employment effects for different low or high income groups and did not find significant effects for high income households. In this study we therefore used a similar matching administrative income dataset from Statistics Netherlands to group each individual in the MRDH-region in income quartiles, based on their registered disposable household income. We report the employment models for Rotterdam and The Hague in Table 11.12 in the appendix.

For all employment models in Table 7.4 we rejected the null hypothesis of exogeneity and report the estimates from the two stage model, which use the estimated and public transport-and-bicycle job accessibility household vehicle access from the first stage model.

The estimated public transport-and-bicycle job accessibility variables are significant and positive in all models, which clearly yield the strongest effect for the lowest income quartile and then gradually decreases with an increasing income level. A 10% increase in public transport-and-bicycle job accessibility yields an employment elasticity of 0.395 for the first income quartile, which seems to follow from the very low employment rate of 44.7% that will be more sensitive to job accessibility changes. The employment elasticity then decreases to 0.139 for individuals in the second income quartile, for whom the substantially higher employment rate is likely to be less sensitive to job accessibility changes. For individuals in the third income quartile the results are barely significant, which indicates that their employment status is not sensitive to accessibility changes, while this slightly increases again for the for the fourth income quartile.

For the estimated household vehicle ownership variable we find a similar pattern, showing decreasing employment effects from vehicle access with increasing income levels. For the lowest income quartile, the uplift on employment probability from having access to a household vehicle is 0.413 and 0.229 for the second income quartile, while the employment sensitivity is again much smaller for higher income groups.

Table 7.4 Individual employment probabilities by household income quartile

Variables	**Coefficients (SE)**				**Elasticities: +10% accessibility/ +1 HHVehicle**
	1st income quartile	2nd income quartile	3rd income quartile	4th income quartile	
Dependent variable					
Empl. (1); Not empl. (0)					
Individual & Household variables					
Age	-0.021*** (0.003)	-0.004 (0.005)	0.044*** (0.005)	0.075*** (0.005)	
Age squared/100	-0.001 (0.003)	-0.116** (0.006)	-0.071*** (0.005)	-0.120*** (0.005)	
Female	0.028*** (0.007)	-0.369*** (0.033)	-0.608*** (0.016)	-0.410*** (0.023)	
Low educated	-0.110*** (0.016)	-0.205*** (0.020)	-0.272*** (0.009)	-0.260*** (0.011)	
Non-Dutch ethnicity	0.049* (0.023)	-0.134*** (0.041)	-0.348*** (0.032)	-0.284*** (0.032)	
Unemployment history	-0.382*** (0.037)	-0.503*** (0.059)	-0.896*** (0.034)	-0.789*** (0.047)	
Young children (< age 12)	-0.089*** (0.007)	-0.082*** (0.004)	-0.022* (0.009)	-0.022*** (0.004)	

Single household	0.734*** (0.007)	1.020*** (0.060)	0.879*** (0.023)	0.561*** (0.043)	
Single parent household	0.244*** (0.027)	0.495*** (0.009)	-0.363*** (0.021)	-0.223*** (0.014)	
Neighbourhood & accessibility variables					
Percent unemployed (excl. students)	-0.438*** (0.053)	-0.422*** (0.039)	-0.238*** (0.057)	-0.389*** (0.056)	
Estimated PT job accessibility/1,000,000	0.907*** (0.060)	1.009*** (0.113)	0.432* (0.169)	1.241*** (0.080)	**0.395, 0.139, 0.012, 0.034**
Estimated household vehicle ownership	2.083*** (0.058)	1.585*** (0.118)	0.792** (0.251)	2.173*** (0.153)	**0.413, 0.229, 0.029, 0.036**
Constant	-0.495*** (0.070)	-0.229 (0.123)	0.439* (0.223)	-1.949*** (0.172)	
Wald Chi-Squared statistic	115631.62 ***	112812.16 ***	43003.28* **	82680.31* **	
Wald Chi-Squared statistic of exogeneity	362.26***	56.53**	17.71***	242.28***	
N	171,333	220,986	308,031	460,501	
Mean job accessibility level	434,029	415,364	378,036	352,165	
Mean hhvehicle rate	30.4%	56.8%	77.9%	87.8%	
Mean employment rate	44.7%	71.5%	85.3%	91.9%	

*Significance levels: *: 0.05% **: 0.01% ***: 0.001%.*

7.4 Concluding remarks: public policy implications

This study was the first addressing the impact of job accessibility on individual employment probabilities within the context of the Rotterdam-The Hague Metropolitan Region, using new Dutch employment micro datasets. While our previous national study of the Netherlands (Bastiaanssen et al., 2021b), under review), as well as other prior studies in US and EU metropolitan areas, have relied on small (Census-based) populations samples, this is the first time to our knowledge that administrative employment micro datasets of the full population have been used for this purpose. By combining these micro datasets with a local area-based public transport-and-bicycle job accessibility measure and vehicle registration and income datasets, we were able to expand on our previous national study and examine in detail which geographical areas types and income groups could benefit from higher levels of public transport-and-bicycle job accessibility and household vehicle access. Our employment models were further corrected for endogeneity in the relationship between job accessibility, vehicle access and employment outcomes by applying an instrumental variable approach.

While most of the early spatial mismatch studies were conducted within the context of US metropolitan areas and, more recently, in some EU cities, over the past decades, the Rotterdam-The Hague metropolitan area has also experienced an increasing decentralisation of employment to peripheral business plots near highways that are often poorly served by public transport services and difficult to reach by bicycle.

The empirical findings of this study showed, in line with our previous national study for the Netherlands (Bastiaanssen et al., 2021b) and prior studies in other European metropolitan areas (e.g. (Korsu and Wenglenski, 2010, Matas et al., 2010, Di Paolo et al., 2014), that higher levels of public transport-and-bicycle job accessibility and household vehicle access could increase individual employment probabilities in the Rotterdam-The Hague Metropolitan Region. These positive employment effects were found to be stronger in Rotterdam as compared to The Hague, which is likely to follow from the higher unemployment levels and relatively fewer (matching) job opportunities in Rotterdam.

In line with our previous national study for the Netherlands, we found that individuals who reside in urban areas would benefit from higher levels of public transport-and-bicycle job accessibility and household vehicle access, but also that people residing in high urban areas are most sensitive to job accessibility changes, while vehicles access also plays an important role in low urban areas. This employment effect of job accessibility is much lower among individuals in medium- and low-urban areas, where the higher employment rates in combination with higher vehicle ownership levels may make people less dependent on public transport services.

In contrast to our previous Dutch national study and prior evidence in US metropolitan areas (e.g. Hu (2016), we found that all income groups were sensitive to higher levels of public transport-and-bicycle job accessibility and household vehicle access. Individuals in the lowest household income quartile would clearly benefit most from higher levels of public transport-and-bicycle job accessibility and vehicle access, for whom the very low employment rates in combination with the low vehicle access levels will make them more sensitive to job accessibility changes. This positive employment effect decreased with increasing income levels.

The usage of these detailed micro datasets of the full population thus seem essential to accurately assess the relationship between job accessibility and employment outcomes, which is not fully captured by small (Census-based) populations samples used in prior studies.

Our study findings imply that employment outcomes of job seekers could be improved by providing higher levels of public transport-and-bicycle job accessibility and household vehicle access, but targeted policy interventions in especially high urban areas and among the lowest income households would be needed to achieve this outcome. What constitutes improvements in their job accessibility is arguably not so much related to major public transport projects, such as the investments in new regional (light)rail connections that were recently proposed by the MRDH Regional Transport Authority to decrease accessibility disparities between car and public transport (MRDH, 2019). As low-income groups in particular tend to reside in social housing in the outskirts of Rotterdam and The Hague, while many low-skilled jobs have been increasingly dispersing out of the centres to business plots in the urban periphery and near highways, an increase in their job accessibility is more about improvements in local bus and tram services through better routing, frequencies and reliability, especially in off-peak hours, between low-income neighbourhoods and peripheral job locations.

Car access can also clearly improve employment probabilities, as shown in this study, but the limited financial resources of low-income groups may not allow them to purchase and/ or maintain a car. However, prior experience with 'Wheels to Work' programs in the UK (Lucas et al., 2009) and more recently with shared transport schemes (Shaheen and Chan, 2016) have demonstrated to increase people's access to transport in areas that are poorly served by public transport. Since commuting costs can be a significant barrier for job uptake, in particular among lower income groups, reduced public transport fares and lower vehicle-related costs may also allow them to increase their job search area and, in turn, their chances of findings a job (Lucas, 2012). While the bicycle can further play an important role in increasing job accessibility, Bastiaanssen and Martens (2013) have previously found that for low-skilled job seekers in Rotterdam peripheral business plots were often difficult to reach by bicycle. It would therefore require improved bicycle facilities to peripheral job locations, potentially in combination with local (public) transport services, to help improve their accessibility to, and probability of, employment.

Acknowledgements

The authors would like to thank the City of Rotterdam and SEOR for their support of this research and Dr. John Pritchard for providing the accessibility models used in the study. Results are based on calculations by the University of Leeds using non-public microdata from Statistics Netherlands.

8. Does public transport help young people to access jobs and how can local transport authorities respond? An in-depth case study of the West Yorkshire region of the UK

Abstract

In recent decades, there has been an increasing interest amongst scholars and policy makers for accessibility assessments to evaluate the performance of public transport services. However, the extent to which *potential* public transport job accessibility opportunity levels match *experienced* job accessibility is rarely examined. This study uses a 3-pronged mixed methods approach to empirically examine the role of public transport in young people's access to employment opportunities, for which we combine a potential public transport job accessibility opportunity measure with young people's reported experiences of accessing employment opportunities using micro-scale analysis of the UK National Travel Survey and in-depth interviews with young job seekers in West Yorkshire, UK. The study found that variations in the coverage of the public transport and land use system resulted in substantial job accessibility disparities across the region. It further showed that young unemployed in particular had turned down jobs due to inadequate public transport or high fare costs, but that this was much less so among those with higher public transport job accessibility levels or with access to a household car. The interviews indicated that their experienced accessibility to employment opportunities included availability, reliability, connectivity and affordability of local bus services, especially in off-peak hours and in peripheral areas. What is clearer from our study, is that young people's dependence on public transport affects their accessibility to, and uptake of, employment opportunities. We suggest that future research pays greater attention to job accessibility measures and best practises to improve young people's employment outcomes.

Key words: public transport, young people, accessibility, employment, England

8.1 Introduction and background

This paper explores the role of public transport in young people's access to jobs. Specifically, we seek to elucidate whether *potential* public transport job accessibility levels match young people's *reported experiences* of accessing employment opportunities, by combining a public transport job accessibility opportunity measure, as developed in our previous GB study (Bastiaanssen et al. (2021a), with micro-scale analysis of National Travel Survey data and in-depth interviews with young job seekers in the West Yorkshire region of the UK.

Over the past decades, the UK has undergone a marked process of deindustrialisation and seen the rise of the service economy. Service-sector jobs, in particular, tend to be concentrated in cities and along the main transport corridors (Davis and Henderson, 2008, Sassen, 2011), where many young people are employed in hospitality, retail and leisure sectors (Furlong, 2015), which are often part-time or casual and can operate outside regular 9 to 5 working hours and also peak hour public transport services. Lower skilled jobs in the service-sector and in various other sectors such as manufacturing and warehousing have simultaneously been dispersing out of the city centres to locations in the urban periphery and near highways (Turok and Edge, 1999, Houston, 2005, Tochtermann and Clayton, 2011). As these peripheral employment locations are often poorly served by traditional public transport services, for low-skilled young people who rely on public transport it is, therefore, typically more difficult to access jobs, in particular when residing outside of the main public transport corridors and city centres (McQuaid et al., 2001, Rae et al., 2016, JRF, 2018).

Various studies have identified lack of private or public transport and transport costs as an important barrier to employment opportunities, in particular among young people, but the causal factors behind this problem are often poorly addressed in transport policies (e.g. (SEU, 2003, British Youth Council, 2012, Tunstall et al., 2013). More than other age groups, young people rely on public transport services to travel to job interviews and work (Kuhnimhof et al., 2011, DfT, 2017, Delbosc et al., 2019). Compared to previous generations, they also take longer to acquire a driving license (Delbosc and Currie, 2013, Hjorthol, 2016, Chatterjee et al., 2018), own fewer cars (Hjorthol, 2016, Klein and Smart, 2017, Chatterjee et al., 2018), and drive less (Kuhnimhof et al., 2011, Chatterjee et al., 2018, McDonald, 2015), which has increased their reliance on other modes, particularly public transport.

The causes of these observed phenomenon have been related by various authors to shifts in attitudes towards transport and travel (Taylor, 2010, France et al., 2013, Garner, 2015), delays in adult life stage milestones (Ministry of Infrastructure and the Environment, 2014, Delbosc and Currie, 2014, Brown et al., 2016), but mostly to changes in their socio-economic situation (Klein and Smart, 2017, Chatterjee et al., 2018, Delbosc et al., 2019). Young people in particular are over-represented in part-time and temporary low-paid jobs, which reduces the disposable income they can allocate to transport costs (Bell and Blanchflower, 2013, Chatterjee et al., 2018). In turn, young people have been found to have more localised job search horizons, thereby reducing their access to, and uptake of, employment (Granovetter, 1995, Green et al., 2005).

In this respect, there has been an increasing interest for accessibility assessments to evaluate the performance of public transport services in providing access to employment opportunities (e.g. (Preston and Rajé, 2007, Golub et al., 2013, Geurs and Ritsema van Eck, 2003). In the UK, for example, local transport authorities have been required between 2006 and 2012 to undertake accessibility assessments as part of their Local Transport Plans (LTPs) and the UK Department for Transport (DfT) provides annually updated job accessibility indices for England (DfT, 2018). In the US, long-term transport plans have also started using accessibility as a performance indicator (Grengs et al. 2010), while Australian States now have transport policies that directly aim to improve accessibility of low-income populations (Lucas and Curry, 2011). To some extent, these policies also have been adopted by local transport authorities, for example in the West Yorkshire region in the UK, where the transport policy strategy is to conduce to 'connecting people to jobs more effectively through public transport, in a way that it also contributes to inclusive growth' (WYCA, 2017). However, since accessibility assessments are no longer a statutory requirement in LTPs, local transport authorities rarely examine the role of public transport in providing access to employment opportunities and the extent to which this affects young people's employment outcomes. While our recent British study found that higher levels of public transport job accessibility could increase youth employment probabilities (Bastiaanssen et al., 2021a), it remains unclear to what extent these *potential* job accessibility levels match young people's *experiences* of accessing employment opportunities. This paper seeks to address this gap by empirically examining the role of public transport in young people's access to jobs.

8.2 Methods and data

The paper is based on a 3-pronged mixed methods quantitative and qualitative approach, which was applied to the West Yorkshire region of the UK. The 3 consecutive stages in the paper are:

i. to explore levels of access to employment opportunities within the case study area of West Yorkshire, using our previously developed public transport job accessibility *opportunity* measure

ii. to identify young people's *reported* experiences of, and barriers to, the uptake of these employment opportunities, through National Travel Survey micro-analysis

iii. to gain a more detailed understanding of these experiences and barriers, the consequences and potential policy solutions, through in-depth interviews with young job seekers in West Yorkshire

In the concluding sections of the paper, we discuss the added value of our mixed methods approach with regards to the role of public transport in young people's job access and make some recommendations on how local transport authorities can respond.

8.2.1 Public transport job accessibility *opportunity* measure

First, the study applied a bespoke location-based public transport job accessibility opportunity measure, as described in detail in Bastiaanssen et al. (2021a). In brief, this measure was used to analyse levels of accessibility to employment opportunities through the public transport system in West Yorkshire. In contrast to the accessibility indices provided by the UK Department for Transport (DfT, 2018), which are based on the number of reachable employment centres (between 1-10 employment centres) within fixed travel time thresholds, we matched the public transport travel time datasets[24] with employment microdata for Great Britain, accessed under Secure Lab conditions by special permission from the Office for National Statistics, as described in Bastiaanssen et al. (2021a).

As data on job vacancies by occupational classes were not available for the UK, we used the number of jobs in each destination LSOA and by industry sector as a proxy for vacancies, given that job-rich areas also tend to generate larger numbers of vacancies (Rogers, 1997). We reworked the 21 industry sectors from the SIC 2007 to 10 aggregated sectors: (1) agriculture and mining; (2) manufacturing; (3) utility services; (4) construction; (5) retail, information and communication; (6) finance and real estate; (7) public administration, education and health; (8) accommodation and administrative services; (9) arts, entertainment and recreation; and (10) activities of extraterritorial organizations.

In order to account for the decreasing attractiveness of distant jobs, we estimated our job accessibility measure based on the widely used gravity model (Hansen, 1959) in which employment opportunities are discounted through an impedance function based on travel time. To account for differences in travel times between urban regions and less densely populated peripheral and rural regions, we estimated separate decay functions for urban areas and for rural areas for each of the seven English regions, Wales and Scotland, based on the 2011 Urban Rural Classification. A log-normal function was derived as the best fit decay function, based on detailed empirical commute time trip data from the UK National Travel Survey 2006-2016 (see for further discussion Bastiaanssen et al. (2021a).

[24] The TRACC© software package was used to compute optimal routing algorithms for PT journeys between population-weighted centroids of LSOAs in the morning peak hours (6:00 - 9:00 am), when most people in Britain travel to work, including walking access time to a bus stop/ rail station through the road network, waiting time at the stop or station, in-vehicle travel time, transfer time, and walking egress times to the final destination (employment location).

This public transport job accessibility *opportunity* measure was then calculated for all Lower Super Output Areas (LSOA) in Great Britain (each LSOA encompasses roughly 500 households) and differentiated by the 10 industry sections.

8.2.2 National Travel Survey microdata

In the second stage of the methodology, which is newly reported in this paper, we combined our previously constructed public transport job accessibility opportunity measure with individual micro-level data from the UK National Travel Survey (NTS). The NTS is the primary source of data on personal travel patterns in England and provides information on whether people on work-related trips have turned down a job (or job interview) in the past 12 months due to inadequate public transport services[25]. This micro dataset allowed us to allocate each sampled individual a level of public transport job accessibility for their LSOA area of residence, in order to assess the relationship between our accessibility *opportunity* measure and young people's *recorded experience* of accessibility to employment.

Due to the small number of observations for young people living in the West Yorkshire region in any one year of this rolling survey, we combined datasets for the period 2013 to 2017 for England. Since we were interested in the role of public transport among (young) unemployed people only, we excluded already employed people and individuals outside the labour force (i.e. students and economically inactive individuals) from our dataset, resulting in a total of 1,538 unemployed individuals. In line with our previous study (Bastiaanssen et al., 2021a), we defined young people as those aged 16-24, based on which 532 records were identified as young unemployed.

We employed a binomial logit model to examine the relationship between public transport job accessibility levels and the probability that (young) unemployed have turned down a job in the past 12 months due to inadequate public transport services[26], which is expressed as follows:

$$(1)\ TP_i = f(A_i, I_i, N_i)$$

where TP_i represents the probability of having turned down a job (interview) on the way to work for individual *i* (1 = turned down job, 0 = not turned down job) as a function of: A_i representing the local

[25] Inadequate public transport was the far most reported reason (8.5%) among young unemployed to have turned down jobs. To a lesser extent jobs have been turned down due to problems with the costs of public transport (3.0%) or due to lack of access to a household car (4.2%) or driver's licence (3.9%).

[26] The NTS only includes a specific question about having turned down jobs due to transport-related difficulties such as inadequate public transport 'on the way to work', which we interpret as job accessibility-related, while other reasons for (young) people to have turned down jobs have not been queried.

public transport job accessibility levels for individual *i*; I_i are individual and household characteristics for individual *i*; and N_i represent neighbourhood characteristics for individual *i*.

The dependent variable and all individual and household explanatory variables were constructed from the UK National Travel Survey (NTS) (DfT, 2019). The individual records were subsequently matched under Secure Lab conditions (as described in 8.2.1) to our public transport job accessibility measure, based on their LSOA code of residence (divided by 1,000,000 to normalise the coefficients). Note that while job vacancies by occupational class would best reflect job opportunities, this data was not available and therefore we used the number of jobs as a proxy for vacancies. We further constructed a neighbourhood variable based on median household income levels from the UK Experian^{tm} dataset to account for the quality of the neighbourhood and adverse social effects (divided by 1,000 to normalise coefficients).

Table 8.1 Descriptive statistics of variables included in the logit models

Variables	Continuous or dummy measure	Means (SD)	
		Unemployed (aged 16-74)	Young unemployed (aged 16-24)
Dependent variable			
Turned down job (1: yes/ 0: no)	*(dummy)*	0.069 (0.253)	0.085 (0.279)
Individual & Household variables			
Age/100	*(continuous)*	33.3 (0.134)	20.2 (0.024)
Female	*(dummy)*	0.423 (0.494)	0.366 (0.482)
Single household	*(dummy)*	0.697 (0.460)	0.989 (0.100)
Educational qualification	*(dummy)*	0.827 (0.378)	0.869 (0.338)
No driving license	*(dummy)*	0.313 (0.464)	0.386 (0.487)
No household car(s)	*(dummy)*	0.390 (0.488)	0.320 (0.467)
Neighbourhood & accessibility variables			
Median household income/1,000	*(continuous)*	29.942 (11.128)	29.474 (10.773)
Public transport job accessibility /1,000,000	*(continuous)*	0.444 (0.858)	0.333 (0.682)
N		1,538	532

Table 8.1 shows the explanatory variables that are included as dummy or continuous variables in the separate models for all unemployed (aged 16 to 74) and young unemployed (aged 16 to 24). The young

unemployed have substantially more often turned down jobs (8.5%) due to inadequate public transport services, as compared to the unemployed (6.9%) in general. The young unemployed are more often male and single, and tend to have an educational qualification[27]. While they tend to have lower levels of driver's licenses, access to household car(s) is actually higher than among the unemployed in general. The slightly lower median household income levels for their neighbourhoods indicates that the young unemployed reside in less affluent areas, while they also have much lower levels of potential public transport job accessibility, indicating they more often reside outside the city centres. We hypothesise that not having a driver's license or household car increases the probability that (young) unemployed have turned down jobs, while residing in areas with higher levels of public transport job accessibility decreases this effect.

8.2.3 In-depth interviews

In the third stage of the methodology, we used a small, qualitative survey, involving 30 in-depth interviews with young job seekers in West Yorkshire. The aim here was to enhance our understanding of the results of the NTS-analysis in a more contextual and expansive way. We wanted to identify how, where, why and when public transport may be experienced as inadequate by young people, as well as how they manage this in their employment and job search activities. We were particularly interested to explore the importance young people place on public transport services and how they themselves would solve inadequacies in its provision. We also wanted to find out about and communicate to policymakers and planners in WYCA the social consequences of their barriers to public transport.

We undertook 30 interviews to provide a good mixture of age, gender and ethnicity, but mostly to get a balance between young people in city centres, outer urban and semi-rural areas. To this end, we used our job accessibility map for the West Yorkshire region (Figure 8.2), and selected the 3 local authorities of Leeds, Bradford and Calderdale to conduct 10 interviews in each, as these provided three contrasting local employment contexts and public transport systems (see section 8.3).

