Ex-ante evaluation of accessibility impacts of Crossrail projects in London

Trilla Cisa, Daniel and Barros, Joana

Geography Department, Birkbeck, University of London

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Summary

This paper presents a study on employment accessibility in London with the future addition of Crossrail I and II to the public transport network and its impact towards equity. Two different accessibility measures have been used to calculate access to all jobs and to low-income jobs. Travel times and monetary costs have been estimated using OpenTripPlanner and public transport schedules acquired in the GTFS format. The results have shown that outer boroughs will see a larger increase in accessibility levels due to the implementation of Crossrail services. The contribution towards equity in transport, however, would be minor.

KEYWORDS: Accessibility, Public Transport, Equity, Crossrail

1. Introduction

Public transport is vital in large metropolitan areas to fulfil the mobility needs of its citizens without the need of a car. The use of mass transit in urban centres has a positive impact on the environment reducing the emission of greenhouse gases, and for many, it is the only means to reach goods, services or employment. Investment in public transport services and infrastructure not only helps boost the economy and reduce the carbon footprint of cities, but it also enables people with less resources to meet their mobility needs. In recent years there has been an increased interest in accessibility measures as a way to evaluate the social distribution of transport as a tool towards social equity (Cuthill et al. 2018, Jedi Yeganeh et al. 2018, Antipova et all. 2020). Assessments of new transport infrastructure projects have often given more attention to the economic and environmental dimensions than the social impacts (Geurs & van Wee 2011, Thomopoulos & Grant-Muller 2013).

Crossrail, an 18.6 billion new east-west rail line through central London, much to the likes of Paris' RER network, has been the major investment in public transport infrastructure in London for the past decade. A second north-south line, dubbed Crossrail 2, had been in the planning stages until a recent funding review by the UK government. Both projects had been appraised for its economic, environmental and network capacity benefits (Crossrail Ltd 2011), however, their social benefits have not been assessed extensively. In order to better inform transport policies, it is paramount that they are assessed on how they affect local communities, and how beneficial the investment is likely to be for different population groups. New public transport services can dramatically reduce travel time, improving people's access to employment, healthcare, educational facilities as well as other services and amenities. However, such improvement can also attract new residents to the area, increasing rents and pushing away local residents.

The present study aims to assess how access to employment would improve with the addition of Crossrail I and II schemes to London's public transport network, focusing on the effect of the investment on communities living in the most deprived areas of the Greater London Authority (GLA) considering both time and cost.

2. Methodology

Accessibility measures were first proposed by Hansen (1959) and have been developed in transport, planning and social equity research over the years. Broadly speaking, accessibility can be defined as the cost, or the ease, of reaching a destination. Although different types of accessibility measures are available in the literature, research in access to jobs by public transport tend to use gravity-based measures, which weigh in the cost of travelling to the destination, against the benefits of reaching it, taking into account the number of opportunities available at the destination. These measures are not centred on individuals and their chances of securing a job, but rather provide with a measure to assess the ease of reaching the locations that have a high concentration of jobs by public transport from across the study area. For this analysis, two gravity-based measures have been used to calculate accessibility to all employment in London, and to low-income employment specifically as follows in the equation below:

$$A_i = \sum_j O_j \, f(C_{ij}) \tag{1}$$

where A_i is the accessibility for zone i, O_j the number of opportunities at zone j and $f(C_{ij})$ is the deterrence function that calculates the cost of getting from zone i to zone j. The first measure defines $f(C_{ij})$ using a 'generalised cost' approach that takes into account money and time to calculate the cost of reaching the destination and is calculated as follows:

$$f(C_{ij}) = \left(\frac{1}{C_{ij}^{a}} \right) \tag{2}$$

where C_{ij} corresponds to a value expressed in travel time that combines monetary costs and time constraints (Department for Transport, 2020, Leslie 2009) and a represents a constant value that decreases the accessibility value as the cost of reaching the destination increases. The second measure, referred to as 'cumulative', defines $f(C_{ij})$ as the sum of the number of jobs reached within a certain travel time threshold and is calculated as follows:

$$f(C_{ij}) = 1 \text{ if } C_{ij} \leq \overline{TC} \text{ and } 0 \text{ if } C_{ij} > \overline{TC} \tag{3}$$

