GLAECONOMICS

Accessibility-based employment projections – Technical Paper 2

Transport for London

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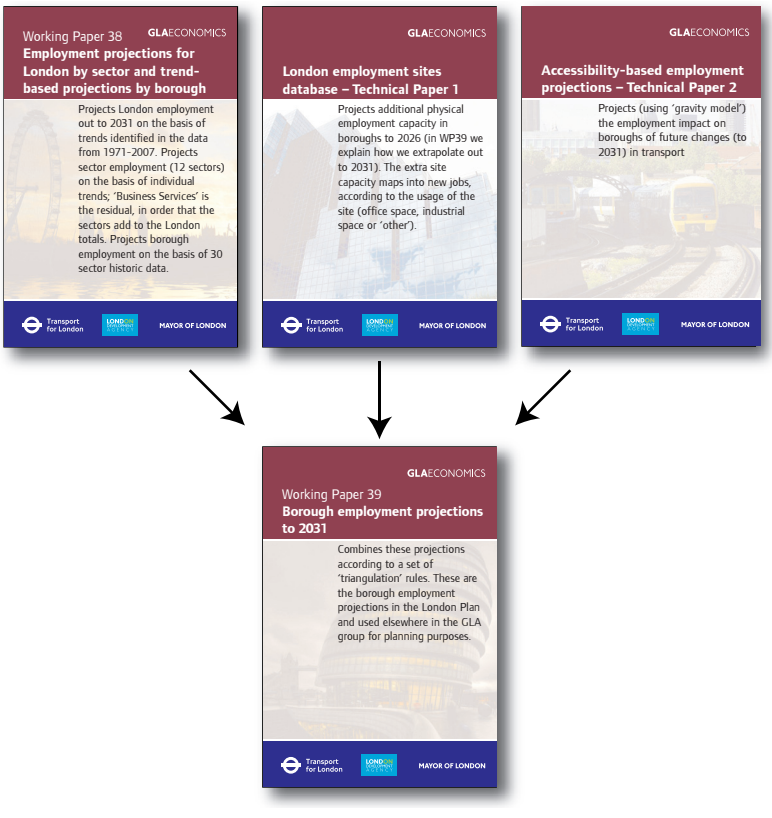

GLA Economics

Accessibility Based Employment Projections

Report

TRANSPORT
TRAFFIC
DEVELOPMENT
PLANNING
URBAN DESIGN
ECONOMICS
MARKET RESEARCH

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Accessibility Based Employment Projections

Report

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Executive Summary

Introduction

There is a strong relationship between the level of accessibility to/from a location and the density of development that takes place in that particular location. Therefore it should be expected that future changes in accessibility will influence the distribution of employment growth across London.

The GLA looks at three key drivers which impact on the employment growth trends. These are:

- Historic trends;
- Site capacity; and
- Transport accessibility.

This study focuses on transport accessibility and builds on previous work undertaken by Colin Buchanan for the GLA in 2002 and 2004 to ascertain the potential influence of transport accessibility on future growth.

The following tasks were undertaken:

- Establish the baseline relationship between accessibility and employment density;
- Determine how accessibility indicators are likely to change given the expected changes to the transport network ; and
- On the basis of those expected changes in accessibility predict how the distribution of growth might change.

Establishing a base relationship

Method

The first stage of the study was to determine the relationship between transport accessibility and development density. Measures of public transport (PT) and highway (HW) accessibility were tested. The base assumptions were that employment density would be determined mostly by labour supply as the greater the potential workforce available the greater the density of employment.

Accessibility indicators were taken from Transport for London's (TfL) London Transportation Studies (LTS) model. LTS is a multi-modal transport model of London.