The interviews were conducted during Youth Obligation workshops at the local job centres in the centre and periphery of each local authority, which allowed us to further capture a mix of urban and rural contexts. These workshops are obligatory for all unemployed aged 18-24 in Britain who receive jobseeker's allowance (Universal Credit), during which groups of 5 to 10 job young unemployed receive work-related training or information about apprenticeships. This allowed us to quasi-randomly select participants for one-on-one in-depth interviews during each workshop (up to 5 interviews per workshop). The interviewed young people were all within the age range of 18 to 22, entailing both

[27] The NTS only registers whether a person has an educational qualification and does not provide any further individual or household details.

male (16) and female (14) job seekers in each of the three local authorities. Most young people still lived at home with their parents and had completed up to one or more years in college, while one in three had only finished high school. Special permission to access interview participants at the local job centres was obtained through a collaboration with the UK Department for Work and Pensions (DWP) and the West Yorkshire Combined Authority (WYCA).

The interviews were semi-structured around open-ended questions focussed on the following topics: socio-demographic profile of the interviewees (personal and family background); employment and travel-to-work history; job search horizon; experience and willingness to travel; transport used to travel to job interviews; and transport problems. The semi-structured interview guide (Table 11.13) allowed us to adjust the order and flow of the interview questions based on the interaction with the participant and follow-up questions (Robson and McCartan, 2016). Maps of the region and public transport network were used during the interviews to gain an understanding of their job search horizon and knowledge of local public transport services. Note that the DWP expects job seekers to travel up to 90 minutes to take up employment. The interviews lasted between 20 to 30 minutes, all of which were anonymised and recorded in audio file format in order to be transcribed for subsequent analysis using NVivo 12.

We used cluster analysis to examine variations in young people's *experiences* of public transport job accessibility, for which we coded and categorised the young people based on their urban/ rural residential locations in Leeds, Bradford and Calderdale, access to public or private transport, job search horizon (areas and maximum commute time) and reported transport problems. We further categorised the young people based on their individual and household characteristics including gender, educational level and household type (e.g. having children, living with parents), to assess whether these affected their experiences of public transport job accessibility.

8.3 Description of the case study area

The case study area where we applied our 3-pronged methodological approach was the West Yorkshire region, a metropolitan area of approximately 2.3 million people in the North of England comprising the five local authority areas of Leeds, Bradford, Wakefield, Calderdale and Kirklees (Figure 8.1). Of these, Leeds constitutes the largest local authority with a population of nearly 780,000 residents. The region constitutes a labour market area with firmly established daily commute patterns between the five local authorities, but they vary substantially in terms of employment contexts and public transport provision.

Leeds forms the largest employment centre with over 40% of all jobs in the region and has the lowest youth (aged 16-24) unemployment rate of 12.3%, as compared to nearly 13% on average for England. Bradford, the second largest local authority in the region, has many small and medium-sized enterprises, but also has a notoriously high youth unemployment rate of 17.9%. The more rural local authorities of Calderdale, Wakefield and Kirklees, on the other hand, largely depend on central Leeds and Bradford for employment, with youth unemployment rates varying from 14.9% in Kirklees to 16.4% in Wakefield respectively (ONS, 2017).

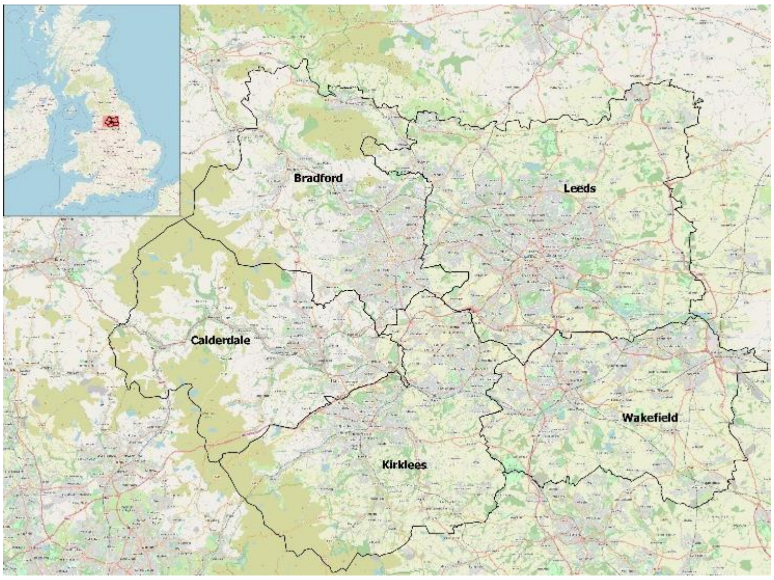


Figure 8.1 Study area of West Yorkshire in the UK

While Leeds and Bradford have extensive bus and rail services in and around their centres, they lack integrated or connected public transport networks such as in other metropolitan areas in England (see also (Mattioli, 2017, Lucas et al., 2019b) and offer poor availability of services in off-peak hours, while peripheral locations and deprived neighbourhoods are often under-served by public transport. The smaller local authorities have rail access in the largest settlements and rely on buses for local transport, but facing similar limitations in public transport supply as Leeds and Bradford. The West Yorkshire Combined Authority (WYCA), which is the local transport authority, acknowledges that local bus services often take a long time to reach their destination, do not always run to timetable or fail to turn up at all, in particular in off-peak hours (WYCA, 2017). The public transport system further lacks integration, with different service operators and limited integrated ticketing options, making it hard to know the actual price of a trip. Whilst the WYCA identifies young people as the biggest growth market and seeks to ensure that public transport is accessible to them (WYCA, 2017), little is known about the role public transport plays in young people's job access.

8.4 Discussion of results

In this section of the paper, we first discuss the results of our public transport job accessibility opportunity measure using West Yorkshire as the case study. We then present the findings of our NTS modelled analysis in order to demonstrate the relationship between public transport job accessibility levels and young people's recorded experience of accessibility to employment. Finally, we present the key insights that were derived from in-depth interview with jobseekers, so as to look at their experienced job accessibility in more detail and better understand the barriers, consequences and potential policy solutions.

8.4.1 Public transport job accessibility opportunity analysis

Figure 8.2 shows the spatial pattern of public transport job accessibility levels for West Yorkshire, as classified on the basis of deciles reachable jobs. The darker LSOAs represent higher levels of job accessibility, and vice versa. This implies that job seekers residing in accessibility-rich LSOAs have greater access to jobs and, hence, will be more likely to gain employment than job seekers living in an accessibility-poor LSOA. The of accessibility pattern reflects the large concentration of employment in Leeds city centre and the radial nature of the public transport network, with bus and train services on the main corridors in the urban centres and few connections that branch out to smaller cities and towns in the urban periphery.

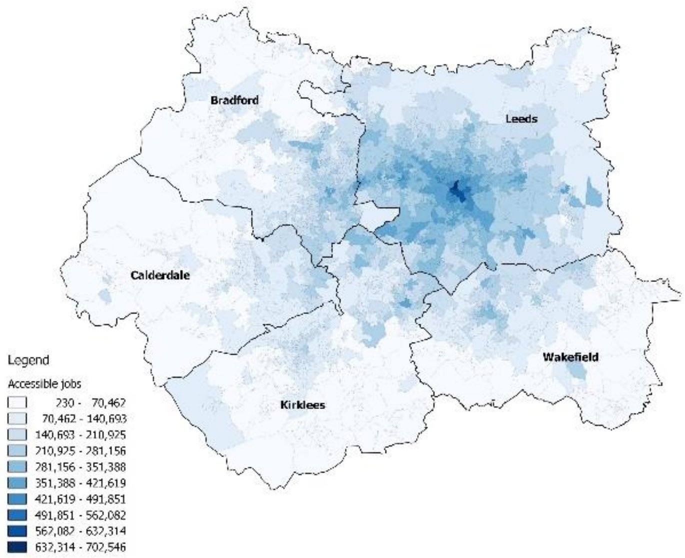


Figure 8.2 Public transport job accessibility in West Yorkshire

When we distinguish these public transport job accessibility levels by types of employment, based on industry sectors (SIC 2007), the accessibility pattern for the region clearly changes. We mapped the job accessibility levels for two distinctive sectors, the service sector in Figure 8.3a and the manufacturing sector in Figure 8.3b, as classified on the basis of deciles[28]. The spatial pattern of public transport accessibility to service sector jobs closely follows the overall accessibility patterns for West Yorkshire, with Leeds clearly providing the highest job accessibility levels. Accessibility to jobs in the manufacturing sector, on the other hand, shifts the accessibility pattern towards the core of the region, including Bradford, Kirklees and Calderdale, which reflects the spatial distribution of manufacturing jobs across the region. This implies that job seekers residing in these areas could be well-off when looking for jobs in the manufacturing industry, but may experience difficulties when searching for service sector jobs.

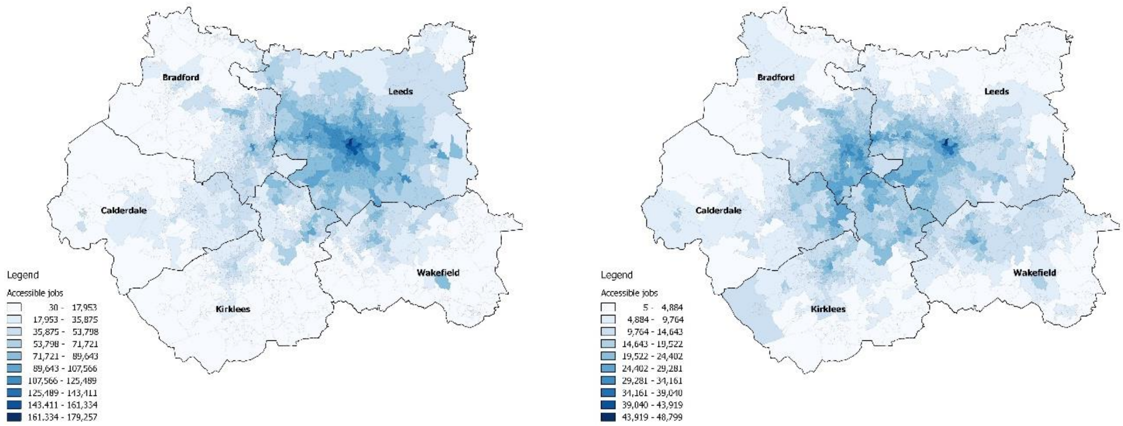


Figure 8.3 (a) PT accessibility to service sector jobs; (b) PT accessibility to manufacturing jobs

The analyses of public transport job accessibility levels in West Yorkshire thus clearly show that variations in the coverage of the public transport network in combination with the spatial distribution of (different types of) employment opportunities results in substantial job accessibility disparities across the region, in particular between the job rich city centre of Leeds and the smaller cities and towns in the urban periphery.

8.4.2 National Travel Survey micro-analysis

In this section, we report and discuss the results of the logit models on the relationship between public transport job accessibility levels and the probability of (young) unemployed to have turned down a job due to inadequate public transport services [29], whilst controlling for individual, household and neighbourhood characteristics. We present models for young unemployed (aged 16-24) and for all

[28] Table 11.14 in the appendix provides the average job accessibility levels by industry sector for West Yorkshire and for each of the five local authorities.

[29] As mentioned before, the NTS only includes specific questions about transport-related difficulties 'on the way to work', which we interpret here as job accessibility-related.

unemployed (aged 16-74), as this allows us to assess the differential employment effects of public transport job accessibility. To compare and interpret the estimated effects we use 'odds-ratios', which describe the ratio of the probability of unemployed having turned down a job, relative to the probability of having not turned down a job.

Table 8.2 shows that our job accessibility measure yields a significant and negative coefficient in both models, in particular for the young unemployed. This implies that higher levels of public transport job accessibility *decrease* the probability that they have turned down jobs, as indicated by the lower odds-ratio of 0.046 for young unemployed as compared to 0.445 for all unemployed. We further found similar, albeit smaller, effects for all economically active individuals (i.e. those employed or unemployed, exclusive of students), which are reported in the appendix (Table 11.15). It therewith supports evidence from our previous study (Bastiaanssen et al., 2021a), in that higher levels of public transport job accessibility could improve youth employment probabilities.

Of the other transport variables in the models, not having a driving licence is only significant for all unemployed and increases the probability of having turned down a job, as indicated by the odds ratio of 1.625. For the young unemployed this variable is only significant at the $p<0.10$ level, which may result from their lack of access to private vehicles. However, not having access to a household car substantially increases the probability of having turned down a job for both groups of unemployed, as indicated by the odds-ratios of 2.231 for the unemployed and 2.106 for young unemployed. These results closely align with previous evidence on the importance of car access among young people (Bastiaanssen et al., 2020), while reliance on public transport services may offer a poor alternative to access employment opportunities.

While most other individual and household variables proved insignificant, having an educational qualification yielded a significant and negative coefficient in both models, i.e. is associated with a higher probability that especially young unemployed have turned down a job. Previous studies among young job seekers in Edinburgh (McQuaid et al., 2001) and Belfast (Pitcher and Green, 1999, Green et al., 2005) found that having qualifications were related to larger job search horizons and increased potential travel-to-work times, which may therefore make them more prone to also experiencing transport difficulties on the way to work.

We further find no statistically significant relationship between (higher) median neighbourhood income levels and the probability of having turned down a jobs, which implies that residing in more affluent neighbourhoods, with potentially less job competition, does not seem to affect job uptake.

Table 8.2 Logit model of probability 'Turned down job in last 12 months due to inadequate PT'

Variables	Unemployed (aged 16-74)		Young unemployed (aged 16-24)	
	Coefficients (SE)	**Odds-ratio**	**Coefficients (SE)**	**Odds-ratio**
Dependent variable				
Turned down job (1: yes/ 0: no)				
Individual & household variables				
Age/100	-0.945 (0.985)		-3.048 (7.452)	
Female	-0.007 (0.211)		0.152 (0.322)	
Single person household	-0.200 (0.300)		-0.806 (1.072)	
Educational qualification	1.373** (0.407)		2.169* (1.046)	
No driving licence	0.485* (0.238)	1.625	0.665 (0.387)	
No household car(s)	0.803*** (0.232)	2.231	0.745* (0.355)	2.106
Neighbourhood & Accessibility variables				
Median neighbourhood income level/1,000	0.005 (0.008)		0.005 (0.015)	
Public transport job accessibility measure/1,000,000	-0.809* (0.355)	0.445	-3.089* (1.437)	0.046
Constant	-4.107*** (0.630)		-3.252 (2.361)	
Wald Chi-Squared statistic	40.65***		16.57*	
Pseudo R2	0.0689		0.0952	
N	1,538		532	
Mean public transport accessibility	*444,062*		*333,315*	

Significance levels: *: 0.05%, **: 0.01%, ***: 0.001%

The NTS micro-analysis clearly showed that while young unemployed in particular have turned down jobs due to inadequate public transport services, higher levels of public transport job accessibility and having access to a household car would *decrease* the probability that they have turned down jobs. Yet, it remains unclear from the analysis in what respects public transport is experienced as inadequate amongst young people. To explore this, we turn to in-depth interviews with young job seekers in West Yorkshire.

8.4.3 Interviews with young job seekers in West Yorkshire

To gain a deeper understanding in the light of the previous quantitative data analysis of young people's reported experiences with public transport to access employment opportunities, we conducted 30 in-depth interviews with young job seekers at local job centres in Leeds, Bradford and Calderdale (10 in each). Figure 8.4 shows the residential locations (postcode sectors) of the young job seekers in West Yorkshire in relation to their public transport job accessibility levels, who resided near the city centres, in outer urban and semi-rural areas of the three local authorities, thereby experiencing different local employment and public transport contexts.

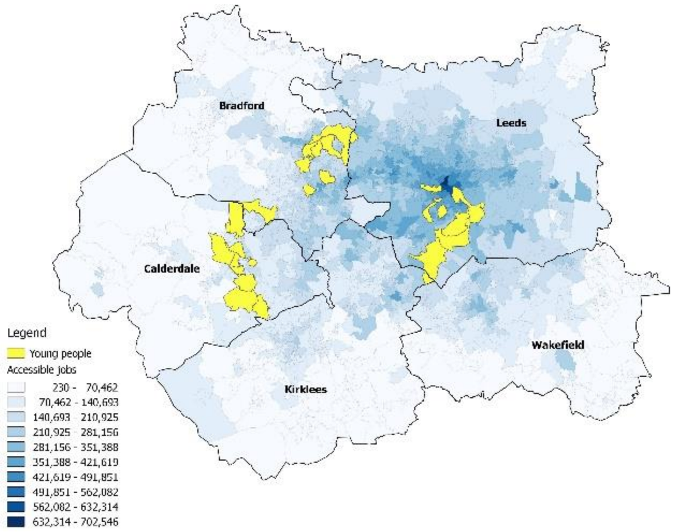


Figure 8.4 Residential locations of young job seekers in West Yorkshire

The interviews with the young job seekers highlighted the importance of the area where they lived in terms of their experiences of accessing employment opportunities, which related to two main elements: (barriers to) suitable employment opportunities in the area of residence and (barriers to) the ability to travel to employment opportunities outside their local area.

8.4.3.1 Barriers to employment

In all three local authorities, the young people searched for mainly (low-skilled) jobs in retail, bars and restaurants, (child care) services, warehousing or construction. Nearly all (27) had some job experience in these sectors, typically temporary, part-time, jobs in their own city region, while three of them came directly from school. Most young people from Leeds (8) had been searching for jobs for up to 3 months and usually mentioned to have good access to employment opportunities in and around Leeds and therefore typically searched for jobs within their own local authority. The young people in Calderdale (5) and especially in Bradford (9), on the other hand, had often been searching for up to 6 to 12 months and also looked for jobs outside their local authorities, as they referred to a lack of (suitable) job opportunities and higher local job competition. For example, a female job seeker from Bradford stated: *"I've been quite frequent with applying for jobs but it's just really hard. I think it's just really competitive. I live in Bradford so it'd be easier, quicker to travel, but I am also looking in Leeds, which has quite a few jobs*" (female, age 21, Bradford Westford House, 09/04/2019), while others mentioned lack of skills and work experience as an important job barrier: "*A lot of these places require you to have prior job experience, but I'd get prior job experience with that job, so it's a bit of a loop"* (male, age 22, Bradford Westfield House, 11/04/2019).

In terms of job search patterns, clear gender differences were manifest: while female job seekers in all local authorities had typically restricted their job search areas to their own or adjacent local authorities (up to 30 to 45 minutes' travel time), male job seekers in especially Calderdale and Bradford also searched for jobs in the wider West Yorkshire region (often 60 to 90 minutes' travel time). Most female job seekers referred to a lack of knowledge with places outside their local authority and/or were unfamiliar with using trains to travel longer distances, for example a female job seeker from Calderdale stated: *"I keep it to Halifax because I'm closer to Halifax. I don't know a lot of places, so I know what I'm like, I get lost."* (female, age 21, Halifax, 08/04/2019). The male job seekers, on the other hand, often had prior work experience outside their local authority and had their job search horizon mainly limited by public transport availability and costs (discussed below). These findings are in line with previous studies among job seekers in the UK (e.g. (McQuaid et al., 2001) and with average commute times for West Yorkshire, which are typically higher in rural areas (on average 54 minutes) as compared to urban areas (46 minutes) due to the paucity of jobs and among men (DfT, 2019). While job search horizons of young (male) job seekers in Calderdale and Bradford thus indicate relatively high commuting tolerances, overall, their reliance on buses and higher travel costs seem at odds with the 90 minutes' travel time to take up employment as generally expected of job seekers by the UK Department for Work and Pensions.

8.4.3.2 Barriers to transport

Most young people mentioned to rely on buses to travel to job interviews and work locations, while train services were often considered expensive or simply not available in their neighbourhoods and/or not connecting them to peripheral job locations. In particular, those residing in Calderdale (8) and the outskirts of Bradford (5) mentioned poor availability and reliability of bus services, especially in off-peak hours, to (shift)work in peripheral job locations. For example, a female job seeker from Bradford stated: *"We have to travel an hour and a half, but that's a bit extreme. I went to an interview in East Garforth [east of Leeds, JB] before, so that's a bus, a train, a bus. But where I live the buses don't start running until about half past six, so if you had to start at seven and it's an hour and a half commute, it's not going to work."* (female, age 18, Bradford, 09/04/2019). For three job seekers from Bradford, poor public transport availability in off-peak hours was a reason to have turned down jobs, for example a male job seeker from Bradford stated: *"It was around Skipton, they offered me the job but the buses to the train station start at about half past six, and then the train to Skipton, and the walk from there* *to the place. I wouldn't get there until about twenty past seven. So, I'd obviously be in late every day and it looks unreliable and bad on me."* (male, age 18, Bradford, 09/04/2019). Similarly, a female job seeker from Leeds who had already started a job in the outskirts of Leeds mentioned: "*I had a job in a warehouse in Seacroft but the only buses that run was like every hour, so I had to quit that job. I didn't realise the off-peak bus problems"* (female, age 20, Leeds Eastgate job centre, 08/04/2019). Even if public transport services allow young people to accept a job, transport problems may therefore still threaten their job retention.

Over half of the job seekers in Calderdale (6) and Bradford (5) further mentioned high fare costs when travelling to peripheral job locations and the lack of an integrated public transport network, especially in relation to the prospective low-wage jobs: *"Even when you have a bus pass and you're jumping from one bus to another bus, and it's a different company, you're paying an extra amount of money to get on that bus, just to go to a different part of town"* (male, age 22, Halifax Crossfield House job centre, 10/04/2019). Three job seekers from Calderdale and Bradford had turned down jobs due to affordability issues, as the latter explained: *"I got a warehouse job offered in Pontefract [east of Wakefield, JB], but then I was thinking about how many hours I'll work in the day and how much I'm going to pay for the bus. Mostly my wage is going to the bus and to my rent and food. At the end of the day I'm making about £20, so I'd left that job opportunity"* (male, age 19, Bradford, 09/04/2019). In the context of low-wage jobs, long commutes may therefore impose unrealistic travel burdens on young people (see also (Bastiaanssen et al., 2020).

Young people's experienced accessibility to employment opportunities thus not only relates to journey times, as reflected by our public transport job accessibility measure, but also to the quality of those services, including reliability, fare costs and comfort. Being without a car whilst having a job, however, was often conceived as simply not viable in Calderdale and the outskirts of Bradford. A female job seeker had therefore bought a car with financial help from her parents, and nine others (mostly women) in mainly Calderdale and Bradford often relied on family and friends to drive them to interviews and jobs, especially during off-peak bus service hours. Nearly all young people would have considered jobs outside their job search area if they had a car or driving license and one in four would have also considered different jobs, as explained by a female job seeker from Calderdale who was looking into day care or retail jobs: *"If I had a car I probably would have done community care services because you can drive around and park up. And it will be easier because you can get to places quicker and better"* (female, age 21, Halifax, 08/04/2019). Most young people therefore wanted to obtain a driver's license and buy a car, once they secured employment. This confirms findings from previous studies (see e.g. Chatterjee et al. (2018), indicating that young people who reside outside the main public transport corridors may still be in need of private transport. This also implies that, given their often low-wage jobs, transport-related economic stress and environmental burdens may remain problematic in our current societies (see also Mattioli et al. (2016).