The function counts as 1 if the travel time is within the threshold and 0 if not, effectively discounting it. The study area was limited to the GLA boundaries because (i) the new rail lines will run almost entirely within its the borders, and (ii) it made modelling monetary costs feasible thanks to TfL's fare zone system. The population-weighted centres of lower-layer super output areas (LSOA) from the 2011 Census have been set as the origin/destination locations to calculate estimated travel times from all the LSOAs within the GLA to those LSOA that have more than 2,500 jobs or more tan 1,000 low-income jobs as per the 2011 Census Workplace Population data. Although the number of jobs is likely to have risen across most LSOAs since 2011 and therefore need updating with recent data, the spatial distribution of jobs is likely to remain stable. Since this dataset does not provide data on earnings estimates, the location of low-income jobs has been determined using the nine Standard Occupational Classification (SOC) categories and the 2019 Weekly Earnings and Working Hours Estimates dataset from the Office for National Statistics (ONS). The median value for each SOC was compared against the 2019 London living wage of £10.75 per hour, or £430 a week. The median weekly income averages for the occupational classes of "Caring, leisure and other services", "Sales and customer service" and "Elementary" were found to be below that London living wage and, thus, considered here as low-income jobs.

Two scenarios have been modelled: Scenario A without Crossrail services (baseline) and Scenario B with both Crossrail schemes in place. Estimated travel times and costs have been calculated with OpenTripPlanner, an open-source journey planner. OTP uses public transport schedules in the General Transit Feed Specification (GTFS) format and street network data from OpenStreetMap to determine the best route according to the parameters set. The analyses modelled travel times and costs on a non-holiday Monday in September with the aim of reaching the destination just before 9 AM.

3. Results and Discussion

The results have shown only minor differences in accessibility levels to low-income jobs in comparison to all jobs. Although accessibility to all jobs have slightly higher values, their spatial distribution remains similar with the exception of some areas in the West, which are the result of Heathrow Airport concentrating a large number of low-income jobs. The increase in accessibility levels was observed across all measures as shown on figure 2, though more accentuated for jobs reached within the 48- and 63- minute threshold. The maps in figure 1 show the 'generalised cost' accessibility levels while the maps in figure 3 illustrate the increase in the number of jobs reached for the 'cumulative' measure. When comparing the results for scenarios A and B, increases in accessibility values in the 'cumulative' measures have generally been observed in LSOAs located in the outer boroughs with higher increases being observed more towards the outer edges of the GLA as travel time thresholds increase. Whereas for the 'generalised cost' measure the increase was noted in areas in close proximity to stations with new Crossrail services. In this measure, the inclusion of monetary costs has meant that LSOAs further from these stations saw a smaller increase in their accessibility values when compared against 'cumulative' measures as the monetary costs of reaching these stations by bus have also been included.