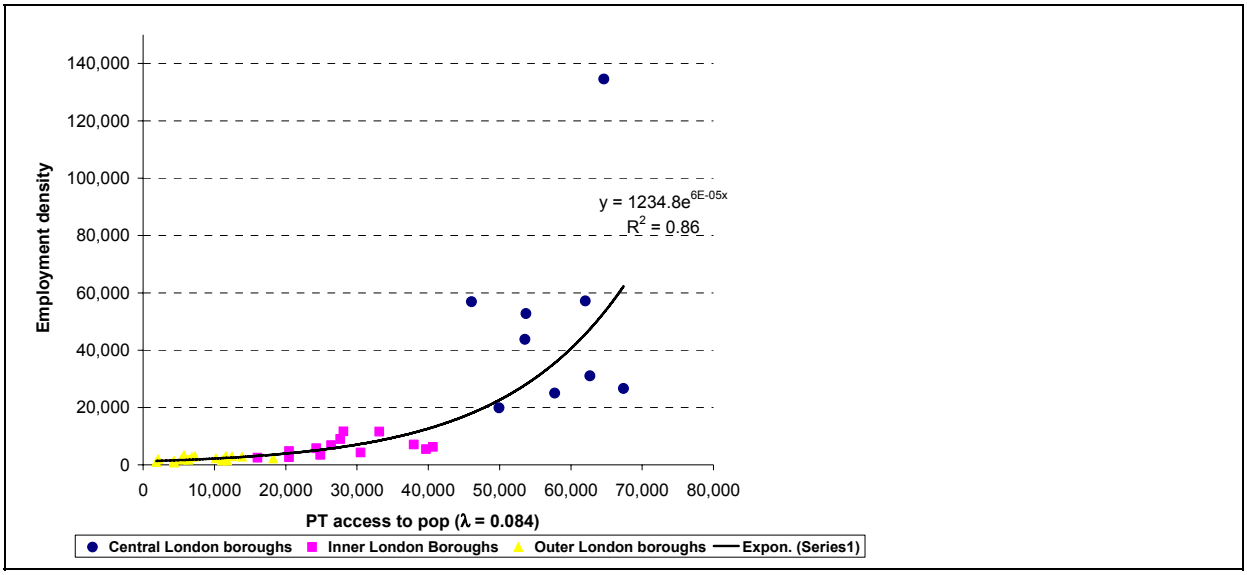
A number of different data sources and relationships were tested in order to determine the best fit relationship between accessibility and employment density. From this analysis it emerged that a gravity model formula based on PT only and a single measure of employment density provided the best fit relationship.

Highway accessibility did not improve the relationship for explaining employment density. Highway accessibility is distributed much more evenly than PT accessibility and it is possible that highway accessibility in London has little effect when compared with the more dominant impact of PT accessibility.

Results

Figure S1 shows a strong exponential relationship between employment density and PT access to population, with density increasing rapidly at high levels of accessibility. For the purpose of the analysis, boroughs were split between Central (corresponding to the Central Activity Zone or CAZ), Inner and Outer London. Three clusters clearly stand out in the graph: Central London, Inner London and Outer London, with Central London presenting high employment density and accessibility, and Outer London with low accessibility and employment density.

Figure S 1: Employment density versus PT access to population



Determining future changes in accessibility

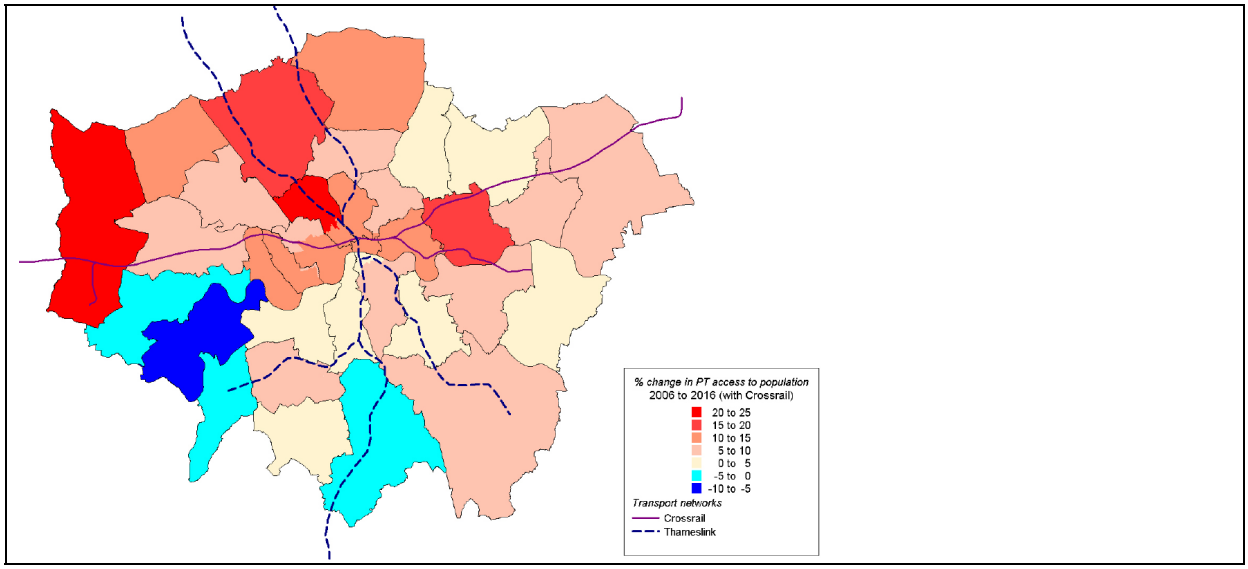
The approach produces an accessibility index that is then compared with density. The formula was applied for future modelled years based on LTS journey time outputs for 2016 without Crossrail, 2016 with Crossrail, 2026 and 2031. In order to isolate the impacts of transport investment on employment density, accessibility indices for future years were calculated using base 2007 population estimates[1]. The main changes in PT accessibility arise from Crossrail and Thameslink 2000, the two major infrastructure schemes.