8.5 Discussion and conclusions

This study used a 3-pronged mixed methods approach to empirically examine whether *potential* public transport job accessibility levels matched young people's reported *experiences* of accessing employment opportunities, within an in-depth case study of the West Yorkshire region of the UK. It therefore combined a public transport job accessibility opportunity measure, as developed in our previous GB study (Bastiaanssen et al., 2021a), with young people's reported experiences of accessing employment opportunities using micro-scale analysis of National Travel Survey data and in-depth interviews with young job seekers in West Yorkshire.

Based on analyses of our public transport job accessibility opportunity measure in West Yorkshire, we found that variations in the coverage of the public transport network in combination with the spatial distribution of (different types of) employment opportunities resulted in substantial job accessibility disparities across the region, in particular in peripheral areas. The NTS micro-analysis of the relationship between public transport job accessibility levels and reported experiences of accessing employment opportunities showed that throughout England, young unemployed in particular had turned down jobs due to inadequate public transport services or high fare costs, but that this was much less so among those with higher levels of public transport job accessibility or when they had access to a household car. These findings support evidence from our previous study (Bastiaanssen et al., 2021a), in that higher levels of public transport job accessibility could improve youth employment probabilities.

Finally, the interviews with young job seekers in West Yorkshire highlighted the importance of higher levels of public transport job accessibility opportunity levels, and indicated that their experienced accessibility to employment opportunities included availability, connectivity, reliability and affordability of local bus services, especially in off-peak hours and in peripheral areas, which would need to be incorporated in future accessibility assessments.

What is clearer from our study, is that young people's dependence on public transport services implies that they could benefit from transport strategies targeted at improving their access to jobs, especially those who reside outside the main public transport corridors. This would require better integration of public transport policy, land use planning and social welfare policies, that need to *explicitly* consider the accessibility needs of young people. The 90 minutes' journey time to take up employment as expected of jobseekers in England imposes unrealistic travel burdens on young people, without considering transports and socioeconomic resources. Since public transport commute times in England are on average well below 60 minutes and vary between different regions (i.e. from 47 minutes in Yorkshire to 69 minutes in the South East) and modes (i.e. by bus 39 minutes and by train 59 minutes), this standard should therefore be more locally specific and dependent upon the transport and socioeconomic resources available to job seekers. Since (low skilled) young people in particular have been impacted by the Covid-19 pandemic due to the nature of their work (ILO, 2020), improved public transport job accessibility may be even more important in helping them back to work.

8.5.1 Public policy implications

If public authorities are indeed committed to connecting people to jobs more effectively through public transport in a way that it contributes to inclusive growth, public transport network planning should be based on principles of accessibility planning. It needs to identify where there are shortfalls in existing public transport services and employment opportunities and how these might be addressed. This would include availability, frequencies, routing and scheduling of public transport services, but also the reliability, integration, affordability, and (perceived) safety of public transport services. As shown in this paper, a mixed-methods approach in which accessibility modelling is combined with reported experiences of accessing employment opportunities is particularly useful to identify population groups and areas that are currently under-served by public transport.

As several city regions in England are set to benefit from national government investments that aim to connect people to economic and education opportunities through better local transport[30], the most targeted use of these investments would be those that actually help to improve young people's experienced job accessibility. Since low-skilled youths in particular tend to reside outside the city centres, this suggests that what constitutes improvements in their accessibility is arguably not so much related to large-scale public transport projects in the region, such as the current high-speed Leeds to Manchester rail project.

Instead, it is more about providing reliable (public) transport services, especially also in off-peak hours, between neighbourhoods where low-skilled youths reside and locations with suitable jobs. This also relates to travel costs that can be a significant barrier for job uptake among young people (SEU, 2003, Green et al., 2005, British Youth Council, 2012). Besides improving local public transport services, 'Wheels to Work' schemes in the UK have also been demonstrated to effectively help young people

[30] Twelve city regions in England, including the Leeds City Region (i.e. the West Yorkshire Combined Authority), have been shortlisted to benefit from £1.28 billion of investment from the Transforming Cities Fund programme (which is entirely capital) over a 5-year period from 2018 to 2022, aimed to drive up productivity through improved public and sustainable transport investment.

gain employment by improving their access to jobs, through interest-free loans for mopeds or bicycles and various transport hiring schemes (Lucas et al., 2009). This may be particularly important for young unemployed, given that public transport services to (low-skilled) job locations in the urban periphery and near highways tend to be limited, while young people may lack the financial resources to buy and maintain private cars.

Connecting people to jobs more effectively through public transport also has implications for land use planning, with regards to both the siting of housing and employment. While many jobs and public services have become organised in larger units in car-based business and industrial parks (Turok and Edge, 1999, Houston, 2005), planning new employment developments in closer proximity to job seekers could help over the longer term to improve their job accessibility. In this respect, better data collection with regards to (low-skilled) employment locations would certainly help to more accurately assess young people's accessibility to employment opportunities. Similarly, accessibility could be improved by ensuring that new low-cost housing developments are located near employment opportunities and public services and are well served by public transport. More research is needed to raise the profile of young people with policymakers and service operators, as well as to learn about best practises to improve young people's experienced accessibility to employment opportunities.

Acknowledgements

The authors would like to thank the West Yorkshire Combined Authority and the UK Department for Work & Pensions for their support of this research. Part of this work was based on data from the NTS 2002-2017, produced by the ESRC and supplied by the Secure Data Service at the UK Data Archive.

9. Discussion and conclusions

This thesis has examined the role of transport in employment outcomes within the contexts of Great Britain and the Netherlands. The research was publicly funded by two regional authorities - the West Yorkshire Combined Authority in the UK and the City of Rotterdam in the Netherlands - and therefore focused on both the regional and national levels, with specific attention for young people.

The association between transport access and employment outcomes has received considerable attention among scholars in urban economics, transport geography and sociology (e.g. (Kain, 1968, Wachs and Kumagai, 1973). Much of the early literature derives from Kain's (1968) Spatial Mismatch Hypothesis, who argued that poor access to employment opportunities was a major factor in inner-city unemployment in US metropolitan areas. In the following decades, a large body of studies in US metropolitan areas and, more recently, in some EU cities have examined the association between transport job accessibility and employment outcomes (Gobillon et al., 2007, Ihlanfeldt and Sjoquist, 1998). Most studies suggested a positive association in line with the Spatial Mismatch Hypothesis, but some found insignificant or even negative outcomes. It is important to establish the exact nature of the relationship between transport access and employment outcomes, since transport policies may be motivated by the assumed effects on employment outcomes. It also unclear whether similar patterns would hold in metropolitan areas in Great Britain or the Netherlands and in smaller cities and towns where travel times and distances are shorter and/or where decentralisation of employment is less pronounced (see also (Ihlanfeldt, 1992). While Spatial Mismatch studies in the US have indicated that low-skilled minority youth in particular could benefit from better transport job accessibility, the existing British and Dutch empirical evidence is predominantly qualitative by nature. It thus remains uncertain whether improved transport job accessibility would increase young people's employment outcomes in a similar way.

The overarching objectives of this thesis were therefore twofold. The first objective of this thesis was to enhance the understanding of the relationship between transport job accessibility and employment outcomes in the relatively unexplored contexts of Great Britain and the Netherlands, with specific attention on young people. The poor employment outcomes of young people in both countries (see also OECD (2020) are hypothesised to partially follow from their constrained transport accessibility to job opportunities. The second objective of this thesis was to provide a methodological contribution to the current assessment of the relationship between transport job accessibility and employment outcomes. To realise these objectives, the existing evidence on the linkage between transport job accessibility and employment outcomes has been reviewed and enhanced with case studies in Great Britain and the Netherlands, consisting of a quantitative phase based on the computation of job accessibility measures combined with national individual-level employment probability models, followed by a qualitative phase of in-depth interviews with young job seekers. The comparative element of the research allowed to take different urban and transport contexts into account that may affect job accessibility and, subsequently, employment outcomes.

This last chapter presents a synthesis of the research in this thesis. Section 9.1 summarises the key findings and contributions of the research. Section 9.2 discusses directions for further research, after which public policy recommendations are provided in section 9.3.

9.1 Key findings and contributions

This thesis firstly presented the theoretical framework adopted in the research in chapter 2, followed by a description of the applied research methodology in chapter 3. The remainder of the thesis comprises five sequential chapters based on academic papers (chapters 4 to 8), each of which has addressed a specific research question, arising from gaps in the knowledge on the relationship between transport job accessibility and employment outcomes as identified in chapter 1. This section draws conclusions from the theoretical framework and how this informed the adopted research methodology. It then summarises the key findings of the academic papers and their respective contributions to the knowledge gaps.

Chapter 2 discussed cross-disciplinary theoretical concepts around agglomeration economies, accessibility and social exclusion to enhance the understanding of how people's transport accessibility to, and probability of, employment is shaped and, subsequently, their risk of social exclusion. While the Spatial Mismatch literature emphasises the role of poor transport job accessibility as a major source accounting for adverse employment outcomes, the processes that shape people's accessibility to employment opportunities remained unclear and not properly linked to theoretical concepts. From the theoretical framework, both a structural dimension and an individual dimension to (in)accessibility to employment were discerned. The structural dimension to accessibility is firstly shaped by land-use patterns, in which agglomeration forces generally promote accessibility by geographically concentrating workers and firms, while processes of geographical dispersion of activities tends to counter accessibility (thereby increasing spatial mismatch). The transport system is considered a key determinant of agglomeration and may enhance accessibility, even when land-use patterns are fixed. The individual dimension to accessibility, on the other hand, is shaped by people's 'motility', which relates to the capacity to be mobile, within the context of our highly mobile societies. Motility results from a person's available transport resources and socio-economic resources which, in combination, determine the extent to which they can take advantage of job accessibility. Job seekers' accessibility to employment opportunities and, subsequently, social inclusion, thus follows from both the organisation of the transport system and land-use patterns as well as by his or her capacity to be mobile. This implies that policy strategies aimed at improving people's accessibility to employment opportunities and, in turn, their employment outcomes, are likely to be more effective when they address both the structural dimension and the individual dimension of accessibility.

Chapter 3 described the research methodology applied in this thesis. Due to the interdisciplinary nature of the research, in which urban economic and sociological theoretical concepts were linked and integrated to enhance the understanding of the relationship between transport job accessibility and employment outcomes, the methodology and study design also moved beyond the scope of a single discipline. In an important departure from standard Spatial Mismatch methodologies, this research therefore adopted a multi-instrument approach using different datasets to look at the relationship between transport job accessibility and employment outcomes and combines this with a case study strategy. The multi-instrument approach followed a sequential explanatory design, consisting of a quantitative phase to gain a general understanding of the relationship between transport access and employment outcomes, followed by a qualitative phase to provide further in-depth insight into experiences of accessing employment opportunities. The quantitative phase is based on a systematic review and meta-analysis of the existing quantitative evidence of the relationship between transport access and employment outcomes, followed by the computation of job accessibility measures combined with national and regional secondary employment micro datasets of Great Britain and the Netherlands, to empirically examine the relationship between transport access and individual employment probabilities within these relatively unexplored contexts. The qualitative phase consists of in-depth interviews with young job seekers in west Yorkshire into the role of public transport in their accessibility to employment opportunities, within their real-life context. Due to the public funding of this research by the West Yorkshire Combined Authority in the UK and the City of Rotterdam in the Netherlands, the multi-instrument approach was combined with case studies on both the national and regional level in Great Britain and the Netherlands. The research thereby importantly permitted for triangulation of the results from the quantitative and qualitative methods and data, which was achieved through the following chapters (academic papers) that build on one another in a sequential order.

Chapter 4 addressed the first research question: *"What is the nature of the relationship between transport and employment outcomes?"*. This chapter systematically reviewed the existing empirical evidence of the relationship between transport access and employment outcomes as measured by the probability of employment, with a particular focus on young people in different contexts. It then synthesised this evidence through a meta-analysis to produce general effect sizes of the relationship between transport and employment probabilities and to determine the sources of variation in the mixed empirical results. This chapter thereby addressed the first gap in the knowledge, concerning the empirical evidence on the relationship between transport and employment outcomes, which was not conclusive or consistent and showed mixed results (Ihlanfeldt and Sjoquist, 1998, Gobillon et al., 2007). By systematically reviewing 93 identified empirical studies in mainly US metropolitan areas, *a positive association between transport access and employment outcomes was established*, with varying effects for four identified categories of transport measures (or combinations thereof): car ownership, public transport access, commute times, and job accessibility levels. *This positive association persisted in studies that controlled for endogeneity between transport and employment, but a larger evidence base would be needed to establish a more robust relationship, in particular for cities and towns outside the US-context and with regard to public transport*. Of the 93 identified studies, 20 methodologically comparable studies were selected for inclusion in the meta-analysis. The meta-regression models clearly showed that *car ownership significantly increases individual employment probabilities. The odds of employment amongst individuals with access to a car were found to be nearly 1.8 times higher than for carless individuals. Young drivers benefit from access to household cars when these are not in use by their parents.* The meta-regression models further showed that *longer mean commute times are related to decreased employment prospects*. *With a ten-minute increase in commute time, the relative odds of employment would be expected to decrease by a factor of 0.14. Young people in particular, were found to be more sensitive to the time and cost implications of longer commutes.* Although meta-analyses had previously been conducted to establish the relationship between transport and urban agglomeration economies (Melo et al., 2009), productivity effects (Melo et al., 2013), and regional growth (Elburz et al., 2017), this meta-analysis was the first of its kind to assess the specific relationship between transport access and employment probabilities. While the systematic review suggested that better access to public transport and higher levels of job accessibility could increase employment probabilities, more consistent measures of public transport access and job accessibility measures were necessary for meta-analysis. It further suggested that a larger evidence base for cities and towns outside the US-context was needed to establish a more robust relationship between transport access and employment probabilities.

Chapter 5 addressed the second research question: *"To what extent do higher levels of public transport job accessibility increase employment probabilities?"*. This chapter was the first national study within the context of Great Britain to empirically examine the relationship between public transport job accessibility and employment probabilities, modelled at the micro-level of individuals. It therewith addressed the second identified gap in the knowledge, related to the lack of studies outside the US-context, in particular in smaller cities and towns and with regards to public transport (see also (Ihlanfeldt, 1992). In an important departure from most standard accessibility methodologies in

Spatial Mismatch studies, first a public transport job accessibility measure was developed based on the widely used gravity model that could be applied nationwide and at the very micro spatial level of Lower Layer Super Output Areas (administrative areas each with approximately 620 households), using detailed public transport timetable data and business register micro datasets. This was then combined with national individual-level employment probability models for Great Britain, so that each individual in the dataset was allocated a unique job accessibility level from his or her area of residence. Since the employment models used cross-sectional data from a random population sample, they were corrected for endogeneity between employment and accessibility by applying an instrumental variable approach. The study then estimated the impact of public transport job accessibility on individual employment probabilities, based on a national employment model for Great Britain and for various geographical area types and population groups, with a particular focus on young people. In line with the Spatial Mismatch literature, *the empirical findings of this study implied that higher levels of public transport job accessibility would increase individual employment probabilities in Great Britain. In particular, individuals residing in urban areas with low car ownership rates would derive the greatest benefit from improved public transport job accessibility. For individuals residing in urban areas with ≥30% non-vehicle owning households, a 10% increase in public transport job accessibility yielded an employment elasticity of 0.038.* This relationship was not straightforward without controlling for individual car ownership, due to lack of available data. In rural areas, higher employment and vehicle ownership rates make individuals less sensitive to public transport, while average public transport job accessibility levels were too low to yield differential employment effects. While it remains uncertain how these changes in individual employment probabilities will affect overall employment, in areas of high unemployment some of this could well be additional at the national level. By combining the employment models with a UK dataset of median neighbourhood (LSOA) household income levels, the study further established that *public transport job accessibility levels were typically lowest in poorer neighbourhoods, where an improvement would increase individual employment probabilities most. The study also showed that mainly lower educated groups and young people would benefit from better public transport job accessibility.* These results support recent evidence of the positive impact of higher levels of public transport job accessibility on employment probabilities in some European metropolitan areas (e.g. (Korsu and Wenglenski, 2010, Matas et al., 2010, Di Paolo et al., 2014).

Chapter 6 addressed the third research question: *"To what extent do higher levels of public transport and bicycle job accessibility and vehicle access increase employment probabilities?"*. In this chapter, and in an important departure from both the British study in chapter 5 and the aforementioned studies in some European metropolitan areas, a Dutch national employment micro dataset was combined with a detailed public transport-and-bicycle job accessibility measure, national vehicle registration and household income datasets, which were missing in the previous British study. The chapter aimed to test whether the same patterns from the British study would hold in the quite different urban and transport context of the Netherlands, with a relatively well-developed public transport and bicycle system and less peripheral urbanization and decentralization. All employment models were also based on cross-sectional data from a random population sample and therefore corrected for endogeneity between job accessibility, vehicle ownership and individual employment outcomes by applying an instrumental variable approach. In line with the empirical evidence for Great Britain, *this study found that higher levels of public transport-and-bicycle job accessibility could improve individual employment probabilities in urban areas, while in rural areas vehicle ownership is a more important factor in driving employment outcomes. A 10% increase in public transport-and-bicycle job accessibility yielded an employment elasticity of 0.017 in urban areas. In contrast with our British study, in rural areas a 10% accessibility increase also yielded a significant employment elasticity of 0.002, while the uplift on employment probability from having access to a household vehicle was 0.012.* By matching the employment models with an individual-level household income micro dataset, the study further revealed - in line with the evidence for Great Britain - that *low-income groups could benefit from both improved public transport-and-bicycle job accessibility and household vehicle access, while we also did not find significant effects for high income groups in the Netherlands. A 10% increase in public transport-and-bicycle job accessibility yielded an employment elasticity of 0.017 for low-income groups, while the uplift on employment probability from having access to a vehicle is 0.055.* In contrast with the British evidence, *low-educated groups and most older age groups could benefit from higher public transport-and-bicycle job accessibility levels, whereas middle-educated groups and especially young people were sensitive to vehicle ownership.*

Chapter 7 addressed the fourth research question: *"To what extent do people in metropolitan areas benefit from higher levels of public transport and bicycle job accessibility and vehicle access?"*. This chapter built on the national study for the Netherlands (based on a random population sample) in chapter 6, and utilized a cross-sectional administrative employment micro dataset providing a full population sample of the Rotterdam-The Hague Metropolitan Region (MRDH-region), combined with detailed urban-rural classification and household income datasets, to empirically examine the differential employment effects of job accessibility and vehicle access for different urban areas and income groups in this metropolitan region. An instrumental variable approach was again applied to control for endogeneity in the relationship between job accessibility, vehicle ownership and individual employment outcomes. This work was supported through a PhD Prestige Grant, awarded by the World Conference on Transport Research Society (WCTRS), on the basis of a research proposal and subsequent paper submitted to, and presented at, the 2019 WCTR Conference in Mumbai. In line with the empirical evidence for the Netherlands, *this study established that higher levels of public transport-and-bicycle job accessibility and household vehicle ownership increases employment probabilities of individual who reside in urban areas, but also that people residing in high-urban areas are most sensitive to job accessibility changes, while vehicles access plays a more important role in low-urban areas.* In contrast with the evidence for the Netherlands in chapter 6, this study further identified that all income groups were sensitive to higher levels of public transport-and-bicycle job accessibility and household vehicle access. *Individuals in the lowest household income quartile would benefit most from higher levels of public transport-and-bicycle job accessibility and vehicle access*, *and this positive employment effect decreases with increasing income levels. A 10% increase in public transport-and-bicycle job accessibility yielded an employment elasticity of 0.395 for the first income quartile, which then decreased to 0.139 for individuals in the second income quartile. For vehicle ownership we found a similar pattern, where the uplift on employment probability from having access to a household vehicle was 0.413 for the lowest income quartile and 0.229 for the second income quartile.* The usage of these detailed micro datasets of the full population thus seem essential to accurately assess the relationship between job accessibility and employment outcomes, which is not fully captured by small populations samples used in prior studies. Very few studies have also examined transport job accessibility effects by income class, while a study by Hu (2016) in the Los Angeles Metropolitan Area only found positive effects among medium- to low-income groups, but not for the lowest or higher income groups. This study of the Rotterdam-The Hague Metropolitan Region established that low income groups, in particular, are sensitive to higher levels of job accessibility and vehicle access.

Chapter 8 addressed the fifth research question: *"To what extent does potential public transport job accessibility match young people's experiences of accessing employment opportunities?"*. This chapter used a 3-pronged mixed methods approach to empirically examine the extent to which *potential* public transport job accessibility opportunity levels matched young people's *experiences* in accessing employment opportunities. It therefore combined the public transport job accessibility opportunity measure developed in chapter 5 with young people's reported experiences of accessing employment opportunities using micro-scale analysis of the UK National Travel Survey and in-depth interviews with young job seekers in West Yorkshire, UK. This chapter addressed the third identified gap in the knowledge, concerning differences between measured and experienced job accessibility. The study found that variations in the coverage of the public transport and land use system resulted in substantial job accessibility disparities across the region. It further showed that *young unemployed in particular had turned down jobs due to inadequate public transport or high fare costs, but that this was much less so among those with higher public transport job accessibility levels or with access to a* *household car.* These findings confirmed the positive relationship between higher levels of public transport job accessibility and employment probabilities, as established in chapter 5. The interviews with young low-skilled job seekers in West Yorkshire further indicated that their experienced accessibility to employment opportunities included availability, reliability, connectivity and affordability of local bus services, especially in off-peak hours and in peripheral areas. In particular, *those residing in areas with low job accessibility levels experienced poor availability and reliability of bus services and high travel costs to job locations in the urban periphery, especially in relation to the prospective (low-wage) jobs. Due to these transport barriers, several young people had missed job interviews or turned down jobs*. These findings closely align with existing empirical evidence on job accessibility problems among young people in the UK (e.g. (SEU, 2003, Green et al., 2005, British Youth Council, 2012) and emphasise the need to improve their transport access.

What is clear from the previous chapters, is that while most of the Spatial Mismatch literature has been conducted within the context of US metropolitan areas, similar patterns do hold in the UK and the Netherlands, but only in certain contexts. In particular, job seekers without access to private vehicles, such as young people, low income and lower educated groups and those residing in urban areas under-served by public transport, such as peripheral and deprived neighbourhoods are sensitive to higher levels of job accessibility. While the employment models in chapters 5 to 7 were corrected for endogeneity in the relationship between job accessibility and employment probabilities by using an instrumental variable approach, this relationship was inferred from cross-sectional data and therefore needs to carefully interpreted because temporality is not known. As discussed in chapter 4, longitudinal datasets have been used in past studies to tease out endogeneity (see e.g. Blumenberg, 2008; Gurley & Bruce, 2005), which generally also established that higher levels of job accessibility increases employment probabilities, although many of these studies lacked complete datasets between baseline and follow-up surveys to fully establish an exogenous relationship. In chapter 8, the interviews with young job seekers in West Yorkshire further revealed that a person's experienced job accessibility goes beyond door-to-door journey times and includes e.g. frequencies and reliability of services, travel costs, comfort and (perceived) safety. This implies that job seekers could benefit from more targeted transport policy strategies that *explicitly* consider their accessibility needs, given the transport and socioeconomic resources available to them. A multi-instrument approach in which quantitative data analysis and accessibility modelling is combined with qualitative data on experienced accessibility can be particularly useful to identify the accessibility needs of different population groups. When employment prospects of job seekers are influenced by job accessibility, as shown by the findings of this thesis, it can be argued that public intervention is necessary, as those without access to private vehicles often cannot personally increase their accessibility.