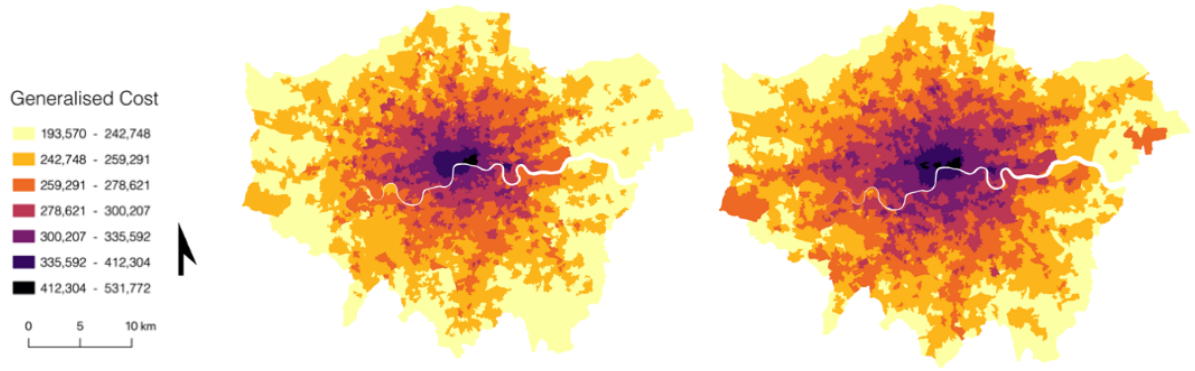

Figure 1 Accessibility maps using the 'generalised cost' measure. On the left, without Crossrail services. On the right with both Crossrail lines available. Greater values indicate higher levels of accessibility to all employment.