9.2 Future research

The research for this thesis could be expanded in several directions with regards to methods, datasets and policy investigations, which are successively discussed below.

9.2.1 Methods

A first direction for pursuing future research would be the refinement of the job accessibility measurement, both in terms of the land-use and transport components. With regard to the land-use component, the accessibility measures applied in this thesis were computed based on the total number of reachable jobs. However, chapter 8 indicated large disparities in levels of accessibility by job type in the West Yorkshire region. A promising future research direction would be to explore how the match between job requirements and workers' skills or educational levels could be incorporated in job accessibility measures. This would result in more accurate job accessibility levels for workers and helps to address the issue of skills mismatches, due to which job seekers may not be able to take advantage of close proximity to job opportunities (see e.g. (Ellwood, 1986, Berechman and Paaswell, 2001, Houston, 2005). This also relates to the usage of job vacancies by occupational classes, which would better reflect actual job openings available to job seekers, as shown in previous studies (e.g. Shen (Shen, 2001, Kawabata, 2003).

With regard to the transport component, the accessibility measures applied in this thesis were computed based on travel times to jobs, which were then discounted through a decay function based on travel time. In line with previous studies (e.g. (Bocarejo and Oviedo, 2012, Farber et al., 2016), however, chapter 8 indicated that not only the availability, frequency and travel times of public transport services affected experienced accessibility to jobs, but also the reliability or services, comfort, fare costs, (perceived) safety and many other intervening factors. While some studies have suggested methods to include fare costs in accessibility measurements (e.g. (Bocarejo and Oviedo, 2012), more research is necessary to explore how the other aforementioned intervening factors can be adequately integrated in job accessibility measures. A related issue would be the incorporation of local job competition in job accessibility measures, as this may substantially affect the number of job opportunities available to workers, in particular at the bottom-end of the labour market (van Wee et al., 2001, Bunel, 2012). Some studies (e.g. (Geurs and van Wee, 2004, De Jong et al., 2007) have further suggested the usage of utility-based accessibility measures (including logsum accessibility), which focus directly on the economic benefits people derive from access to spatially distributed employment opportunities, but these are also more complex and difficult to communicate. It would require further research to examine the extent to which utility-based measures can be used to assess employment outcomes.

A second research direction would be to further explore the individual component of accessibility. The Capabilities Approach (Sen, 1979, Sen, 2009) and the concept of motility (Kaufmann, 2002, Kaufmann, 2004) draw attention to the various factors that influence a person's ability to be mobile, including access to different forms and degrees of mobility, but also the competence to recognize and make use of access, and the appropriation of a particular choice, which all determine the extent to which a person can take advantage of transport job accessibility. It follows that all of these components may therefore play a role in shaping the extent to which job seekers can actually appropriate potential accessibility to employment opportunities. Few recent studies have operationalized accessibility as capability and motility (e.g. (Ryan et al., 2015, Kaufmann et al., 2017), but this has not been adopted in job accessibility measurements. While this thesis showed that levels of potential job accessibility largely matched experienced accessibility to employment opportunities through in-depth interviews with young job seekers in West Yorkshire, more bottom-up research is needed to explore how the various components of motility affect people's job accessibility. Place-based accessibility measures as applied in this thesis do not incorporate this individual component, but more sophisticated people-based accessibility measures (see e.g. (Kwan, 1998, Neutens et al., 2012) could capture interpersonal differences and the extent to which this affects a person's accessibility to employment opportunities. This could also be extended beyond the spatial domain as ICT allows people to access employment opportunities without physical mobility (Kenyon et al., 2002, Banister and Hickman, 2006), but this may be a less viable option for low-skilled jobs.

A third direction for future research would be to further explore the labour supply effects of improved transport job accessibility and the contribution of employment uptake to the economy. While this thesis has focussed on the role of job accessibility in employment probabilities, there may well be a labour supply employment effect from inducing more people to enter the labour market. Improved transport job accessibility may increase the willingness and ability of individuals to participate in the labour force and could therefore influence both the employment rate and labour force participation rate (McQuaid et al., 2001). Various studies have also shown that improved job accessibility lead to increased wages and hours worked (see e.g. (Sanchez, 1999, Danziger et al., 2000, Rotger and Nielsen, 2015). It further remains uncertain how employment effects of job accessibility would work out on the national level. A reasonable assumption is that there is a net economic impact from a redistribution of employment to an area with higher unemployment through the user benefits related to a change in job accessibility (i.e. reduced travel time or costs), but more research is needed to examine these distributional effects. A related issue are the labour demand side effects of improved job accessibility, which plays out principally through better connectivity of workers and firms promoting agglomeration of economic activities (see also (Banister and Berechman, 2001), thereby increasing productivity and the demand for labour. A British study by Gibbons et al. (2012), for example, found increased firm entry and employment near major roads following from improved car job accessibility, but this does not necessarily increase overall firm employment when these displace existing firms (see also (What Works Centre, 2015) report for further discussion). Also, continuing processes of agglomeration often lead to increases in housing and commuting costs, which may particularly affect job accessibility of low-income groups (Fujita and Thisse, 2002, Glaeser and Kohlhase, 2004). More research is therefore required that examines the downside of agglomerations effects on (experienced) transport job accessibility and employment outcomes.

9.2.2 Datasets

A fourth research direction would be utilising longitudinal datasets and transport-related 'shocks' to assess the relationship between changes in job accessibility and employment outcomes over time. This would also allow to attribute changes in job accessibility levels to changes in the transport system and to changing employment and residential locations, which may all have differential effects as shown in previous studies (see e.g. (Cervero et al., 1999, Geurs and Ritsema van Eck, 2003, Levinson et al., 2010). While this thesis used cross-sectional data to infer a relationship between job accessibility and employment probabilities in which temporality is not known, longitudinal datasets have been used to tease out endogeneity in this relationship (see e.g. (Gurley and Bruce, 2005, Blumenberg, 2008), thereby overcoming the difficulties of finding appropriate instruments. Many existing studies, however, lacked complete datasets between baseline and follow-up surveys to fully establish an exogenous relationship. New longitudinal studies with more complete datasets could help to establish a robust relationship between changes in job accessibility and employment outcomes over time. Some recent studies have further controlled for endogeneity through transport-related 'shocks' such as policy-induced rail infrastructure extensions (e.g. (Rotger and Nielsen, 2015, Tyndall, 2017) and the introduction of a commuter train on a pre-existing rail line (Aslund et al., 2015), but more research is needed to gain a better understanding of the impact on employment outcomes as well as potential displacement effects of new stations, in particular among low-income groups (see also (Padeiro et al., 2019).

9.2.3 Policy investigations

A fifth direction for pursuing future research would be to examine what land-use and transport strategies under which circumstances most effectively help to improve job accessibility and, subsequently, employment outcomes. It is suggested in this thesis that targeted transport strategies could help to improve job accessibility, which is particularly important for disadvantaged groups. Over the longer term, however, job accessibility could also be improved by planning new employment developments in closer proximity to job seekers or by ensuring that new low-cost housing developments are located near employment opportunities and are well served by public transport. Transit Oriented Development (TOD), in which housing, employment and services are planned in close proximity of public transport, has also become a significant way to improve accessibility, facilitate pedestrian- and bicycle friendly environments and support the economic viability of public transport investments (see e.g. (Cervero, 1998, Curtis et al., 2009). Few studies have developed robust identification strategies to measure accessibility changes following from integrated land-use and transport interventions (e.g. Cervero and Duncan (2002), but more research is needed to gain a better understanding of how targeted transport policies and planning of employment, services and housing developments affects job accessibility and employment outcomes.

9.3 Public policy recommendations

This thesis has shown that employment probabilities of job seekers could be improved through higher levels of transport job accessibility. This would require better integration of transport policies, land use planning and social welfare policies that explicitly consider the accessibility needs of different groups of job seekers, in particular those without access to private vehicles and in areas under-served by public transport. As illustrated in the theoretical framework in chapter 2, a person's accessibility to employment opportunities is shaped by the organisation of the transport system and land-use patterns of home and work locations as well as the capacity of individuals to be mobile. Policy strategies aimed at improving people's job accessibility and, in turn, their employment outcomes, are therefore likely to be more effective when they address both this structural dimension and individual dimension of accessibility.

In spite of early Accessibility Planning policies in the UK, which required local transport authorities between 2006 and 2011 to undertake accessibility assessments as part of Local Transport Plans (LTPs) and for which the Department for Transport (DfT) provides annually updated job accessibility indices for England (DfT, 2018), these accessibility assessments are no longer a statutory requirement in LTPs. Yet, an increasing number of studies have since indicated large and widening disparities in accessibility to employment opportunities, particularly affecting job uptake of people without access to private vehicles and residing outside the main public transport corridors (Rae et al., 2016, Curl et al., 2017, JRF, 2018). In contrast to the UK, some Dutch regional authorities (e.g. the Rotterdam-The Hague Metropolitan Region) have started using job accessibility measures to assess socio-economic inequalities, but accessibility planning and measurements lack at the national level (see also Geurs (2018), for discussion). The Dutch Scientific Council for Government Policy (WRR), however, concluded that increasing disparities in accessibility to employment opportunities may reduce the participation of people in Dutch society and prevents the full utilization of the potential labour force, therefore advising the government to address these accessibility disparities in public policies (WRR, 2018). More recently, the Dutch Council for the Environment and Infrastructure (Rli) also concluded that Dutch citizens increasingly experience transport-related problems when accessing employment or public services, due to inadequate or unaffordable public transport services, inability to use a bicycle or lack of a car. They therefore advised the government to make 'access for all' the basic principle of transport policy, on the basis that all citizens should have sufficient possibilities to access key activities on foot, by bicycle or by public transport, within reasonable transport costs (in terms of money, time and effort). According to the Rli, this requires a fundamental change in the current national, regional and local transport policies, which mainly focus on the economic utility of transport investments (Rli, 2020).

9.3.1 Accessibility planning

If public authorities in the UK and the Netherlands are indeed committed to improve job seekers' access to employment opportunities in a way that contributes to their social and economic inclusion, this would require transport policies to be based on principles of accessibility planning. As shown in this thesis, job seekers could benefit from public transport strategies targeted at improving their job accessibility. These need to identify shortfalls in the public transport system and how these might be addressed through targeted interventions and revenue spending support, rather than capital infrastructure projects. Since low-skilled job seekers in particular tend to reside outside the city centres, this suggests that what constitutes improvements in their public transport job accessibility is arguably not so much related to large-scale rail projects, but more about providing adequate local bus, tram and metro services between their neighbourhoods and locations with matching employment opportunities. While ridership levels of (new) public transport services are often monitored by service providers, in general, little attention is being paid to ex-post accessibility evaluations and labour market effects (see also Cervero and Duncan (2002)). People's experienced accessibility also has many components beyond door-to-door journey times and includes availability, frequencies, routing and scheduling of local public transport services, but also reliability, comfort, costs and (perceived) safety, which all affect job seekers' accessibility to employment opportunities. This is particularly important for job seekers without access to private vehicles, such as young people, low income and lower educated groups and those residing in areas under-served by public transport, such as rural areas and peripheral and deprived urban areas. The Dutch cases in this theses have further indicated the substantial accessibility gains of integrated transport systems, in which bicycles play a major role in the first/last mile connections of train journeys (Pucher and Buehler, 2012, KiM, 2016). Recent transport innovations such as shared mobility, Mobility-as-a-Service (MaaS) and automated vehicles also have the potential to offer new mobility options and increase job accessibility, but this requires transport policies targeted at providing these services in neighbourhoods with limited coverage by traditional public transport services, rather than exclusively in the city centres (see Lucas et al. (2019b) for further discussion).

Basing transport policies on principles of accessibility also has implications for land use planning. The decentralisation of employment and services to car-based locations in the urban periphery has made it more difficult for people to access jobs in both the UK and the Netherlands, in particular for those who depend on public transport services (see e.g. (SEU, 2003, JRF, 2018, Bastiaanssen and Martens, 2013, Jeekel, 2015). Planning new employment developments in closer proximity to job seekers could therefore help over the longer term to improve their accessibility to, and probability of, employment. This also relates to the siting of services such as hospitals and schools and retail developments in out-of-town locations that are often under-served by traditional public transport services. In this sense, accessibility planning can provide a basis for better integration of transport policies and land use planning. This also touches on the location of low income and social housing. Both in the UK and the Netherlands, increasing housing prices and a gradual decline in social housing stock in the inner-cities have made many low-skilled workers to relocate to neighbourhoods in the urban periphery, where accessibility to employment opportunities is typically much lower, in particular when relying on public transport. While socio-economic segregation varies between and within Dutch cities this is generally limited due to extensive income- and public housing policies (see e.g. (PBL, 2010), but in the UK rural areas and the poorest neighbourhoods in the periphery of cities and towns are sometimes simply cut-off from job opportunities (Rae et al., 2016, Curl et al., 2017). Job accessibility could therefore also be improved by ensuring that residents of new low-cost housing developments have good access to matching employment opportunities and are well served by public transport. Again, little attention is generally being paid to ex-post accessibility evaluations of land use planning.

It is further important that social welfare policies also consider the role of transport in job seekers' access to employment opportunities. While these typically focus on educational programmes and work-related training, this thesis has shown that better transport access may also increase the labour market position of job seekers. Since low-skilled and young people in particular have been impacted through the nature of their work by the current Covid-19 pandemic (ILO, 2020), transport may be even more important in helping them into employment. Most notably those without access to private vehicles often cannot afford to personally improve their transport alternatives by purchasing cars, but small-scale vehicle donation initiatives in the US (e.g. (Lucas and Nicholson, 2003) and 'Wheels to

Work' programmes[31] in the UK (Lucas et al., 2009) have demonstrated to help job seekers gain employment. Since travel costs can also be a significant barrier for job uptake, in particular among young people who are not in education, employment or training (NEET), concessionary travel cards and reduced fares for young job seekers could be considered to enhance their access to jobs (SEU, 2003, British Youth Council, 2012). This further implies that the standard 90 minutes' journey time expected of jobseekers in the UK and the Netherlands to take up employment, regardless of the time and financial costs of this imposition for individual job seekers, may impose unrealistic travel burdens on people. Since average commute times are below 60 minutes in both countries and also vary between regions and between different transport modes and populations groups, this standard would need to be more locally specific and dependent upon the socioeconomic and transport resources of job seekers.

9.3.2 Accessibility measures and datasets

As shown in this thesis, accessibility measures are particularly useful to identify neighbourhoods that are under-served by the transport system. While the Netherlands currently lacks national job accessibility indices, the UK Department for Transport (DfT) provides readily available accessibility indices for England (DfT, 2018). Yet, these are not available for Wales, Scotland and Northern-Ireland. Since these accessibility indices are based on reachable employment centres (between 0 and 10) within certain travel time thresholds, they also lack information about individual jobs outside these thresholds and neglect the decreasing attractiveness of jobs with increasing travel time and costs. As indicated in chapter 8 of this thesis, the selection of different employment centres and travel time thresholds has substantial implications for the identification of shortfalls in the coverage of the public transport network and the spatial distribution of employment opportunities. This can be overcome by the usage of employment microdata and the estimation of a travel time decay function based on empirical commute time data from the National Travel Survey (see for further discussion (Bastiaanssen et al., 2021a). Using employment microdata also allows for the computation of accessibility measures to jobs by industry sector, which helps to more accurately identify job seekers' access to employment opportunities as shown in chapter 8, but this also increases the burden of data analysis. Existing transport models may, however, also allow for accessibility assessments, as shown by Cervero and Duncan (2002). A recent policy study in the Netherlands (PBL and CPB, 2020) also calculated job accessibility measures using the Dutch National Transport Model (LMS), which were then used within the LMS to identify accessibility changes following from various land-use and

[31] The UK Wheels to Work programs aim at helping people who are unable to take up employment because of a lack of public or private transport, by providing interest free loans for mopeds or bicycles and various transport hiring schemes.

transport interventions. This could further be applied in regional and local transport models to identify effective accessibility strategies.

Better data collection could also help to more accurately assess job seekers' accessibility to, and probability of, employment. For example, both the UK Business Structure Database and the Dutch LISA employment dataset provide detailed information on each business' total employment but do not differentiate between employment by educational or occupational level. This would help to address the associated issue of skills mismatches, but may be costly. A related issue is the lack of transport-related questions in the UK and Dutch Labour Force Survey (LFS), such as which transport modes workers rely on to travel to work or job interviews and whether they have access to private cars. While the Dutch LFS could be combined with a national vehicle registration dataset to identify workers with access to household vehicles, this was not possible for the UK LFS due to a lack of available data. It is important to include these transport-related questions, since the relationship between job accessibility and employment probabilities is not straightforward without controlling for car ownership, as shown in chapter 5 of this thesis. The Dutch National Travel Survey (ODiN), on the other hand, could benefit from incorporating questions around experienced transport difficulties of workers on the way to work or to job interviews, for which it could draw from the UK NTS. This could help to move beyond measuring travel patterns of already mobile groups towards latent travel demand of less mobile groups, thereby addressing issues of economic and social inclusion.

9.3.3 Transport policy appraisal

The employment effects of improved transport job accessibility as discussed in this thesis also have implications for transport policy appraisal. Detailed guidelines for the appraisal of transport projects are provided in the UK (Transport Analysis Guidance, 'TAG') and in the Netherlands (Overview Impacts Investments, 'OEI' in Dutch), which are required for all transport projects/ studies that need government approval. These guidelines are predicated on full employment and frictional unemployment, assuming that improved transport accessibility following from reduced generalised travel cost has labour supply effects (economically inactive to enter the labour market) and productivity effects (those in employment moving to more productive jobs). However, the impact of improved transport accessibility on the economically active moving from unemployment to employment, as shown in this thesis, has remained underexposed in transport appraisal. While the relationship between transport job accessibility and employment probabilities in chapters 5 to 7 has been inferred from cross-sectional data, and therefore has to be carefully interpreted because temporality is not known, past studies using longitudinal datasets (see e.g. Blumenberg, 2008; Gurley & Bruce, 2005) generally established similar patterns. In spite of the pockets of structural unemployment across the UK and the Netherlands, ‘wider economic impacts’ (WEIs) of transport accessibility improvements on structural unemployment and thin labour markets do not feature in the appraisal guidelines. The UK transport appraisal guidance (TAG) further includes a broad spectrum of social and distributional impacts including access to public transport services, with reference to the SEU (2003) report on transport and social exclusion. The Dutch appraisal guidance (OEI), on the other hand, is more limited to distributional effects for regions and populations groups (see (Geurs et al., 2009) for further discussion). Yet, neither of these appraisal guidelines refer to measures of accessibility to employment opportunities or key services such as health services and education, which are essential when basing transport policies on principles of accessibility planning.

10. References

ALAM, B. 2009. Transit Accessibility to Jobs and Employment Prospects of Welfare Recipients Without Cars. *Transportation Research Record: Journal of the Transportation Research Board,* 2110**,** 78-86.

ALONSO, W. 1964. *Location and Land Use: Toward a General Theory of Land Rent*, Cambridge, Mass.: Harvard University Press 11,204 S.

ANDERSSON, F., HALTIWANGER, J. C., KUTZBACH, M. J., POLLAKOWSKI, H. O. & WEINBERG, D. H. 2018. Job Displacement and the Duration of Joblessness: The Role of Spatial Mismatch. *The Review of Economics and Statistics,* 100**,** 203-218.

ASLUND, O., BLIND, I. & DAHLBERG, M. 2015. All aboard, Commuter train access and labor market outcomes. *(Working Paper No. 2015:25)*.

ASLUND, O. O., J.; ZENOU, Y. 2009. How Important is Access to Jobs? Old Question - Improved Answer. *Centre for Research and Analysis of Migration*.

ATKINSON, R. & KINTREA, K. 2001. Disentangling area effects: evidence from deprived and non-deprived neighbourhoods. *Urban Studies,* 31**,** 2277-2298.

BANIA, N., COULTON, C. & LEETE, L. 2003. Public Housing Assistance, Public Transportation, and the Welfare-to-Work Transition. *Cityscape: A Journal of Policy Development and Research,* 6**,** 7-44.

BANIA, N., LEETE, L. & COULTON, C. 2008. Job Access, Employment and Earnings: Outcomes for Welfare Leavers in a US Urban Labour Market. *Urban Studies,* 45**,** 2179-2202.

BANISTER, D. & BERECHMAN, Y. 2001. Transport investment and the promotion of economic growth. *Journal of Transport Geography,* 9**,** 209-218.

BANISTER, D. & HICKMAN, R. 2006. How to design a more sustainable and fairer built environment: transport and communications. *Intelligent Transport Systems, IEE Proceedings,* 153**,** 276–291.

BANSAK, C. A., MATTSON, H. & RICE, L. 2010. Cars, Employment, and Single Mothers: The Effect of Welfare Asset Restrictions. *Industrial Relations,* 49**,** 321-345.

BASTIAANSSEN, J. 2012. Vervoersarmoede op Zuid. Een verkennend onderzoek naar de mate waarin verplaatsingsmogelijkheden van invloed zijn op de arbeidsre-integratie van werklozen [Transport poverty in Rotterdam South. An exploratory study of the extent to which potential mobility affects the job reintegration of unemployed]. *Masterthesis. Nijmegen: Radboud University*.

BASTIAANSSEN, J., JOHNSON, D. & LUCAS, K. 2020. Does transport help people to gain employment? A systematic review and meta-analysis of the empirical evidence. *Transport Reviews,* 40**,** 607-628.

BASTIAANSSEN, J., JOHNSON, D. & LUCAS, K. 2021a. Does better job accessibility help people gain employment? The role of public transport in Great Britain. *Urban Studies***,** 1-21.

BASTIAANSSEN, J., JOHNSON, D. & LUCAS, K. 2021b. Does better public transport-and-bicycle job accessibility and vehicle access increase employment probabilities? A study of The Netherlands. *Urban Studies [forthcoming]*.

BASTIAANSSEN, J., JOHNSON, D. & LUCAS, K. 2021c. Job accessibility and employment outcomes: a case study of the Rotterdam-The Hague Metropolitan Region. *Regional Studies [forthcoming]*.

BASTIAANSSEN, J. & MARTENS, K. 2013. Vervoersarmoede belemmert arbeidsre-integratie [Transport poverty impedes labour reintegration]. *ESB Economic Statistisch Berichten,* 98**,** 654-655.

BAUDER, H. & PERLE, E. 1999. Spatial and skills mismatch for labor-market segments. *Environment and Planning A,* 31**,** 959-977.

BAUM, C. L. 2009. The effects of vehicle ownership on employment. *Journal of Urban Economics,* 66**,** 151-163.

BEE, C. A. 2009. The Effect of Car Ownership on Employment: Evidence from State Insurance Rate Regulation.
BELL, D. N. F. & BLANCHFLOWER, D. G. 2013. Underemployment in the uk revisited. *National Institute Economic Review*.
BERECHMAN, J. & PAASWELL, R. 2001. Accessibility Improvements and Local Employment: An Empirical Analysis. *Bureau of Transportation Statistics*.
BLUMENBERG, E. 2002. On the Way to Work: Welfare Participants and Barriers to Employment. *Economic Development Quarterly,* 16**,** 314-325.
BLUMENBERG, E. 2008. Immigrants and transport barriers to employment: The case of Southeast Asian welfare recipients in California. *Transport Policy,* 15**,** 33-42.
BLUMENBERG, E. & PIERCE, G. 2014. A Driving Factor in Mobility? Transportation's Role in Connecting Subsidized Housing and Employment Outcomes in the Moving to Opportunity (MTO) Program. *Journal of the American Planning Association,* 80**,** 52-66.
BLUMENBERG, E. & PIERCE, G. 2017. The Drive to Work. *Journal of Planning Education and Research,* 37**,** 66-82.
BOCAREJO, S. J. P. & OVIEDO, H. D. R. 2012. Transport accessibility and social inequities: a tool for identification of mobility needs and evaluation of transport investments. *Journal of Transport Geography,* 24**,** 142-154.
BOLAND, A., GEMMA CHERRY, M. & DICKSON, R. 2014. Doing a systematic review; a student's guide. *London: Sage*.
BORENSTEIN, M., HEDGES, L. V., HIGGINS, J. P. T. & ROTHSTEIN, H. R. 2009. Introduction to meta-analysis. *Chichester, UK: Wiley*.
BRITISH YOUTH COUNCIL 2012. Transport and Young People. *BRITISH YOUTH COUNCIL Youth Select Committee*.
BROWN, A. E., BLUMENBERG, E., TAYLOR, B. D., RALPH, K. & TURLEY VOULGARIS, C. 2016. A taste for transit? Analyzing public transit use trends among youth. Journal of Public. *Journal of Public Transportation,* 19**,** 49-67.
BUNEL, M., TOVAR, E. 2012. Local job accessibility measurement: when the model makes the results. Methodological Contribution and Empirical Benchmarking on the Paris Region. *Center for Research in Economics and Management*.
BURCHARDT, T., LE GRAND, J. & PIACHAUD, D. 2002. Introduction' in Hills, J., Le Grand J. and Piachaud D. (2002) Understanding Social Exclusion Oxford,. *United Kingdom: Oxford University Press*.
CASS, N., SHOVE, E. & URRY, J. 2005. Social exclusion, mobility and access. *Sociological Review,* 53**,** 539-555.
CAVACO, S. & LESUEUR, J.-Y. 2004. Contraintes spatiales et durée de chômage. *Revue française d'économie,* 18**,** 229-257.
CBS 2016. Arbeidsdeelname; kerncijfers [Labour participation; key figures] https://www.cbs.nl/nl-nl/visualisaties/dashboard-arbeidsmarkt/werklozen/werkloosheid-naar-leeftijd-en-geslacht.
CBS 2019. Enquete Beroepsbevolking (EBB) [Labour Force Survey] https://www.cbs.nl/nl-nl/onze-diensten/methoden/onderzoeksomschrijvingen/korte-onderzoeksbeschrijvingen/enquete-beroepsbevolking--ebb--.
CEBOLLADA, A. 2009. Mobility and labour market exclusion in the Barcelona Metropolitan Region. *Journal of Transport Geography,* 17**,** 226-233.
CERVERO, R. 1998. *Transit Metropolis: A Global Inquiry*, Washington, D.C.: Island Press.
CERVERO, R. & DUNCAN, M. 2002. Land value impacts of rail transit services in Los Angeles County. *Report prepared for National Association of Realtors Urban Land Institute*.
CERVERO, R., ROOD, T. & APPLEYARD, B. 1999. Tracking accessibility: Employment and housing opportunties in the San Francisco Bay Area. *Environment and Planning A,* 31**,** 1259-1278.
CERVERO, R., SANDOVAL, O. & LANDIS, J. 2002. Transportation as a Stimulus of Welfare-to-Work Private versus Public Mobility. *Journal of Planning Education and Research,* 22**,** 50-63.

CERVERO, R. & TSAI, Y. H. 2003. Job Access and Reverse Commuting Initiatives in California; Review and Assessment. *Transportation Research Record,* 1859**,** 79-86.

CHATTERJEE, K., GOODWIN, P., SCHWANEN, T., CLARK, B., JAIN, J., MELIA, S., MIDDLETON, J., PLYUSHTEVA, A., RICCI, M., SANTOS, G. & STOKES, G. 2018. Young people's travel – What's changed and why? *Review and analysis UWE Bristol, UK, report to department for transport*.

CHEN, Y., JAUPART, P., MORENO-MONROY, A. & PICARELLI, N. 2017. Unequal commutes; Job accessibility & employment in Accra. *Final report C-33401-GHA-1, IGC International Growth Centre*.

CHURCH, A., FROST, M. & SULLIVAN, K. 2000. Transport and social Exclusion in London. *Transport Policy,* 7 195-205.

CLARK, G. 2014. The Son Also Rises: Surnames and the History of Social Mobility. . *Princeton, NJ: Princeton University Press.*

COMPETITIONCOMMISSION 2011. Local bus services market investigation: a report on the supply of local bus services in the UK. *London: Competition Commission*.

COOKE, T. J. 1997. Geographic Access to Job Opportunities and Labor-Force Participation among Women and African Americans in the Greater Boston Metropolitan Area. *Urban Geography,* 18**,** 213-227.

CRANE, J. 1991. The epidemic theory of ghettos and neighborhood effects on dropping out and teenage childbearing. *American Journal of Sociology,* 96**,** 1226-1259.

CRESWELL, W. C. & PLANO CLARK, V. L. 2011. Designing and Conducting Mixed Methods Research Second Edition.

CURL, A., CLARK, J. & KEARNS, A. 2017. Household car adoption and financial distress in deprived urban communities over time: a case of 'forced car ownership'? *Transport Policy,* 65**,** 61-71.

CURRIE, G. & STANLEY, J. 2008. Investigating links between social capital and public transport. *Transport Reviews,* 28**,** 529-547.

CURTIS, C., J.L., R. & BERTOLINI, L. 2009. *Transit Oriented Development: Making it Happen*, Farnham: Ashgate.

DANZIGER, S., CORCORAN, M., DANZIGER, S., HEFLIN, C., KALIL, A., LEVINE, J., ROSEN, D., SEEFELDT, K., SIEFERT, K. & TOLMAN, R. 2000. Barriers to the employment of welfare recipients. In: Cherry, R., Rodgers, W.M. (Eds.), Prosperity for All? The Economic Boom and African Americans. Russell Sage Foundation, New York, NY, pp. 245–278.

DAVIS, J. C. & HENDERSON, J. V. 2008. The agglomeration of headquarters. *Regional Science and Urban Economics,* 38**,** 445-460.

DAWKINS, C. J., SHEN, Q. & SANCHEZ, T. W. 2005. Race, space, and unemployment duration. *Journal of Urban Economics,* 58**,** 91-113.

DE JONG, G., DALY, A., PIETERS, M. & VAN DER HOORN, T. 2007. The logsum as an evaluation measure: Review of the literature and new results. *Transportation Research Part A: Policy and Practice,* 41**,** 874-889.

DE KONING, J., DE HEK, P. & DE VLEESCHOUWER, E. 2017. De ruimtelijke aansluiting tussen vraag en aanbod op de arbeidsmarkt in de Metropoolregio Rotterdam Den Haag [The spatial connection between supply and demand in the labor market in the Rotterdam The Hague Metropolitan Area]. *Rotterdam: SEOR, Erasmus School of Economics*.

DEFRA 2011. Defra classification of local authority Districts and unitary authorities in England and Wales. http://archive.defra.gov.uk/evidence/statistics/rural/documents/ruraldefn/LAClassifications_technicalguide.pdf.

DELBOSC, A. & CURRIE, G. 2013. Causes of youth licensing decline: A synthesis of evidence. *Transport Reviews,* 33**,** 271–290.

DELBOSC, A. & CURRIE, G. 2014. Impact of attitudes and life stage on decline in rates of driver's license acquisition by young people in Melbourne, Australia. *Transportation Research Record,* 2452**,** 62–70.

DELBOSC, A., MCDONALD, M., STOKES, G., LUCAS, K., CIRCELLA, G. & LEE, Y. 2019. Millennials in cities: Comparing travel behaviour trends across six case study regions. *Cities,* 90**,** 1-14.
DÉTANG-DESSENDRE, C. & GAIGNÉ, C. 2009. Unemployment duration, city size, and the tightness of the labor market. *Regional Science and Urban Economics,* 39**,** 266-276.
DFT 2017. Transport Statistics Great Britain 2017. *Department for Transport*.
DFT 2018. Journey Time Statistics; Notes and Definitions. *Department for Transport*.
DFT 2019. National Travel Survey, 2002-2017: Secure Access. [data collection]. 5th Edition. *UK Data Service. SN: 7559, http://doi.org/10.5255/UKDA-SN-7559-5*.
DI PAOLO, A., MATAS, A. & LLUÍS RAYMOND, J. 2014. Job Accessibility, Employment and Job-Education Mismatch in the Metropolitan Area of Barcelona. *IREA and AQR*.
DOBBS, L. 2005. Wedded to the car: women, employment and the importance of private transport. *Transport Policy,* 12**,** 266-278.
DUGUET, E., L'HORTY, Y. & SARI, F. 2009. Sortir du chômage en Île-de-France. *Revue économique,* 60**,** 979.
DUJARDIN, C., SELOD, H. & THOMAS, I. 2008. Residential Segregation and Unemployment: The Case of Brussels. *Urban Studies,* 45**,** 89-113.
DURANTON, G. & PUGA, D. 2004. Micro-foundations of urban agglomeration economies. *Handbook of Regional and Urban Economics; edited by J.V. Henderson and J.F. Thisse, published by North-Holland,* 4.
DURANTON, G. & TURNER, M. A. 2012. Urban Growth and Transportation. *Review of Economic Studies,* 79**,** 1407-1440.
EL-GENEIDY, A., LEVINSON, D., DIAB, E., BOISJOLY, G., VERBICH, D. & LOONG, C. 2016. The cost of equity: Assessing transit accessibility and social disparity using total travel cost. *Transportation Research Part A: Policy and Practice,* 91**,** 302-316.
ELBURZ, Z., NIJKAMP, P. & PELS, E. 2017. Public infrastructure and regional growth: Lessons from meta-analysis. *Journal of Transport Geography,* 58**,** 1-8.
ELLIOTT, A. & URRY, J. 2010. *Mobile Lives*, Routledge.
ELLWOOD, D. 1986. The spatial mismatch hypothesis: Are there teenage jobs missing in the ghetto?, in "The Black Youth Employment Crisis" (R. Freeman and H. Holzer Eds.), University of Chicago Press, Chicago, Il (1986).
EWING, R. & CERVERO, R. 2010. Travel and the Built Environment. *Journal of the American Planning Association,* 76**,** 265-294.
FARBER, S., RITTER, B. & FU, L. 2016. Space–time mismatch between transit service and observed travel patterns in the Wasatch Front, Utah: A social equity perspective. *Travel Behaviour and Society,* 4**,** 40-48.
FARRINGTON, J. & FARRINGTON, C. 2005. Rural accessibility, social inclusion and social justice: towards conceptualisation. *Journal of Transport Geography,* 13**,** 1-12.
FAYYAZ, S. K., LIU, X. C. & PORTER, R. J. 2017. Dynamic transit accessibility and transit gap causality analysis. *Journal of Transport Geography,* 59**,** 27-39.
FOTH, N., MANAUGH, K. & EL-GENEIDY, A. M. 2013. Towards equitable transit: examining transit accessibility and social need in Toronto, Canada, 1996-2006. *Journal of Transport Geography,* 29**,** 1-10.
FRANCE, A., BOTTRELL, D. & HADDON, E. 2013. Managing everyday life: The conceptualisation and value of cultural capital in navigating everyday life for working-class youth. *Journal of Youth Studies,* 16**,** 597-611.
FRANKLIN, S. 2015. Location, search costs and youth unemployment: A randomized trial of transport subsidies in Ethiopia. *Oxford: Oxford University*.
FRANSEN, K., NEUTENS, T., FARBER, S., DE MAEYER, P., DERUYTER, G. & WITLOX, F. 2015. Identifying public transport gaps using time-dependent accessibility levels. *Journal of Transport Geography,* 48**,** 176-187.
FUJITA, M. 1989. Urban economic theory: Land use and city size. *CAMBRIDGE UNIVERSITY PRESS*.

FUJITA, M. & THISSE, J. F. 2002. Economics of Agglomeration. *Cambridge: Cambridge University Press*.
FUJITA, M., THISSE, J. F. & ZENOU, Y. 1997. On the endogenous formation of secondary employment centers in a city. *Journal of Urban Economics*.
FURLONG, A. 2015. *Unemployment, insecurity, and poor work: young adults in the new economy.*, In: Wyn, J. and Cahill, H. (Eds.) Handbook of Children and Youth Studies, p. 531-542. Singapore: Springer.
GAO, S., MOKHTARIAN, P. L. & JOHNSTON, R. A. 2008. Exploring the connections among job accessibility, employment, income, and auto ownership using structural equation modeling. *The Annals of Regional Science,* 42**,** 341-356.
GARASKY, S., FLETCHER, C. N. & JENSEN, H. H. 2006. Transiting to Work: The Role of Private Transportation for Low-Income Households. *Journal of Consumer Affairs,* 40**,** 64-89.
GARNER, B. 2015. Young non-drivers: Will they always steer clear of getting behind the wheel? *Paper presented at 47th Universities' Transport Study Group Conference, January, London*.
GEURS, K. 2018. Transport Planning With Accessibility Indices in the Netherlands. *Discussion Paper, International Transport Forum, Paris*.
GEURS, K. & RITSEMA VAN ECK, J. 2003. Evaluation of accessibility impacts of land-use scenarios: the implications of job competition, land-use, and infrastructure developments for the Netherlands. *Environment and Planning B: Planning and Design,* 30**,** 69-87.
GEURS, K. T., BOON, W. & VAN WEE, B. 2009. Social Impacts of Transport: Literature Review and the State of the Practice of Transport Appraisal in the Netherlands and the United Kingdom. *Transport Reviews,* 29**,** 69-90.
GEURS, K. T., LA PAIX, L. & VAN WEPEREN, S. 2016. A multi-modal network approach to model public transport accessibility impacts of bicycle-train integration policies. *European Transport Research Review,* 8.
GEURS, K. T. & VAN WEE, B. 2004. Accessibility evaluation of land-use and transport strategies: review and research directions. *Journal of Transport Geography,* 12**,** 127-140.
GIBBONS, S., LYYTIKAINEN, T., OVERMAN, H. & SANCHIS-GUARNER, R. 2012. New Road Infrastructure: the Effects on Firms. *SERC DISCUSSION PAPER 214*.
GLAESER, E. L. 1996. Spatial effects upon employment outcomes: the case of New Jersey teenagers. *Discussion paper, New England Economic Review, May/June***,** 58-64.
GLAESER, E. L. & KOHLHASE, J. E. 2004. Cities, regions and the decline of transport costs. *Papers in Regional Science,* 83**,** 197-228.
GOBILLON, L., MAGNAC, T. & SELOD, H. 2011. The effect of location on finding a job in the Paris region. *Journal of Applied Econometrics,* 26**,** 1079-1112.
GOBILLON, L. & SELOD, H. 2007. The effects of segregation and spatial mismatch on enemployment, evidence from france. *CEPR Discussion Papers*.
GOBILLON, L., SELOD, H. & ZENOU, Y. 2007. The Mechanisms of Spatial Mismatch. *Urban Studies,* 44**,** 2401-2427.
GOLUB, A. & MARTENS, K. 2014. Using principles of justice to assess the modal equity of regional transportation plans. *Journal of Transport Geography,* 41**,** 10-20.
GOLUB, A., ROBINSON, G. & NEE, B. 2013. Making accessibility analyses accessible: A tool to facilitate the public review of the effects of regional transportation plans on accessibility. *Journal of Transport and Land Use,* 6**,** 17-28.
GRAHAM, D. J. 2007. Agglomeration, productivity and transport investment. *Journal of Transport Economics and Policy,* 41**,** 317-343.
GRANOVETTER, M. 1995. Getting a job; a study of contacts and careers. . *Chicago: University of Chicago Press*.
GREEN, A. E., SHUTTLEWORTH, I. & LAVERY, S. 2005. Young People, Job Search and Local Labour Markets: The Example of Belfast. *Urban Studies,* 42**,** 301-324.

GRENGS, J. 2010. Job accessibility and the modal mismatch in Detroit. *Journal of Transport Geography,* 18**,** 42-54.
GRENGS, J., LEVINE, J., QING, S. & QINGYUN, S. 2010. Intermetropolitan Comparison of Transportation Accessibility: Sorting Out Mobility and Proximity in San Francisco and Washington, D.C. *Journal of Planning Education and Research,* 29**,** 427-443.
GURLEY, T. & BRUCE, D. 2005. The effects of car access on employment outcomes for welfare recipients. *Journal of Urban Economics,* 58**,** 250-272.
HANDY, S. L. & NIEMEIER, D. A. 1997. Measuring accessibility: an exploration of issues and alternatives. *Environment and Planning A,* 29**,** 1175-1194.
HANSEN, W. G. 1959. How Accessibility Shapes Land Use. *Journal of the American Institute of Planners,* 25**,** 73-76.
HIGGS, G. & WHITE, S. 2000. Alternatives to census-based indicators of social disadvantage in rural communities. *Progress in Planning,* 53**,** 1-81.
HINE, J. & GRIECO, M. 2003. Scatters and clusters in time and space: implications for delivering integrated and inclusive transport. *Transport Policy,* 10**,** 299-306.
HJORTHOL, R. 2016. Decreasing popularity of the car? Changes in driving licence and access to a car among young adults over a 25-year period in Norway. *Journal of Transport Geography,* 51**,** 140–146.
HODGSON, F. C. & TURNER, J. 2003. Participation not consumption: the need for new participatory practices to address transport and social exclusion. *Transport Policy,* 10**,** 265-272.
HOLLOWAY, S. R. 1996. Job Accessibility and Male Teenage Employment, 1980–1990: The Declining Significance of Space?∗. *The Professional Geographer,* 48**,** 445-458.
HOLZER, H. J., IHLANFELDT, K. R. & SJOQUIST, D. L. 1994. Work, Search, and Travel among White and Black Youth. *Journal of Urban Economics,* 35**,** 320-345.
HOLZER, H. J., QUIGLEY, J. M. & RAPHAEL, S. 2003. Public transit and the spatial distribution of minority employment: Evidence from a natural experiment. *Journal of Policy Analysis and Management,* 22**,** 415-441.
HOUSTON, D. 2005. Employability, skills and spatial mismatch in metropolitan labour markets. *Urban Studies,* 42**,** 221-243.
HU, L. 2015. Job accessibility of the poor in Los Angeles. *Journal of the American Planning Association,* 81**,** 30-45.
HU, L. 2016. Job accessibility and employment outcomes: which income groups benefit the most? *Transportation,* 44**,** 1421–1443.
HU, L. & GIULIANO, G. 2017. Poverty concentration, job access, and employment outcomes. *Journal of Urban Affairs,* 39**,** 1-16.
IHLANFELDT, K. 2006. A primer on spatial mismatch within urban labor markets, in: R. J. Arnott and D. P. McMillen (Eds) A Companion to Urban Economics. *Oxford: Blackwell Publishing***,** 404-417.
IHLANFELDT, K. R. 1992. Spatial Mismatch and the Commutes, Employment, and Wages of Young Puerto Ricans Living in New York. *Policy Research Center, Georgia State University Research Paper No. 31, 1992.*
IHLANFELDT, K. R. 1993. Intra-urban job accessibility and hispanic youth employment rates. *Journal of Urban Economics,* 33**,** 254-271.
IHLANFELDT, K. R. & SJOQUIST, D. L. 1990. Job accessibility and racial differences in youth employment rates. *American Economic Review,* 80**,** 267-276.
IHLANFELDT, K. R. & SJOQUIST, D. L. 1991. The effect of job access on black and white youth employment: a cross-sectional analysis. *Urban Studies,* 28**,** 255-265.
IHLANFELDT, K. R. & SJOQUIST, D. L. 1998. The spatial mismatch hypothesis: A review of recent studies and their implications for welfare reform. *Housing Policy Debate,* 9**,** 849-892.

ILO 2020. Youth and covid-19: impacts on jobs, education, rights and mental well-being *Retrieved 31 August 2020, from* https://www.ilo.org/wcmsp5/groups/public/---ed_emp/documents/publication/wcms_753026.pdf.
JEEKEL, H. 2015. *De autoafhankelijke samenleving [The car-dependent society],* Utrecht, Utrecht: Eburon.
JOHNSON, D., ERCOLANI, M. & MACKIE, P. 2017. Econometric analysis of the link between public transport accessibility and employment. *Transport Policy,* 60**,** 1-9.
JOHNSON, R. B. & ONWUEGBUZIE, A. J. 2004. Mixed Methods Research: A Research Paradigm Whose Time Has Come. *Educational Researcher,* 33**,** 14-26.
JOHNSON, R. C. 2006. Landing a job in urban space: The extent and effects of spatial mismatch. *Regional Science and Urban Economics,* 36**,** 331-372.
JRF 2018. Tackling transport-related barriers to employment in low-income neighbourhoods. *York: Joseph Rowntree Foundation*.
KAGER, R., BERTOLINI, L. & TE BRÖMMELSTROET, M. 2016. Characterisation of and reflections on the synergy of bicycles and public transport. *Transportation Research Part A: Policy and Practice,* 85**,** 208-219.
KAIN, J. F. 1968. Housing segregation, negro employment, and metropolitan decentralization. *The Quarterly Journal of Economics,* 82**,** 175-197.
KASARDA, J. 1988. Jobs, migration, and emerging urban mismatches. *In: Mcgeary and Lynn (Eds) Urban Change and Poverty, 148-188. Washington, DC: National Academy Press*.
KAUFMANN, D. 2002. Re-thinking mobility. *Routledge*.
KAUFMANN, V., DUBOIS, Y. & RAVALET, E. 2017. Measuring and typifying mobility using motility. *Applied Mobilities,* 0**,** 1-16.
KAUFMANN, V. B., M.D.; JOYE, DOMINIQUE 2004. Motility: Mobility as Capital*. *International Journal of Urban and Regional Research*.
KAWABATA, M. 2002. Job access and work among autoless adults in welfare in los angeles. *The Ralph and Goldy Lewis Center for Regional Policy Studies UCLA*.
KAWABATA, M. 2003. Job access and employment among low-skilled autoless workers in US metropolitan areas. *Environment and Planning A,* 35**,** 1651-1668.
KAWABATA, M. & SHEN, Q. 2007. Commuting Inequality between Cars and Public Transit: The Case of the San Francisco Bay Area, 1990-2000. *Urban Studies,* 44**,** 1759-1780.
KENYON, S., LYONS, G. & RAFFERTY, J. 2002. Transport and social exclusion: investigating the possibility of promoting inclusion through virtual mobility. *Journal of Transport Geography,* 10**,** 207-219.
KIM 2016. Mobiliteitsbeeld 2016 [Mobility View 2016]. *Netherlands Institute for Transport Policy Analysis, The Hague*.
KLEIN, N. J. & SMART, M. J. 2017. Millennials and car ownership: Less money, fewer cars. *Transport Policy,* 53**,** 20-29.
KORSU, E. & WENGLENSKI, S. 2010. Job Accessibility, Residential Segregation and Risk of Long-term Unemployment in the Paris Region. *Urban Studies,* 47**,** 2279-2324.
KRUGMAN, P. 1991. Increasing Returns and Economic Geography. *Massachusetts Institute of Technology*.
KRUGMAN, P. 1998. The Role of Geography in Development. *Annual World Bank Conference on Development Economics*.
KUHNIMHOF, T., BUEHLER, R. & DARGAY, J. 2011. A new generation: Travel trends for young Germans and Britons. *Transportation Research Record,* 2230**,** 58-67.
KWAN, M. P. 1998. Space-time and integral measures of individual accessibility: a comparative analysis using a point-based framework. *Geographic Analysis,* 30**,** 191–216.
LAFOURCADE, M. & THISSE, J. F. 2011. New economic geography: A guide to transport analysis. *PSE Working Papers n2008-02*.