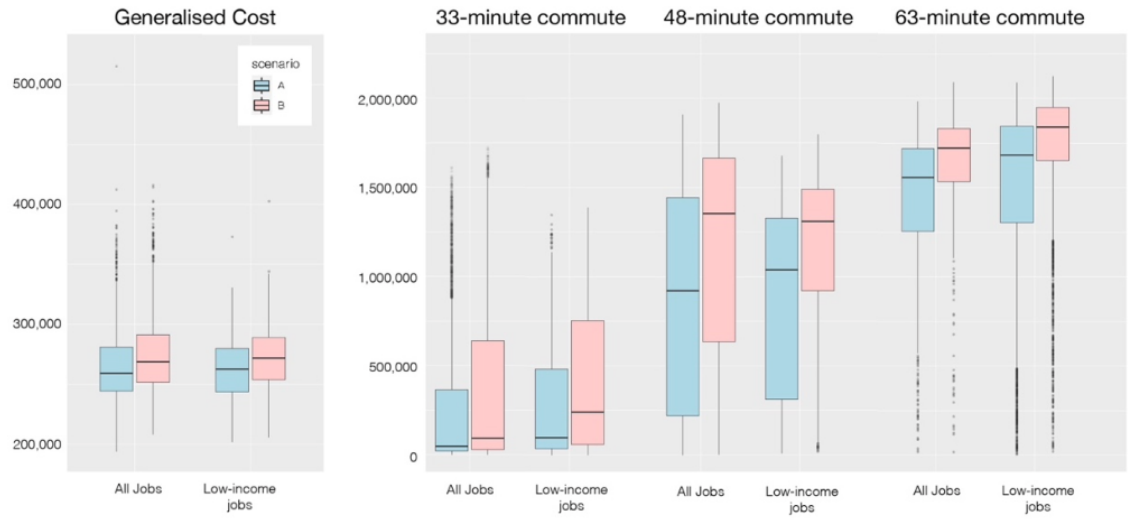

Figure 2 Boxplots of all the accessibility measures calculated

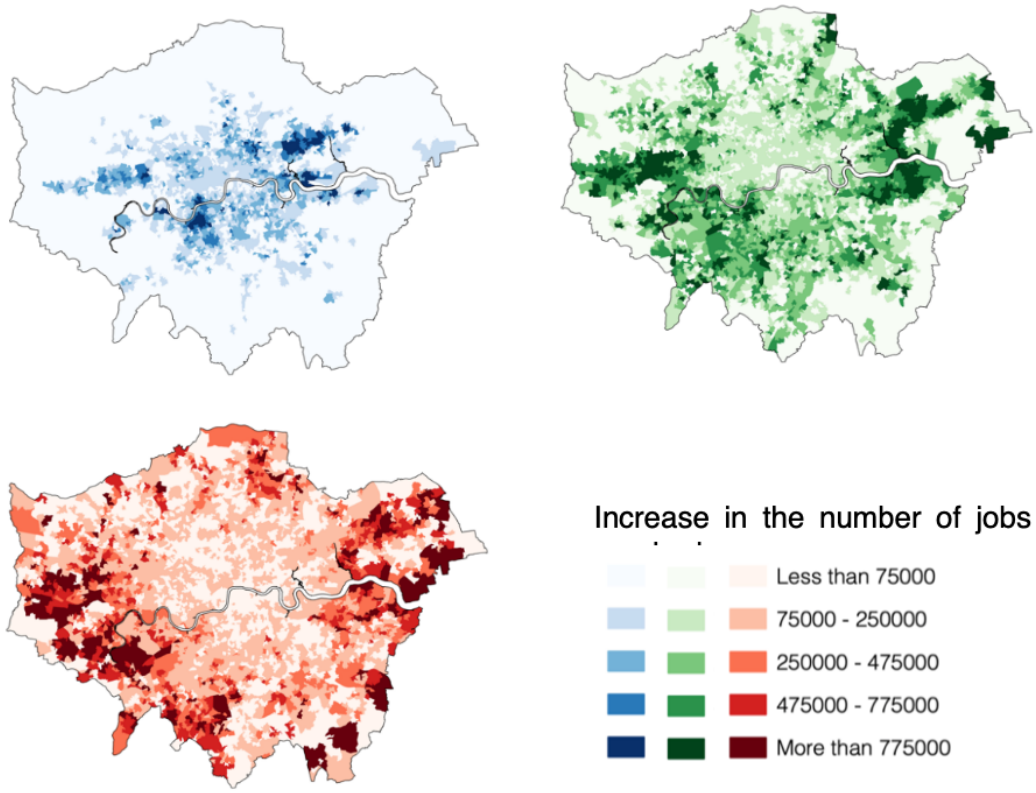

Figure 3 Increase in the number of jobs reached at the 33-minute (blue), 48-minute (green) and 63-minute (red) travel time thresholds.

A vertical equity approach has been used to assess equity in the results using Pearson's correlation coefficient, looking at the relationship between accessibility levels and the Indices of Multiple Deprivation (IMD) scores for each LSOA. Vertical equity increases when the distribution of benefits from a transport policy favours disadvantaged groups. The coefficients for all accessibility measures returned a very week positive, yet significant, relationship between the two variables indicating that the Crossrail services implementation will have a minor contribution towards equity. To better understand the beneficial effects of Crossrail in London, z-scores for all accessibility measures were calculated and aggregated by borough. Table 1 shows the top boroughs with increased accessibility as a result of the project and where they stand on various socio-economic levels assessed through the study.

Table 1 IMD scores, percentage of social rent and average income of the boroughs that have seen increased accessibility as a result of new Crossrail services

Borough	Z-scores rank	IMD	Social Rent	Income
Ealing	1	22.55	43%	£44,236
Wandsworth	2	16.42	37%	£60,093
Greenwich	3	24.28	52%	£43,816
Richmond upon Thames	4	9.42	36%	£57,905
Barking and Dagenham	5	32.88	64%	£35,005
Merton	6	14.35	46%	£50,420
Newham	7	29.77	49%	£34,552

4. Conclusion

Accessibility measures can provide tangible insight on transport policy and investment from a social and equitable point of view by providing figures that are easy to understand among stakeholders. The intent of this study was to highlight the importance of including a social assessment of the impacts of transport infrastructure in the appraisal process. This analysis has looked at how Crossrail schemes will–or would, in the case of now cancelled Crossrail 2– contribute to social equity in the GLA. The results of modelling and comparing employment accessibility before and after the implementation of the Crossrail services showed that although the contribution to full equity is minor the benefits of the new services in terms of access to jobs would be observed across communities of various degree of need. The next steps of this study include on improvements to the analysis techniques to refine the results. There are also plans to extend the analysis in order to investigate the impacts of the project on the accessibility of the different ethnic groups, as well as the relationship between increased transport links and desirability of an area to gentrification and the displacement of local communities.

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Biographies

Daniel Trilla Cisa has completed his MSc Geographic Information Science at Birkbeck. He currently works within the online payments industry and is interested in in the application of geographic information data to the fields of transport and urban planning.

Dr Joana Barros is a Senior Lecturer in Geographic Information Science at Birkbeck, University of London. She is an urban planner and geographic information scientist with experience in applying geographic information data, tools, and technologies to improve the understanding of urban inequalities and promote social justice.