LE GALLO, J., L'HORTY, Y. & PETIT, P. 2017. Does enhanced mobility of young people improve employment and housing outcomes? Evidence from a large and controlled experiment in France. *Journal of Urban Economics,* 97**,** 1-14.
LEVINE, J., GRENGS, J., SHEN, Q. & SHEN, Q. 2012. Does Accessibility Require Density or Speed? *Journal of the American Planning Association,* 78**,** 157-172.
LEVINSON, D., MARION, B., OWEN, A. & CUI, M. 2017. The City is flatter: Changing patterns of job and labor access. *Cities,* 60**,** 124-138.
LEVINSON, D., MARION, B., OWEN, M. & CUI, M. 2010. The City is Flatter, Changing Patterns of Job and Labor Access in Minneapolis-Saint Paul, 1995-2005. *Cities,* 60**,** 124-138.
LEVITAS, R. 1998. The Inclusive Society? Social Exclusion and New Labour. *Basingstoke: Macmillan*.
LEVITAS, R. 2006. *The Concept and Measurement of Social Exclusion in: Pantazis, C., Gordon, D. and Levitas, R. (2006) Poverty and Social Exclusion in Britain, Bristol, The Policy Press.*
LEVITAS, R., PANTAZIS, C., FAHMY, E., GORDON, D., LLOYD, E. & PATSIOS, D. 2007. The multi-dimensional analysis of social exclusion. Department of Sociology and School for Social Policy,Townsend Centre for the International Study of Poverty and Bristol Institute for PublicAffairs. University of Bristol, Bristol.
LIN, J.-J., CHEN, C.-H. & HSIEH, T.-Y. 2014. Job accessibility and ethnic minority employment in urban and rural areas in Taiwan. *Papers in Regional Science,* 95**,** 363-382.
LITTELL, J. H., CORCORAN, J. & PILLAI, V. 2008. Systematic reviews and meta-analyis. *New York: Cambridge University Press*.
LUCAS, K. 2012. Transport and social exclusion: Where are we now? *Transport Policy,* 20**,** 105-113.
LUCAS, K., GROSVENOR, T. & SIMPSON, R. 2001. Transport, the Environment and Social Exclusion. *Joseph Rowntree Foundation/ York Publishing Ltd, York*.
LUCAS, K., MARTENS, K., DI CIOMMO, F. & DUPONT-KIEFFER, A. 2019a. *Measuring Transport Equity,* Amsterdam, The Netherlands: Elsevier.
LUCAS, K., STOKES, G., BASTIAANSSEN, J. & BURKINSHAW, J. 2019b. Inequalities in Mobility and Access in the UK Transport System. *In:* FORESIGHT, G. O. F. S. (ed.) *Future of Mobility: Evidence Review.* London.
LUCAS, K., TYLER, S. & CHRISTODOULOU, G. 2009. Assessing the 'value' of new transport initiatives in deprived neighbourhoods in the UK. *Transport Policy,* 16**,** 115-122.
LUCAS, M. T. & NICHOLSON, C. F. 2003. Subsidized vehicle acquisition and earned income in the transition from welfare to work. *Transportation,* 30**,** 483-501.
LUPTON, R. & POWER, A. 2002. Social Exclusion and Neighbourhoods. *in Hills, J., Le Grand, J. and Piachaud, D. (eds.) Understanding Social Exclusion. Oxford: Oxford University Press*.
MACKIE, P., LAIRD, J. & JOHNSON, D. 2012. Buses and economic growth. *Leeds: University of Leeds*.
MARADA, M. & KVĚTOŇ, V. 2016. Transport Supply and Demand Changes in Relation to Unemployment: Empirical Evidence from the Czech Republic in a Time of Crisis. *Tijdschrift voor Economische en Sociale Geografie,* 107**,** 611-627.
MARSHALL, A. 1890. Principles of Economics. *London: Macmillan and Co. 8th ed. 1920*.
MARTENS, K. 2004. The bicycle as a feedering mode: Experiences from three European countries. *Transportation Research Part D: Transport and Environment,* 9**,** 281-294
MARTENS, K. 2012. Justice in transport as justice in accessibility: applying Walzer's 'Spheres of Justice' to the transport sector. *Transportation,* 39**,** 1035-1053.
MARTENS, K. & BASTIAANSSEN, J. 2019. An index to measure accessibility poverty risk. In: Lucas, K., K. Martens, F. Di Ciommo & A. Dupont-Kieffer. Measuring Transport Equity. *Amsterdam, The Netherlands: Elsevier*.
MARTENS, K., BASTIAANSSEN, J. & LUCAS, K. 2019. Measuring transport equity: Key components, framings and metrics In: Lucas, K., K. Martens, F. Di Ciommo & A. Dupont-Kieffer. Measuring Transport Equity. *Amsterdam, The Netherlands: Elsevier*.
MARTIN, G. 2007. Global motorization, social ecology and China. *Area,* 39 66-67.

MATAS, A., RAYMOND, J. L. & ROIG, J. L. 2010. Job Accessibility and Female Employment Probability: The Cases of Barcelona and Madrid. *Urban Studies,* 47**,** 769-787.

MATTIOLI, G. 2017. 'Forced Car Ownership' in the UK and Germany: Socio-Spatial Patterns and Potential Economic Stress Impacts. *Social Inclusion,* 5**,** 147-160.

MATTIOLI, G., LUCAS, K. & MARSDEN, G. 2016. The affordability of household transport costs: quantifying the incidence of car-related economic stress in Great Britain. *Universities' Transport Study Group. 48th Annual Universities' Transport Study Group, 06-08 Jan 2016, Bristol*.

MCDONALD, N. C. 2015. Are millennials really the "go-nowhere" generation? *Journal of the American Planning Association,* 81**,** 90-103.

MCLAFFERTY, S. & PRESTON, V. 1996. Spatial mismatch and employment in a decade of restructuring. *Professional Geographer,* 48**,** 420-431.

MCQUAID, R. W., GREIG, M. & ADAMS, J. 2001. Unemployed Job Seekers Attitudes towards Potential Travel-to-Work Times. *Growth and Change,* 32**,** 355-368.

MELO, P. C., GRAHAM, D. J. & BRAGE-ARDAO, R. 2013. The productivity of transport infrastructure investment: A meta-analysis of empirical evidence. *Regional Science and Urban Economics,* 43**,** 695-706.

MELO, P. C., GRAHAM, D. J. & NOLAND, R. B. 2009. A meta-analysis of estimates of urban agglomeration economies. *Regional Science and Urban Economics,* 39**,** 332-342.

MERLIN, L. A. 2017. A portrait of accessibility change for four US metros. *The Journal of Transport and Land Use*.

MILLS, E. S. 1972. Studies in the syructure of the urban economy. *Baltimore: John Hopkins Press*.

MINISTRY OF INFRASTRUCTURE AND THE ENVIRONMENT 2014. Not car-less, but car-later. *Netherlands: Institute for Transport Policy Analysis*.

MOLLENKOPF, J. & CASTELLS, M. 1991a. Dual City: Restructuring New York *New York: Russell Sage Foundation*.

MOLLENKOPF, J. & CASTELLS, M. 1991b. *Dual City: Restructuring New York*.

MRDH 2019. Samen aan het werk; Strategisch agenda metropoolregio Rotterdam Den Haag 2022 [Working together; Strategic agenda metropolitan region Rotterdam The Hague 2022]. *Rotterdam, The Netherlands: MRDH*.

MUDDIMAN, D., DURRANI, S., DUTCH, M., LINLEY, R., PATEMAN, J. & VINCENT, J. 2000. Open to All? The Public Library and Social Exclusion; Volume One: Overview and Conclusions. Leeds: Library and Information Commission Research Report 84.

NEUTENS, T., DELAFONTAINE, M., SCOTT, D. M. & DE MAEYER, P. 2012. An analysis of day-to-day variations in individual space–time accessibility. *Journal of Transport Geography,* 23**,** 81-91.

NORMAN, G. & BORJESSON, M. 2012. Job accessibility and labor market distortions. *Draft paper: Jönköping International Business School and Center of Transportation Studies @ KTH*.

NORMAN, T., BORJESSON, M. & ANDERSTIG, C. 2017. Labour market accessibility and unemployment. *Journal of Transport Economics and Policy,* 51**,** 47–73.

O'CONNELL, P. J., MCGUINNESS, S. & KELLY, E. 2012. The Transition from Short- to Long-Term Unemployment: A Statistical Profiling Model for Ireland. *Economic and Social Review,* 43**,** 135-164.

O'REGAN, K. M. & QUIGLEY, J. M. 1991. Labor market access and labor market outcomes for urban youth. *Regional Science and Urban Economics,* 21**,** 277-293.

O'REGAN, K. M. & QUIGLEY, J. M. 1996. Spatial effects upon employment outcomes: the case of New Jersey teenagers. *New England Economic Review, May/June***,** 41-58.

O'REGAN, K. M. & QUIGLEY, J. M. 1998. Where youth live: economic effects of urban space on employment prospects. *Urban Studies,* 35**,** 1187-1205.

OECD 2020. Youth unemployment rate. *Retrieved 31 August 2020, from https://data.oecd.org/unemp/youth-unemployment-rate.htm*.

ONG, P. M. 1996. Work and automobile ownership among welfare recipients. *Social Work Research,* 20**,** 255-262.
ONG, P. M. 2002. Car ownership and welfare-to-work. *Journal of Policy Analysis and Management,* 21**,** 239-252.
ONG, P. M. & HOUSTON, D. 2002. Transit, Employment and Women on Welfare. *Urban Geography,* 23**,** 344-364.
ONG, P. M. & MILLER, D. 2005. Spatial and Transportation Mismatch in Los Angeles. *Journal of Planning Education and Research,* 25**,** 43-56.
ONS 2011. Census aggregate data. *UK Data Service (Edition: February 2017)*.
ONS 2017. Regional labour market statistics in the UK: Jan 2017. *Office for National Statistics*.
ONS 2018. Quarterly Labour Force Survey, 1992-2018: Secure Access [data collection]. 14th Edition. *UK Data Service. SN: 6727, http://doi.org/10.5255/UKDA-SN-6727-15*.
ONS 2019. Business Structure Database, 1997-2018: Secure Access. [data collection]. 10th Edition. *UK Data Service. SN: 6697, http://doi.org/10.5255/UKDA-SN-6697-10*.
OWEN, A. & LEVINSON, D. 2012. Annual accessibility measure for the Twin Cities metropolitan area. *Technical Report 2012-34, Minnesota Department of Transportation*.
OZBAY, K., OZMAN, D. & BERECHMAN, J. 2006. Modeling and Analysis of the Link between Accessibility and Employment Growth. *Journal of Transportation Engineering,* 132**,** 385–393.
PADEIRO, M., LOURO, A. & MARQUES DA COSTA, N. 2019. Transit-oriented development and gentrification: a systematic review. *Transport Reviews,* 39**,** 733-754.
PAINTER, G., CATHY YANG, L. & DUAN, Z. 2007. Immigrants and the Spatial Mismatch Hypothesis: Employment Outcomes among Immigrant Youth in Los Angeles. *Urban Studies,* 44**,** 2627-2649.
PARKS, V. 2004. Access to work: The effects of spatial and social accessibility on unemployment for native-born black and immigrant women in Los Angeles. *Economic Geography,* 80**,** 141-172.
PATACCHINI, E. & ZENOU, Y. 2005. Spatial mismatch, transport mode and search decisions in England. *Journal of Urban Economics,* 58**,** 62-90.
PBL 2010. Nieuwbouw, verhuizingen en segregatie. Effecten van nieuwbouw op de bevolkings samenstelling van stadswijken. [New construction, relocations and segregation. Effects of new construction on the population composition of urban areas.]. *Netherlands Environmental Assessment Agency, The Hague.*
PBL 2012. Balans van de Leefomgeving 2012 [Environmental Balance 2012]. *Netherlands Environmental Assessment Agency, The Hague*.
PBL 2014. Kiezen en delen; Strategieën voor een betere afstemming tussen verstedelijking en infrastructuur [Choosing and sharing; Strategies for a better coordination between urbanisation and infrastructure.]. *Netherlands Environmental Assessment Agency, The Hague***,** 15-17.
PBL & CPB 2020. *Kansrijk mobiliteitsbeleid 2020 [Effective mobility policies 2020],* The Hague: Environmental Assessment Agency, CPB Netherlands Bureau for Economic Policy Analysis.
PERLE, E. D., BAUDER, H. & BECKETT, N. 2002. Accessibility measures in spatial mismatch models. *Professional Geographer,* 54**,** 106-110.
PHILLIPS, D. C. 2014. Getting to work: Experimental evidence on job search and transportation costs. *Labour Economics,* 29**,** 72-82.
PITCHER, J. & GREEN, A. E. 1999. Factors affecting the choices made by young people aged 16. *Final Report to Focus Central London. IER, University of Warwick, Coventry.*
PRESTON, J. & RAJÉ, F. 2007. Accessibility, mobility and transport-related social exclusion. *Journal of Transport Geography,* 15**,** 151-160.
PRESTON, V., MCLAFFERTY, S. & LIU, X. F. 1998. Geographical barriers to employment for American-born and immigrant workers. *Urban Studies,* 35**,** 529-545.

PRITCHARD, J. P., STEPNIAK, M. & GEURS, K. 2019. Equity analysis of dynamic bike-and-ride accessibility in the Netherlands, in K. Lucas, K. Martens, F. Di Ciommo, A. Dupont-Kieffer (Eds.) Measuring Transport Equity.

PUCHER, J. & BUEHLER, R. 2012. City Cycling. *Massachusetts Institute of Technology, Cambridge, London.*

QUINTANAR, S. A. K. 2012. Job accessibility and probability of being employed by educational level and informality in Metropolitan Area of Mexico City.

RAE, A., HAMILTON, R., CRISP, R. & POWELL, R. 2016. Overcoming deprivation and disconnection in UK cities. *York: JRF*.

RAPHAEL, S. 1998. The spatial mismatch hypothesis and black youth joblessness Evidence from the San Francisco Bay Area. *Journal of Urban Economics,* 43**,** 79-111.

RAPHAEL, S. & RICE, L. 2002. Car ownership, employment, and earnings. *Journal of Urban Economics,* 52**,** 109-130.

RAPHAEL, S., STOLL, M. A., SMALL, K. & WINSTON, C. 2001. Can Boosting Minority Car-Ownership Rates Narrow Inter-Racial Employment Gaps? *Brookings-Wharton Papers on Urban Affairs 2001***,** 99-145.

RICE, L. 2001. Public Transit and Employment Outcomes. *Job Market Paper*.

RIETVELD, P. 1994. Spatial economic impacts of transport infrastructure supply. *Transportation Research Part A: Policy and Practice,* 28**,** 329-341.

RLI 2020. *Toegang tot de stad; hoe publieke voorzieningen, wonen en vervoer de sleutel voor burgers vormen [Access to the city; how public facilities, housing and transport are key to citizens],* The Hague: Council for the Environment and Infrastructure.

ROBSON, C. & MCCARTAN, K. 2016. *Real world research second edition*.

ROGERS, C. L. 1997. Job Search and Unemployment Duration: Implications for the Spatial Mismatch Hypothesis. *Journal of Urban Economics,* 42**,** 109-132.

ROSENTHAL, S. S. & STRANGE, W. C. 2004. The Micro-Empirics of Agglomeration Economies. *Blackwell Companion to Urban Economics*.

ROTGER, G. P. & NIELSEN, T. S. 2015. Effects of Job Accessibility Improved by Public Transport System: Natural Experimental Evidence from the Copenhagen Metro. *European Journal of Transport and Infrastructure Research,* 15**,** 419-441.

ROTTERDAM 2018. Verplaatsingen in de metropoolregio Rotterdam Den Haag en Nederland 2004-2017 [Trips in the Rotterdam-The Hague Metropolitan Region and The Netherlands]. *Rotterdam, The Netherlands: Gemeente Rotterdam*.

ROTTERDAM, G. 2016. Stedelijk Verkeersplan Rotterdam 2016 - 2030+ [Urban Transportplan Rotterdam 2016 - 2030+]. *Gemeente Rotterdam*.

RYAN, J., WRETSTRAND, A. & SCHMIDT, S. M. 2015. Exploring public transport as an element of older persons' mobility: A Capability Approach perspective. *Journal of Transport Geography,* 48**,** 105–114.

SAGER, T. 2006. Freedom as Mobility: Implications of the Distinction between Actual and Potential Travelling. *Mobilities,* 1**,** 465–488.

SANCHEZ, T., SHEN, Q. & PENG, Z.-R. 2004. Transit mobility, jobs access and low-income labour participation in us metropolitan areas. *Urban Studies,* 41**,** 1313-1331.

SANCHEZ, T. W. 1999. The connection between public transit and employment the cases of Portland and Atlanta. *Journal of the American Planning Association,* 65**,** 284-296.

SANCHEZ, T. W. 2008. Poverty, policy, and public transportation. *Transportation Research Part A: Policy and Practice,* 42**,** 833-841.

SANCHIS-GUARNER, R. 2013. Driving Up Wages. The Effects of Road Construction in Great Britain. *SERC Spatial Economics Research Centre*.

SANDOVAL, J. S. O., CERVERO, R. & LANDIS, J. 2011. The transition from welfare-to-work How cars and human capital facilitate employment for welfare recipients. *Applied Geography,* 31**,** 352-362.

SARI, F. 2015. Public transit and labor market outcomes: Analysis of the connections in the French agglomeration of Bordeaux. *Transportation Research Part A: Policy and Practice,* 78**,** 231-251.

SASSEN, S. 2011. *Cities in a World Economy, Fourth Edition*, Thousand Oaks, CA: Pine Forge Press.

SCHWANEN, T., LUCAS, K., AKYELKEN, N., SOLSONA, D. C., CARRASCO, J. A. & NEUTENS, T. 2015. Rethinking the links between social exclusion and transport disadvantage through the lens of social capital. *Transportation Research Part A: Policy and Practice,* 74**,** 123-135.

SEN, A. 1979. Equality of what? The Tanner Lectures on Human Values. 1**,** 353–369.

SEN, A. 2009. *The idea of justice*, Cambridge, Mass: Harvard University Press.

SEU 2003. Making the connections: Final Report on Transport and Social Exclusion. *London: Social Exclusion Unit.*

SG 2011. Urban Rural Classification for Scotland https://www2.gov.scot/Topics/Statistics/About/Methodology/UrbanRuralClassification.

SHAHEEN, S. & CHAN, N. 2016. Mobility and the Sharing Economy. Potential to Facilitate the First- and Last-Mile Public Transit Connections. *Built Environment.,* 42**,** 573-588.

SHEN, Q. 2001. A Spatial Analysis of Job Openings and Access in a U.S. Metropolitan Area. *Journal of the American Planning Association,* 67**,** 53-68.

SHEN, Q. & SANCHEZ, T. W. 2005. Residential Location, Transportation and Welfare-to-Work in the United States. A case Study of Milwaukee. *Housing Policy Debate,* 16**,** 391-431.

SMART, M. J. & KLEIN, N. J. 2015. A Longitudinal Analysis of Cars, Transit, and Employment Outcomes. *MNTRC Mineta National Transit Research Consortium***,** 12-49.

STANLEY, J., STANLEY, J. & HENSHER, D. 2012. Mobility, social capital and sense of community: what value? *Urban Studies,* 49**,** 3595-3609.

STATISTICS, O. F. N. 2018. Business Structure Database, 1997-2017: Secure Access. *Office for National Statistics. Colchester, Essex: UK Data Archive*.

STOLL, M. A. 2005. Geographical skills mismatch, job search and race. *Urban Studies,* 42**,** 695-717.

SULLIVAN, K. 2003. Transportation & Work: Exploring Car Usage and Employment Outcomes in the LSAL Data. *NCSALL Occasional Paper*.

TAYLOR, B. D. & ONG, P. M. 1995. Spatial Mismatch or Automobile Mismatch? An examination of Race, Residence and Commuting in US Metropolitan Areas. *Urban Studies,* 32**,** 1453-1473.

TAYLOR, E. 2010. Trends in Attitudes to Transport 1990-2009: Report based on results from the British Social Attitudes surveys. *In:* HTTPS://WWW.GOV.UK/GOVERNMENT/STATISTICS/BRITISH-SOCIAL-ATTITUDES-SURVEY-2011-ATTITUDES-TO-TRANSPORT, N. R. T. D. F. T. A. O. A. F. (ed.).

THAKURIAH, P. 2011. Variations in employment transportation outcomes: Role of site-level factors. *Papers in Regional Science,* 90**,** 755-772.

THAKURIAH, P. & METAXATOS, P. 2000. Effect of Residential Location and Transportation on Employment Opportunities. *Transportation Research Record,* 1726**,** 24-32.

THOMPSON, G. L. 2001. New Insights into the Value of Transit; Modeling Inferences of Dade County. *Transportation Research Record 1753 Paper NO. 01-2229***,** 52-58.

THOMPSON, M. A. 1997. The impact of spatial mismatch on female labor force participation. Economic Development. *Economic Development Quarterly,* 11**,** 138-145.

TOCHTERMANN, L. & CLAYTON, N. 2011. Moving On Up, Moving On Out? Overcoming the Jobs-skills Mismatch. London: Centre for Cities.

TUNSTALL, R., LUPTON, R., GREEN, A., WATMOUGH, S. & BATES, K. 2013. Disadvantaged young people looking for work. A job in itself? *In:* JOSEPH ROWNTREE FOUNDATION (ed.).

TUROK, I. & EDGE, N. 1999. The jobs gap in Britain's cities; Employment loss and labour market consequences. *Bristol: The Policy Press and the Joseph Rowntree Foundation*.

TYNDALL, J. 2017. Waiting for the R train: Public transportation and employment. *Urban Studies,* 54**,** 520-537.

TYNDALL, J. 2019. The Local Labour Market Effects of Light Rail Transit. *University of Hawai'i Economic Research Organization*.
URRY, J. 2000. *Sociologies beyond Societies: Mobilities for the Twenty-Firsy Century,* Routledge, NewYork.
URRY, J. 2007. *Mobilities*, Polity Press, Cambridge, United Kingdom.
VAN WEE, B., HAGOORT, M. & ANNEMA, J. A. 2001. Accessibility measures with competition. *Journal of Transport Geography,* 9**,** 199-208.
VENABLES, A. J. 2007. Evaluating urban transport improvements - Cost-benefit analysis in the presence of agglomeration and income taxation. *Journal of Transport Economics and Policy,* 41**,** 173-188.
WACHS, M. & KUMAGAI, T. G. 1973. Physical accessibility as a social indicator. *Socio-Economic Planning Science,* 6**,** 357-379.
WALDORF, B. & BYUN, P. 2005. Meta-analysis of the impact of age structure on fertility. *journal of population economics,* 18**,** 15-40.
WHAT WORKS CENTRE 2015. Evidence Review 7: Transport. *What Works Centre for Local Economic Growth*.
WILSON, W. J. 1987. The Truly Disadvantaged: the Inner City, the Underclass and Public Policy. *Chicago: University of Chicago Press*.
WRR 2018. Sturen op sociale waarde van infrastructuur [Focus on social value of infrastructure]. *Wetenschappelijke Raad voor het Regeringsbeleid [Scientific Council for Government Policy], The Hague*.
WYCA 2017. West Yorkshire Bus Strategy 2040. Leeds: West Yorkshire Combined Authority.
YI, C. 2006. Impact of public transit on employment status disaggregate analysis of Houston, Texas. *Transportation Research Record: Journal of the Transportation Research Board,* 1986**,** 137–144.
YIN, R. K. 2009. Case study research: Design and methods (4th Ed.). *Thousand Oaks, CA: Sage.*

11. Appendix

Table 11.1 Abbreviations used in the meta-analyses

Sample:	W(F)	Welfare recipient (Female)
	LS	Low-skilled individuals
	M/F	Male or Female
	Y (B/L/W/CIT/SUB)	Youth (Black/ Latin (Hispanic)/ White/ Central city/ Suburbs)
	(E/NE/H/NH)	(Not) Enrolled in education/ (Not) Living at home
	(L/M)INC	Income class (Low- or Middle)
	ABOR	Aboriginals
Transport:	CAR (I/ HH)	Car ownership (Individual or Household)
	CAR1/2 (HH)	One or Multiple cars (Household)
	MCARCT	Mean car commute time
	M(G)CT	Mean (gravity-based) commute time
	WMCARCT	Weighted mean car commute time
IV/S:	IV	Instrumental variable approach
	S	Sample approach

Table 11.2 Non-IV and base-employment model with first stage and second-stage regression

Variables	Coefficients (SE)							Elasticities: +10% accessibility
	Base-model			≥ 15% no- vehicle hh		≥ 30% no- vehicle hh		
	Probit	IVprobit		Probit	IVprobit	Probit	IVprobit	
Dependent variable								
Emp. (1); unemp. (0)		**1st stage** *Job access.*	**2nd stage** *Emp.*					
Indiv. & hh variables								
Age	0.082*** (0.004)	0.004* (0.002)	0.082*** (0.004)	0.084*** (0.006)	0.085*** (0.006)	0.084*** (0.008)	0.083*** (0.007)	
Age squared/100	-0.082*** (0.005)	-0.004* (0.002)	-0.081*** (0.005)	-0.085*** (0.007)	-0.086*** (0.007)	-0.087*** (0.009)	-0.087*** (0.009)	
Female	0.049* (0.023)	-0.012 (0.007)	0.050* (0.023)	0.058* (0.032)	0.061* (0.027)	0.066 (0.036)	0.070 (0.036)	
Low educated	-0.283*** (0.029)	-0.059*** (0.009)	-0.279*** (0.029)	-0.302*** (0.032)	-0.290*** (0.032)	-0.312*** (0.041)	-0.312*** (0.040)	
Non-white	-0.249*** (0.032)	0.244*** (0.016)	-0.278*** (0.034)	-0.231*** (0.036)	-0.274*** (0.037)	-0.250*** (0.043)	-0.282*** (0.046)	
Young children (< age 15)	-0.040** (0.013)	-0.019*** (0.004)	-0.038** (0.013)	-0.048*** (0.015)	-0.047*** (0.015)	-0.063*** (0.019)	-0.054** (0.019)	
Single household	-0.391*** (0.035)	0.037** (0.014)	-0.395*** (0.035)	-0.399*** (0.040)	-0.405*** (0.040)	-0.402*** (0.052)	-0.420*** (0.051)	
Single parent household	-0.435*** (0.031)	0.019 (0.011)	-0.435*** (0.031)	-0.447*** (0.036)	-0.443*** (0.035)	-0.475*** (0.046)	-0.471*** (0.046)	

Neighbourhood & Accessibility variables								
Percent unemployed (excl. students)	-3.440*** (0.239)	-1.791*** (0.097)	-3.512*** (0.239)	-3.185*** (0.281)	-3.193*** (0.276)	-2.688*** (0.379)	-2.427*** (0.401)	
Population density (pop/hectare)		0.012*** (0.000)						
PT job accessibility/ 1,000,000	0.009 (0.015)			0.010 (0.016)		0.018 (0.017)		
Estimated PT job accessibility/1,000,000			0.059** (0.024)		0.067** (0.024)		0.069** (0.027)	**0.002 | 0.003 0.006**
Constant	0.306*** (0.088)	-0.110*** (0.031)	0.299*** (0.087)	0.268* (0.108)	0.222* (0.108)	0.246 (0.152)	0.186 (0.150)	
Pseudo R2	0.0965			0.0880		0.0803		
Wald Chi-Squared stat	1434.83***		1448.13***	932.07***	994.27***	478.11***	508.86***	
Wald Chi-Squared stat of exogeneity			7.30**		9.24**		5.79*	
Cragg-Donald Wald F		28437.77						
Kleibergen-Paap F stat		4552.66***						
Stock-Yogo Weak ID critical value		16.38 (10%)						
N	44,351			27,936		13,578		
Mean PT accessibility	*384,509.7*			*537,386.7*		*852,899.3*		

25th percentile	*40,587*	*63,936*	*98,794*	
75th percentile	*275,720*	*396,798*	*906,824*	
Mean emp. rate %	*95.0%*	*93.9%*	*92.2%*	
Mean hh vehicle %	*75.2%*	*66.8%*	*55.6%*	

Significance levels: *: 0.05%, **: 0.01%, ***: 0.001%

Table 11.3 Public transport job accessibility coefficients and elasticities for non-IV and IV employment models

Models	**Classes**	**Coefficient (SE)**			
		Non-IV models	IV models		Elasticities: +10% accessibility
			Second stage	First stage	
Base model	Full sample	0.009 (0.015)	**0.059** (0.024)**	0.012*** (0.000)	0.002
	≥ 15% no- vehicle hh	0.010 (0.015)	**0.067** (0.024)**	0.013*** (0.000)	0.003
	≥ 30% no- vehicle hh	0.018 (0.017)	**0.069** (0.027)**	0.013*** (0.000)	0.006
Rural-Urban Classification	London	**-0.057* (0.024)**	-0.042 (0.037)	0.014*** (0.000)	-0.005
	Urban areas	0.077 (0.086)	**1.154** (0.430)**	0.001*** (0.000)	0.013
	Rural areas	**0.206 (0.367)**	-3.418 (2.082)	0.001*** (0.000)	
Rural-Urban Classification >30% no- vehicle hh	London	**-0.051 (0.029)**	-0.042 (0.037)	0.014*** (0.000)	
	Urban areas	0.200 (0.130)	**1.709* (0.724)**	0.001*** (0.000)	0.038
	Rural areas	**3.111 (2.084)**	-3.401 (2.073)	0.001*** (0.000)	
Neighbourhood income levels	>= £31,834	**-0.002 (0.018)**	0.025 (0.027)	0.014*** (0.000)	

	<= £31,833	0.052 (0.033)	**0.190**** **(0.066)**	0.007 *** (0.000)	0.004
Age groups	50-64	-0.007 (0.034)	**0.120*** **(0.060)**	0.011*** (0.000)	0.002
	35-49	**0.012** **(0.029)**	0.018 (0.042)	0.013*** (0.000)	
	25-34	0.003 (0.030)	**0.120**** **(0.048)**	0.013*** (0.000)	0.004
	16-24	**-0.043** **(0.036)**	-0.070 (0.061)	0.010*** (0.001)	
Educational levels	High educated	**-0.021** **(0.021)**	0.031 (0.034)	0.014*** (0.000)	
	Middle educated	**-0.028** **(0.028)**	-0.037 (0.051)	0.009*** (0.000)	
	Low educated	0.049 (0.039)	**0.166**** **(0.059)**	0.011*** (0.000)	0.006

Significance levels: *: 0.05%, **: 0.01%, ***: 0.001%
IV models: first stage estimates for instrumental variable (i.e. population density) on PT job accessibility measure; second stage estimates for estimated PT job accessibility measure on employment probability.
Coefficients (SE) in bold: reported model estimates based on acceptance null hypothesis of exogeneity (i.e. when job accessibility is found endogenous with employment)

Table 11.4 Individual employment probabilities by Rural-Urban Classification with >30% no-vehicle households

Variables	**Coefficients (SE)**						**Elasticities: +10% accessibility**
	London		**Urban areas**		**Rural areas**		
	Probit	IVprobit	Probit	IVprobit	Probit	IVprobit	
Dependent variable							
Employed (1); unemployed (0)							
Individual & Household variables							
Age	0.101*** (0.016)	0.102*** (0.017)	0.085*** (0.006)	0.071*** (0.009)	0.039 (0.049)	0.039 (0.043)	

Age squared/100	-0.110*** (0.019)	-0.111*** (0.019)	-0.086*** (0.007)	-0.070*** (0.011)	-0.039 (0.057)	-0.041 (0.049)	
Female	-0.014 (0.077)	-0.011 (0.078)	0.089*** (0.027)	0.101* (0.041)	0.208 (0.223)	0.035 (0.198)	
Low educated	-0.064 (0.099)	-0.062 (0.099)	-0.342*** (0.033)	-0.370*** (0.047)	-0.107 (0.243)	-0.058 (0.234)	
Non-white	-0.464*** (0.081)	-0.464*** (0.082)	-0.219*** (0.042)	-0.340** (0.093)	(omitted)	(omitted)	
Young children (< age 15)	-0.095* (0.038)	-0.093* (0.039)	-0.041** (0.025)	-0.021 (0.025)	-0.026 (0.143)	-0.104 (0.122)	
Single household	-0.278* (0.116)	-0.264* (0.117)	-0.413*** (0.041)	-0.419*** (0.060)	-0.817*** (0.250)	-0.761 (0.465)	
Single parent household	-0.399*** (0.097)	-0.401*** (0.097)	-0.440*** (0.037)	-0.449*** (0.058)	-0.785** (0.284)	-0.726 (0.516)	
Neighbourhood & Accessibility variables							
Percent unemployed (excl. students)	-1.054 (0.953)	-0.745 (1.017)	-3.683*** (0.272)	-3.136*** (0.414)	-0.442 (2.083)	-0.181 (1.765)	
Public transport job accessibility/ 1,000,000	-0.051 (0.029)		0.077 (0.086)		3.111 (2.084)		**0.018**
Estimated public transport job accessibility/1,000,000		-0.012 (0.056)		1.709* (0.724)		-11.435 (13.747)	**0.057**
Constant	0.092 (0.342)	0.092 (0.342)	0.269* (0.108)	0.058 (0.232)	0.841 (1.011)	1.157 (0.860)	

Wald Chi-Squared statistic	116.34***	115.31***	1080.91***	418.67***	23.99**	47.68***	
Wald Chi-Squared statistic of exogeneity		0.38		4.17*		0.58	
Pseudo R2	0.0908		0.1022		0.0963		
N	3,347		9,806		417		
Mean PT accessibility	*2,346,411*		*203,900.2*		*37,255.2*		
25th percentile	*1,315,312*		*103,492*		*10,840*		
75th percentile	*3,349,525*		*275,278*		*41,527*		
Mean employment rate %	*93.5%*		*91.4%*		*93.2%*		
Mean hh vehicle ownership %	*49.4%*		*58.2%*		*63.9%*		

Significance levels: *: 0.05%, **: 0.01%, ***: 0.001%

Table 11.5 Employment model by age groups

Variables	**Coefficients (SE)**								**Elasticities: +10% accessibility**
	Age 16-24		**Age 25-34**		**Age 35-49**		**Age 50-64**		
	Probit	IVprobit	Probit	IVprobit	Probit	IVprobit	Probit	IVprobit	
Dependent variable									
Employed (1); unemployed (0)									
Individual & Household variables									
Age	0.312 (0.175)	0.313 (0.175)	0.185 (0.200)	0.151 (0.198)	-0.118 (0.104)	-0.118 (0.104)	0.002 (0.163)	0.002 (0.163)	
Age squared/100	-0.535 (0.434)	-0.534 (0.434)	-0.269 (0.339)	-0.215 (0.336)	0.145 (0.124)	0.145 (0.124)	-0.008 (0.144)	-0.008 (0.144)	
Female	0.163*** (0.047)	0.163*** (0.047)	-0.033 (0.053)	-0.032 (0.052)	-0.021 (0.043)	-0.021 (0.043)	0.147** (0.047)	0.148** (0.047)	
Low educated	-0.386*** (0.070)	-0.387*** (0.070)	-0.364*** (0.064)	-0.348*** (0.064)	-0.316*** (0.052)	-0.316*** (0.052)	-0.212*** (0.053)	-0.203*** (0.053)	
Non-white	-0.347*** (0.074)	-0.327*** (0.086)	-0.196** (0.068)	-0.253*** (0.069)	-0.245*** (0.055)	-0.249*** (0.058)	-0.272*** (0.075)	-0.347*** (0.083)	

Young children (< age 15)	-0.090** (0.029)	-0.091** (0.029)	-0.055 (0.028)	-0.036 (0.029)	-0.005 (0.024)	-0.005 (0.024)	-0.092* (0.044)	-0.099* (0.044)	
Single household	0.052 (0.144)	0.052 (0.144)	-0.209* (0.098)	-0.209* (0.098)	-0.356*** (0.067)	-0.357*** (0.067)	-0.586*** (0.053)	-0.600*** (0.053)	
Single parent household	-0.248*** (0.054)	-0.248*** (0.054)	-0.662*** (0.065)	-0.658*** (0.065)	-0.327*** (0.060)	-0.327*** (0.060)	-0.422*** (0.082)	-0.435*** (0.082)	
Neighbourhood & Accessibility variables									
Percent unemployed (excl. students)	-2.697*** (0.518)	-2.657*** (0.523)	-3.415*** (0.528)	-3.586*** (0.520)	-4.410*** (0.425)	-4.410*** (0.425)	-3.213*** (0.492)	-3.392*** (0.491)	
Public transport job accessibility/ 1,000,000	-0.043 (0.036)		0.003 (0.030)		0.012 (0.029)		-0.007 (0.034)		
Estimated public transport job accessibility/1,000,000		-0.067 (0.061)		0.120** (0.048)		0.018 (0.042)		0.120* (0.060)	**0.004 | 0.002**
Constant	-2.675 (1.747)	-2.678 (1.746)	-0.849 (2.929)	-0.391 (2.904)	4.752* (2.163)	4.752* (2.163)	2.287 (4.586)	2.279 (4.590)	
Wald Chi-Squared statistic	281.71***	282.87***	289.98***	289.98***	326.72***	327.34***	250.14***	256.28***	
Wald Chi-Squared statistic of exogeneity		0.27		9.67**		0.05		7.32**	
Pseudo R2	0.0745		0.0876		0.0705		0.0705		
N	5,105		8,872		15,672		12,896		
Mean PT accessibility	*342,493.6*		*539,970.2*		*388,633.9*		*280,744.7*		
25th percentile	*43,867*		*51,280*		*43,439*		*32,110*		
75th percentile	*270,270*		*386,501*		*279,648*		*206,681*		
Mean employment rate %	*86.9%*		*95.3%*		*96.7%*		*96.2%*		
Mean hh vehicle ownership %	*73.1%*		*70.8%*		*75.9%*		*78.4%*		

Significance levels: *: 0.05%, **: 0.01%, ***: 0.001%

Table 11.6 Employment model by educational level

Variables	**Coefficients (SE)**						**Elasticities: +10% accessibility**
	Low educated		**Middle educated**		**High educated**		
	Probit	IVprobit	Probit	IVprobit	Probit	IVprobit	
Dependent variable							
Employed (1); unemployed (0)							
Individual & Household variables							

Age	0.051*** (0.009)	0.051*** (0.009)	0.094*** (0.006)	0.094*** (0.006)	0.061*** (0.011)	0.061*** (0.011)	
Age squared/100	-0.038*** (0.010)	-0.037*** (0.010)	-0.096*** (0.007)	-0.096*** (0.007)	-0.065*** (0.012)	-0.061*** (0.011)	
Female	0.006 (0.055)	0.006 (0.055)	0.059 (0.033)	0.059 (0.033)	0.006 (0.041)	0.011 (0.041)	
Non-white	-0.054 (0.070)	-0.126 (0.075)	-0.339*** (0.053)	-0.334*** (0.060)	-0.356*** (0.053)	-0.377*** (0.055)	
Young children (< age 15)	-0.028 (0.026)	-0.025 (0.026)	-0.053** (0.018)	-0.053** (0.018)	0.007 (0.028)	0.011 (0.028)	
Single household	-0.580*** (0.076)	-0.587*** (0.076)	-0.431*** (0.055)	-0.431*** (0.055)	-0.265*** (0.060)	-0.268*** (0.061)	
Single parent household	-0.562*** (0.073)	-0.579*** (0.073)	-0.386*** (0.042)	-0.385*** (0.043)	-0.304*** (0.068)	-0.299*** (0.068)	
Neighbourhood & Accessibility variables							
Percent unemployed (excl. students)	-5.032*** (0.471)	-5.059*** (0.467)	-3.121*** (0.355)	-3.108*** (0.361)	-1.416** (0.516)	-1.616** (0.513)	
Public transport job accessibility/1,000,000	0.049 (0.039)		-0.028 (0.028)		-0.021 (0.021)		
Estimated public transport job accessibility/ 1,000,000		0.166** (0.059)		-0.037 (0.051)		0.031 (0.034)	**0.006**
Constant	0.597** (0.195)	0.579** (0.194)	0.044 (0.112)	0.045 (0.112)	0.813*** (0.230)	0.786*** (0.230)	
Wald Chi-Squared statistic	383.44***	399.67***	758.64***	758.43***	161.50***	163.96***	
Wald Chi-Squared statistic of exogeneity		6.72**		0.04		3.74	
Pseudo R2	0.1244		0.1043		0.0395		
N	6,301		19,040		18,341		
Mean PT accessibility	*365,404.9*		*249,194.4*		*530,446.6*		
25th percentile	*41,120*		*35,973*		*46,678*		
75th percentile	*285,725*		*202,132*		*374,259*		
Mean employment rate %	*91.5%*		*94.2%*		*97.0%*		
Mean hh vehicle ownership %	*70.9%*		*76.4%*		*75.5%*		

Significance levels: *: 0.05%, **: 0.01%, ***: 0.001%

Table 11.7 Non-IV and base-employment model with first stage and second stage regression

Variables	Coefficients (SE)				Elasticities: +10% accessibility/ Margin. effect veh
	Probit	IVProbit			
		1st stage	**1st stage**	**2nd stage**	
Dependent variable					
Emp. (1); unemp. (0)		*PT access*	*HH vehicle*	*Emp.*	
Individual & Household variables					
Age	0.158*** (0.003)	0.001*** (0.000)	0.018*** (0.001)	0.147*** (0.011)	
Age squared/100	-0.186*** (0.035)	-0.000* (0.000)	-0.000*** (0.000)	-0.175*** (0.001)	
Female	-0.598*** (0.009)	0.002*** (0.001)	0.005*** (0.002)	-0.593*** (0.015)	
Low educated	-0.258*** (0.013)	-0.014*** (0.001)	-0.042*** (0.003)	-0.228*** (0.028)	
Non-Western migrant	-0.218*** (0.019)	0.026*** (0.002)	-0.025*** (0.005)	-0.219*** (0.021)	
Unemployment history	-0.333*** (0.012)	-0.003** (0.001)	-0.024*** (0.003)	-0.317*** (0.021)	
Young children (< age 12)	-0.028*** (0.007)	0.002*** (0.000)	0.011*** (0.001)	-0.032*** (0.008)	
Single household	-0.073*** (0.015)	-0.011*** (0.001)	-0.228*** (0.004)	-0.031* (0.093)	
Single parent household	-0.059*** (0.021)	-0.000 (0.002)	-0.155*** (0.006)	-0.011* (0.064)	
Neighbourhood & accessibility variables					
Percent unemployed (excl. students)	-0.034*** (0.001)	-0.003*** (0.000)	-0.001* (0.000)	-0.033*** (0.002)	
Population density		0.002*** (0.000)	-0.001*** (0.000)		
Percentage households with vehicles		-0.010*** (0.000)	0.001*** (0.000)		
Public transport-and-bicycle job accessibility/1,000,000	**0.349***** **(0.029)**				**0.007**

Estimated public transport-and-bicycle job accessibility/1,000,000				**0.706** (0.224)**	**0.014**
Household vehicle	**0.286*** (0.012)**				**0.023**
Estimated Household vehicle				**0.740* (0.374)**	**0.038**
Constant	-1.491*** (0.055)	0.569*** (0.006)	0.127*** (0.018)	-1.746*** (0.190)	
Wald Chi-Squared statistic	11573.05***			12054.80***	
Wald Chi-Squared statistic of exogeneity				15.96***	
Pseudo R2	0.1239				
Kleibergen-Paap F stat				64.11***	
Anderson-Rubin Wald F-statistic				54.88***	
Stock-Yogo Weak ID critical value				7.03 (10%)	
N	174,657			174,657	
Mean PT-and-bicycle job accessibility	206,187			206,187	
Mean Household vehicle rate	81.3%			81.3%	
Mean employment rate	93.4%			93.4%	

*Significance levels: *: 0.05% **: 0.01% ***: 0.001%.*

Table 11.8 Job accessibility coefficients and elasticities for non-IV and IV employment models

Models	**Classes**	**Coefficient (SE)**				
		PT job accessibility		Household vehicle		Elasticities: +10% Accessibility / Margin. effect veh
		Probit	IV probit	Probit	IV probit	
Base model	Full sample	0.349*** (0.029)	**0.706** (0.224)**	0.286*** (0.012)	**0.740* (0.374)**	0.014 | 0.038

Rural-Urban Classification	Urban areas	0.322*** (0.034)	**0.606*** **(0.256)**	0.310*** (0.014)	**0.553** **(0.392)**	0.017
	Rural areas	**0.298**** **(0.112)**	-0.736 (1.561)	**0.166***** **(0.026)**	-1.617 (0.624)	0.002 | 0.012
Household income levels	≥ €44,913	0.510*** (0.042)	**1.021** **(1.161)**	0.188*** (0.019)	**1.182** **(2.924)**	
	≤ €44,912	0.155*** (0.040)	**0.604***** **(0.189)**	0.326*** (0.016)	**0.760**** **(0.249)**	0.017 | 0.055
Age groups	50-63	**0.270***** **(0.048)**	-1.288 (0.204)	**0.155***** **(0.021)**	-2.801 (0.203)	0.006 | 0.015
	35-49	0.505*** (0.056)	**1.250**** **(0.413)**	0.274*** (0.024)	**2.042** **(1.445)**	0.023
	25-34	0.303*** (0.066)	**1.197***** **(0.285)**	0.396*** (0.028)	**1.575***** **(0.359)**	0.021 | 0.034
	15-24	**-0.115** **(0.080)**	-0.195 (0.340)	**0.382***** **(0.032)**	0.883* (0.377)	0.127
Educational levels	High educated	0.161*** (0.034)	**0.211***** **(0.350)**	0.229*** (0.020)	**0.772**** **(0.593)**	0.004 | 0.016
	Middle educated	0.165*** (0.044)	**0.398** **(0.237)**	0.336*** (0.017)	**0.856*** **(0.342)**	0.052
	Low educated	**0.286***** **(0.067)**	0.390 (0.314)	**0.226***** **(0.024)**	-1.130* (0.521)	0.008 | 0.032

Significance levels: *: 0.05%, **: 0.01%, ***: 0.001%
IV models: first stage estimates for instrumental variable (i.e. population density) on PT job accessibility measure; second stage estimates for estimated PT job accessibility measure on employment probability.
Coefficients (SE) in bold: reported model estimates based on acceptance null hypothesis of exogeneity (i.e. when job accessibility is found endogenous with employment)

Table 11.9 Individual employment probabilities by age group

Variables	Coefficients (SE)								Elasticities: +10% accessibility/ Margin. effect veh
	Age 15-24	**Age 15-24**	**Age 25-34**	**Age 25-34**	**Age 35-49**	**Age 35-49**	**Age 50-63**	**Age 50-63**	
	Probit	IV Probit	Probit	IV Probit	Probit	IV Probit	Probit	IV Probit	
Dependent variable									
Emp. (1); unemp. (0)									
Individual & Household variables									
Age	0.058 (0.121)	0.096 (0.124)	0.682*** (0.092)	0.491*** (0.127)	0.015 (0.043)	-0.020 (0.049)	0.005 (0.601)	0.254* (0.043)	
Age squared/100	0. 326 (0.288)	0. 211 (0.300)	-0.107*** (0.157)	-0.778*** (0.205)	-0.037 (0.050)	-0.004 (0.060)	0.030 (0.050)	-0.243*** (0.030)	
Female	-0.230** (0.026)	-0.209** (0.033)	-0.399*** (0.024)	-0.287*** (0.031)	-0.829*** (0.018)	-0.686* (0.336)	-0.691*** (0.015)	-0.190 (0.206)	
Low educated (omitted)	0.127** (0.035)	0.117** (0.035)	-0.348*** (0.047)	-0.224** (0.068)	-0.249*** (0.026)	-0.049 (0.232)	-0.243*** (0.018)	-0.192** (0.066)	
Non-Western migrant	-0.301*** (0.044)	-0.274*** (0.049)	-0.359*** (0.036)	-0.297** (0.049)	-0.101** (0.034)	-0.065 (0.076)	-0.049 (0.045)	0.000 (0.042)	
Unemployment history	-0.301*** (0.039)	-0.258*** (0.053)	-0.385*** (0.027)	-0.294*** (0.053)	-0.379*** (0.020)	-0.256 (0.204)	-0.319*** (0.018)	-0.103 (0.095)	
Young children (<age 12)	0.138*** (0.038)	0.144*** (0.038)	-0.176*** (0.015)	-0.160*** (0.019)	-0.014 (0.010)	-0.038* (0.019)	-0.023 (0.028)	-0.021 (0.018)	
Single household	-0.126** (0.046)	-0.125 (0.046)	-0.135*** (0.033)	0.183 (0.112)	-0.124*** (0.030)	-0.304 (0.404)	-0.143*** (0.022)	-0.500*** (0.028)	
Single parent household	-0.009 (0.107)	-0.181 (0.170)	-0.230*** (0.056)	0.043 (0.110)	0.014 (0.031)	-0.318 (0.259)	0.072* (0.033)	-0.246*** (0.043)	
Neighbourhood & accessibility variables									
Percent unemployed (excl. students)	-0.033*** (0.002)	-0.030*** (0.004)	-0.037*** (0.002)	-0.029*** (0.005)	-0.037*** (0.001)	-0.025 (0.020)	-0.033*** (0.001)	-0.010 (0.010)	
PT-and-bicycle job accessibility/ 1,000,000	-0.115 (0.080)		0.303*** (0.066)		0.505*** (0.056)		**0.270*** (0.048)**		**0.006**
Estimated PT-and-bicycle job accessibility/ 1,000,000		-0.195 (0.340)		**1.197*** (0.285)**		**1.250** (0.413)**		-1.288 (0.204)	**0.021 | 0.023**

Household vehicle	**0.382***** (0.032)		0.396*** (0.028)		0.274*** (0.024)		**0.155*** (0.021)**		**0.127 | 0.015**
Estimated Household vehicle		0.883* (0.377)		**1.575*** (0.359)**		**2.042 (1.445)**		-2.801 (0.203)	**0.034**
Constant	-2.142 (1.257)	-2.939* (1.390)	-8.975*** (1.359)	-7.362*** (1.572)	1.893* (0.902)	0.410 (1.906)	2.296 (1.685)	-3.469 (1.467)	
Wald Chi-Squared statistic	1399.71***	1457.93***	1726.43***	2765.56***	3430.02***	7339.62***	3851.28***	4778.20***	
Wald Chi-Squared statistic of exogeneity		3.51		7.71*		23.71***		38.50***	
Pseudo R2	0.1127		0.1186		0.1183		0.0948		
N	15.031		30.583		63.045		65.998		
Mean PT-and-bicycle job accessibility	205,781		236,338		203,955		184,764		
Mean Household vehicle rate	68.4%		74.9%		83.9%		84.6%		
Mean employment rate	86.5%		94.3%		95.1%		92.9%		

*Significance levels: *: 0.05% **: 0.01% ***: 0.001%.*

Table 11.10 Individual employment probabilities by educational level

Variables	Coefficients (SE)						Elasticities: +10% accessibility/ Margin. effect veh
	Low educated		Middle educated		High educated		
Dependent variable							
Emp. (1); unemp. (0)							
Individual & Household variables							
Age	0.166*** (0.005)	0.151*** (0.017)	0.153 *** (0.004)	0.140*** (0.011)	0.124*** (0.006)	0.057 (0.039)	
Age squared/100	-0.188*** (0.006)	-0.168*** (0.020)	-0.180*** (0.005)	-0.165*** (0.012)	-0.152*** (0.007)	-0.078*** (0.040)	
Female	-0.833*** (0.019)	-0.746*** (0.089)	-0.655*** (0.013)	-0.640*** (0.022)	-0.443*** (0.016)	-0.394*** (0.064)	
Low educated (omitted)							
Non-Western migrant	-0.312*** (0.031)	-0.334*** (0.034)	-0.208*** (0.025)	-0.183*** (0.027)	-0.250*** (0.029)	-0.197*** (0.055)	

Unemployment history	-0.324*** (0.024)	-0.326*** (0.031)	-0.323*** (0.016)	-0.304*** (0.023)	-0.328*** (0.019)	-0.238*** (0.070)	
Young children (<age 12)	0.003 (0.015)	0.002 (0.014)	-0.034*** (0.010)	-0.036*** (0.010)	-0.046*** (0.010)	-0.064*** (0.009)	
Single household	-0.072* (0.033)	-0.445*** (0.014)	-0.096*** (0.020)	0.032 (0.084)	-0.083*** (0.023)	-0.258 (0.149)	
Single parent household	-0.111* (0.045)	-0.381*** (0.104)	0.042 (0.029)	0.127* (0.060)	-0.026 (0.035)	-0.167 (0.087)	
Neighbourhood & accessibility variables							
Percent unemployed (excl. students)	-0.035*** (0.002)	-0.035*** (0.003)	-0.035*** (0.001)	-0.032*** (0.002)	-0.031*** (0.001)	-0.022*** (0.007)	
PT-and-bicycle job accessibility/ 1,000,000	**0.286*** (0.067)**		0.165*** (0.044)		**0.161*** (0.034)**		**0.008 | 0.004**
Estimated PT-and-bicycle job accessibility/ 1,000,000		0.390 (0.314)		**0.398 (0.237)**		0.211*** (0.350)	
Household vehicle	**0.226*** (0.024)**		0.336*** (0.017)		**0.229*** (0.020)**		**0.032 | 0.016**
Estimated Household vehicle		-1.130 (0.521)		**0.856* (0.342)**		0.772** (0.593)	**0.052**
Constant	-1.915** (0.049)	-0.598 (0.623)	-1.524** (0.072)	-1.776*** (0.180)	-0.618** (0.122)	-1.106*** (0.160)	
Wald Chi-Squared statistic	4162.35***	5455.05***	6433.79***	6812.62***	2657.54***	5281.07***	
Wald Chi-Squared statistic of exogeneity		4.79		10.60**		55.35	
Pseudo R2	0.1798		0.1276		0.0759		
N	35,020		81,468		80,151		
Mean PT-and-bicycle job accessibility	178,227		178,592		255,017		
Mean Household vehicle rate	77.1%		81.8%		79.1%		
Mean employment rate	88.7%		92.4%		95.2%		

*Significance levels: *: 0.05% **: 0.01% ***: 0.001%.*

Table 11.11 Base models with and without IV for the MRDH-region

Variables	Coefficients (SE)		Elasticities: +10% accessibility/ +1 HHVehicle
	Probit model	IVprobit model	
Dependent variable			
Empl. (1); Not empl. (0)			
Individual & Household variables			
Age	0.083*** (0.001)	0.020*** (0.002)	
Age squared/100	-0.118*** (0.001)	-0.043*** (0.002)	
Female	-0.437*** (0.003)	-0.238*** (0.008)	
Low educated	-0.373*** (0.004)	-0.162*** (0.008)	
Non-Dutch ethnicity	-0.628*** (0.003)	-0.067*** (0.014)	
Unemployment history	-0.998*** (0.003)	-0.433*** (0.019)	
Young children (< age 12)	-0.041*** (0.002)	-0.046*** (0.002)	
Single household	-0.045*** (0.004)	0.656*** (0.011)	
Single parent household	-0.099*** (0.005)	0.372*** (0.009)	
Neighbourhood & accessibility variables			
Percent unemployed (excl. students)	-0.668*** (0.020)	-0.420*** (0.018)	
Estimated PT job accessibility/1,000,000	-0.089*** (0.011)	1.192*** (0.029)	**0.083**
Estimated household vehicle ownership	0.477*** (0.003)	2.281*** (0.021)	**0.105**

Constant	0.134*** (0.018)	-1.393*** (0.030)	
Wald Chi-Squared statistic	290426.53 ***	918030.24 ***	
Wald Chi-Squared statistic of exogeneity		1181.72***	
Pseudo R2	0.2221		
N	1,214,066	1,214,066	
Mean job accessib. level	384,361	384,361	
Mean hhvehicle rate	69.9%	69.9%	
Mean employment rate	77.1%	77.1%	

Table 11.12 Individual employment probabilities by income quartile for the Rotterdam and The Hague Metropolitan Areas

Variables	Rotterdam metropolitan area Coefficients (SE)				The Hague metropolitan area Coefficients (SE)				Elasticities: +10% accessibility/ +1 HHVehicle
	1st income quartile	2nd income quartile	3rd income quartile	4th income quartile	1st income quartile	2nd income quartile	3rd income quartile	4th income quartile	
Dependent variable									
Empl. (1); Not empl. (0)									
Individual & Household variables									
Age	-0.033*** (0.002)	-0.009 (0.008)	0.056*** (0.004)	0.076*** (0.016)	-0.002 (0.004)	0.015** (0.005)	0.049*** (0.004)	0.082*** (0.005)	
Age squared/100	0.023*** (0.004)	-0.010 (0.010)	-0.079*** (0.003)	-0.104*** (0.019)	-0.030*** (0.006)	-0.038** (0.006)	-0.077*** (0.005)	-0.109*** (0.005)	
Female	-0.048*** (0.008)	-0.378*** (0.070)	-0.643*** (0.067)	-0.530*** (0.109)	0.006 (0.011)	-0.432*** (0.025)	-0.538*** (0.014)	-0.361*** (0.017)	
Low educated	-0.011 (0.021)	-0.208*** (0.046)	-0.277*** (0.032)	-0.297*** (0.038)	-0.168*** (0.017)	-0.230*** (0.015)	-0.247*** (0.013)	-0.256*** (0.013)	
Non-Dutch ethnicity	0.131*** (0.024)	-0.137 (0.080)	-0.401*** (0.016)	-0.225* (0.091)	-0.061 (0.034)	-0.257*** (0.040)	-0.398*** (0.029)	-0.390*** (0.035)	
Unemployment history	-0.138** (0.047)	-0.532*** (0.130)	-0.933*** (0.067)	-0.939*** (0.201)	-0.583*** (0.035)	-0.676*** (0.047)	-0.886*** (0.027)	-0.782*** (0.038)	
Young children (< age 12)	-0.078*** (0.008)	-0.080*** (0.006)	0.031 (0.024)	0.004 (0.016)	-0.097*** (0.010)	-0.086*** (0.006)	-0.028*** (0.009)	-0.034*** (0.005)	

Single household	0.695*** (0.016)	1.025*** (0.136)	0.694*** (0.186)	0.711*** (0.206)	0.706*** (0.023)	1.150*** (0.036)	0.829*** (0.026)	0.407*** (0.043)	
Single parent household	0.422*** (0.026)	0.540*** (0.015)	0.216 (0.117)	0.251*** (0.039)	0.049* (0.038)	0.421*** (0.017)	0.316*** (0.021)	0.175*** (0.020)	
Neighbourhood & accessibility variables									
Percent unemployed (excl. students)	0.173** (0.056)	-0.000 (0.062)	0.129 (0.068)	-0.334* (0.149)	-0.988*** (0.077)	-0.877*** (0.087)	-0.661*** (0.098)	-0.908*** (0.091)	
Estimated PT job accessibility/1,000,000	0.876*** (0.043)	0.690*** (0.199)	-0.411 (0.373)	0.834* (0.403)	0.622*** (0.140)	1.053*** (0.182)	0.527** (0.191)	1.915*** (0.108)	**0.457, 0.099, 0.014** **0.205, 0.144, 0.015, 0.054**
Estimated household vehicle ownership	2.306*** (0.018)	1.610*** (0.246)	-0.660 (0.730)	1.757 (0.982)	1.545*** (0.137)	1.170*** (0.149)	0.767*** (0.190)	2.021*** (0.129)	**2.334, 0.245** **0.815, 0.206, 0.029, 0.036**
Constant	-0.764*** (0.070)	-0.125 (0.260)	1.561 (0.436)	-1.164 (1.090)	-0.167 (0.111)	-0.086 (0.137)	0.366 (0.187)	-2.197*** (0.146)	
Wald Chi-Squared statistic	151273.39 ***	65075.99* **	23792.58* **	29842.39* **	21927.77* **	31847.59* **	18594.47* **	39177.17* **	
Wald Chi-Squared statistic of exogeneity	171.01***	72.04***	61.89**	4.40***	56.39***	32.96**	15.65***	363.10***	
N	93,310	122,881	170,472	238,811	78,023	98,105	137,559	221,690	
Mean job accessib. level	435,916	410,150	364,710	352,165	431,772	421,895	394,551	374,007	
Mean hhvehicle rate	31.0%	58.0%	77.9%	87.8%	29.7%	55.4%	76.4%	87.0%	
Mean employment rate	42.4%	70.5%	85.3%	91.9%	47.4%	72.8%	85.7%	91.4%	

*Significance levels: *: 0.05% **: 0.01% ***: 0.001%.*

Table 11.13 Interview guide job seekers

A. Introduction

- PhD research project Youth Mobility and Job Access, ITS, University of Leeds, in collaboration with DWP and WYCA on the role (public) transport for job seekers.
- 30 semi structured interviews with young people (aged 16-30) in Leeds, Bradford, and Calderdale

  - Topics: your job search & travel experience, past employment, and personal situation;
  - If you do not understand a question or do not want to answer it, you can simply say so;
  - Interview is confidential, you remain anonymous;
  - Results of the interview are processed in a research report;
  - Use interviews to inform existing/ new transport services (better) to specific needs of job-seekers.

- Questions/ objections so far? If not: have CONSENT FORM signed.
- Permission audio recording of the interview (anonymous)?

B. Thinking of your current job search:

1. Why are you looking for a job (laid-off, finished school)?

2. How is your job search like? (experience, period, ways to search for jobs)

3. What type of job are you looking for (days / times, skills/ training, employment aspirations)?

4. Are suitable jobs/ training opportunities available within reach of your home (underemployment)?

5. Where/ in which areas are you looking for work (show locations/ search area on MAP), reasons?

6. How much time/ distance are you willing to commute to jobs/ interviews (why, restrictions by other activities)?

7. Which means of transportation are used for job search/ job interviews (why, how often, certain days / times)?

   a. Do you make use of public transport (which modes, why, when: MAP with stops and routes provided)?

   b. Do you make use (public) transport budgets offered by the DWP (what, why, when, where to)?

8. Can you tell me about this travel experience? (easy to reach job locations/ interviews, reasons?)

   - transport availability (walking/ bicycle, moped/ car/ motorcycle, PT), PT service frequencies

   - driver's license, can drive/ cycle in traffic, understand PT information

   - transport time or costs, comfort/ safety

   - alignment of family tasks, caring responsibilities, and / or other activities (appointments dentist, doctor etc.)

- disability/ health issues

a. Have transport problems ever been a reason for rejecting job interviews / potential work (which, where, reasons), consequences?

b. if so, how are transport problems dealt with (other modes of transport / work, search area job interviews / work reduced, family responsibilities and / or other activities adapted, moving)?

9. How far and where would you consider job locations if better transport were available (why, where)?

- specific desirable job locations, can you show these job locations on the MAP?

- what if you could use (better) public transport?

- what if you had private transport available (bike / moped / car / motorcycle)?

10. Would be willing to move home for a job, why/ why not?

11. If you find a job, would you use different transport to work (what, why)?

C. Thinking back to your last job:

12. Do you have any recent work experience (type of work, working hours / days, duration of employment, until when, reasons)? If not, continue with question 16.

13. If so, where was the job location (show location on MAP)?

14. How did you travel to work (walking / transport means, why, use transport on which days / times)?

- transport availability (walking/ bicycle, moped/ car/ motorcycle, PT)

15. Related to your last job, what is your best and worst travel-to-work experience?

- In case of transport problems, how have these been dealt with (other means of transport / work, family responsibilities and / or other activities adapted, moved)?

Move to question 18.

16. What did you do before your job search (school, other activities)?

17. Where was this located (show MAP), and how did you get there (travel experience)?

D. Personal characteristics

18. Age (male / female)

19. Family composition

a. Single / cohabiting (married)/ living with parents

b. Children (number / age)

20. Education

a. Highest level of education (occupation)

b. Currently following training / work-related course (why or not?)

21. Disabilities/ Health problems?

22. Residential location (neighbourhood / postal code)?

23. Period living in neighbourhood?

24. Receiving (welfare) benefits?

E. Closing

- Do you have any questions or comments?
- May I contact you again (by telephone / e-mail) for any additional questions?

Table 11.14 Accessibility levels by 10 aggregated industry sectors (SIC2007) in West Yorkshire

	Average accessib.	Average accessibility by aggregate industry section (SIC 2007) Agricult.	Manufact.	Utility services	Construct.	Retail	Finance	Public services	Private services	Leisure
Bradford	158,774	275	15,372	2,040	5,653	37,129	10,907	46,512	34,980	5,905
Calderdale	105,848	157	12,175	944	4,721	22,869	8,699	27,427	24,751	4,105
Kirklees	119,316	208	13,087	1,188	5,414	31,013	5,186	31,233	27,516	4,471
Leeds	271,782	332	14,888	4,027	9,790	59,395	21,502	71,153	78,325	12,371
Wakefield	111,201	156	9,846	1,367	4,785	29,003	5,167	30,212	26,553	4,111
West York.	178,611	254	13,651	2,369	6,828	41,181	12,451	48,004	46,427	7,446

Table 11.15 Turned down job in last 12 months due to inadequate public transport, 2016-2017

Variables	Full model		Young people (aged 16-24)	
	Coefficients (SE)	Odds-ratio	Coefficients (SE)	Odds-ratio
Age/100	0.444 (0.035)		-0.876 (0.875)	
Age squared	-0.001* (0.000)	0.999	0.020 (0.021)	
Female	0.858 (0.086)		0.196 (0.458)	
No degree level	-0.402** (0.133)	0.669	0.042 (0.377)	
Single household	0.200 (0.154)		-0.819 (0.646)	
No Driving Licence	0.256 (0.194)		0.048 (0.336)	
No Car	1.320*** (0.180)	3.743	1.106*** (0.311)	3.023

Public transport job accessibility	-0.286** (0.102)	0.751	-1.028*** (0.322)	0.358
Median household Income	0.000 (0.000)		0.000 (0.000)	
Constant	-4.079*** (0.711)		6.567 (8.916)	
Wald Chi-Squared statistic	188.35***		26.32**	
Pseudo R2	0.0701		0.0414	
N	15.413		1.847	

Significance levels: *: 0.05%, **: 0.01%, ***: 0.001%

---

[i] Of the 42 identified studies that assessed the association between car access and employment outcomes, a total of 30 studies were excluded due to (combinations of): i) different employment measures (6 studies used employment rate or labour force participation rate, unemployment probability, or unemployment duration); ii) different transport access measures (4 studies used lost a car, number of cars, or car-to-adults-ratio); iii) different model specifications (14 studies used multinomial logit, probit, or tobit); iv) or missing required data (3 studies). Of these, 19 studies (also) reported individual employment probabilities associated with car access. Several of these studies used probit models (Rice, 2001; Stoll, 2005; Garasky et al., 2006; Matas et al., 2010; Di Paolo et al., 2010; O'Connell et al., 2012), multinomial logit models (Cervero et al. 2002; Cervero and Tsai, 2003; Kawabata, 2003; Gurley and Bruce, 2005; Sandoval et al., 2011; Blumenberg and Pierce, 2014; Blumenberg and Pierce, 2017), censored regression models (Lucas, 2003) or OLS models (Raphael et al., 2001; Bee, 2009; Bansak et al., 2010). These studies were excluded due to their different functional form yielding incomparable coefficients and because they are not designed to derive odds-ratios in order to compare and interpret the estimated effects, while most did not report employment elasticities or the required descriptive statistics for all (sub)models by which to derive them. Di Paolo et al. (2010) used cars per adult in the household as transport measure, instead of a car ownership dummy, while Ong and Houston (2002) used no car or being unable to borrow a car as transport measure. Finally, Cavaco and Lesueur (2004) reported incomplete datasets that are required for the weight calculation of the meta-regressions. These studies were therefore also excluded from the meta-analysis.
Of the 22 identified studies that assessed the association between commute time and employment outcomes, a total of 14 studies were excluded due to (combinations of): i) different employment measures (10 studies used employment or labour force participation rate, unemployment probability, or unemployment rate); ii) different model specifications (1 study used probit); iii) or missing required data (4 studies). Of these, Ozbay et al. (2006) also reported individual employment probabilities, but used modelled travel times to the nearest employment centre rather than actual travel times reported by commuters, whilst not reporting the SE and sample sizes required for the weight calculation of the meta-regressions.