Figure S2 overleaf shows the percentage change in PT accessibility to population by borough for 2016 (with Crossrail). It clearly highlights that boroughs along the Thameslink and Crossrail corridors benefit from the highest increases in accessibility levels. On the other hand, four boroughs see a fall or stagnation in their levels of accessibility. These boroughs are Richmond upon Thames, Hounslow, Kingston upon Thames and Croydon.

A large number of boroughs see accessibility peak with the 2016 with Crossrail scenario, and then fall in 2026 and 2031. The LTS model does not allow for any transport infrastructure investment from 2016 onwards, but increases highway congestion and rail crowding. If no investment is planned to counter these effects, bus speeds and hence journey times will increase as well as rail generalised time, leading to a fall in accessibility. However as congestion and crowding worsen, TfL is likely to respond with new infrastructure investment schemes not included in the current LTS scenarios. It seems reasonable to assume that the drop in accessibility after 2016 will to a certain extent be offset by future investments that have not been accounted for in this analysis.

[1] Source: ONS small area population estimates: mid year population estimates for 2007 by ward

Figure S 2: Percentage change in PT access to population (2006 – 2016 with Crossrail)

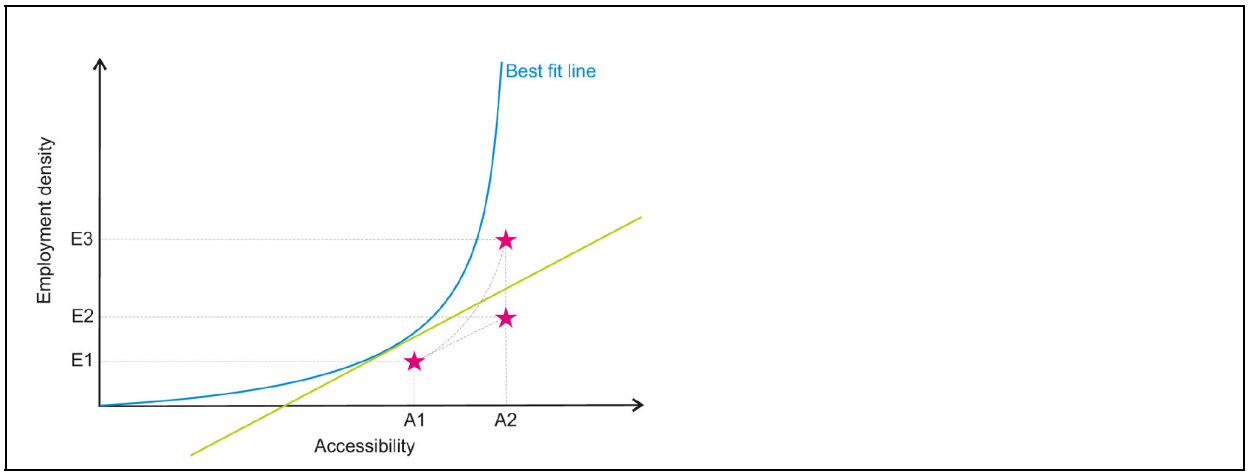


Impact on distribution of employment

Approach

To estimate the impact of changes in accessibility on employment distribution by borough for future years, it was assumed that growth in employment for future years would follow the same pattern as the best fit relationship shown in Figure S1. However the gap between the best fit curve and the borough will remain; i.e. for a borough under the curve, if accessibility increases, employment density will increase following the same progression as the best fit curve, but the percentage difference between the two will remain. This scenario is therefore based on the relative change in accessibility. As the curve is exponential, small increases in accessibility for boroughs that are already accessible gives place to very high growth in employment density. Above a certain level of accessibility, the growth in employment density has been constrained to a straight line, as shown in Figure S3. This means that for an increase in PT access from A1 to A2, employment will grow to E2 rather than E3.

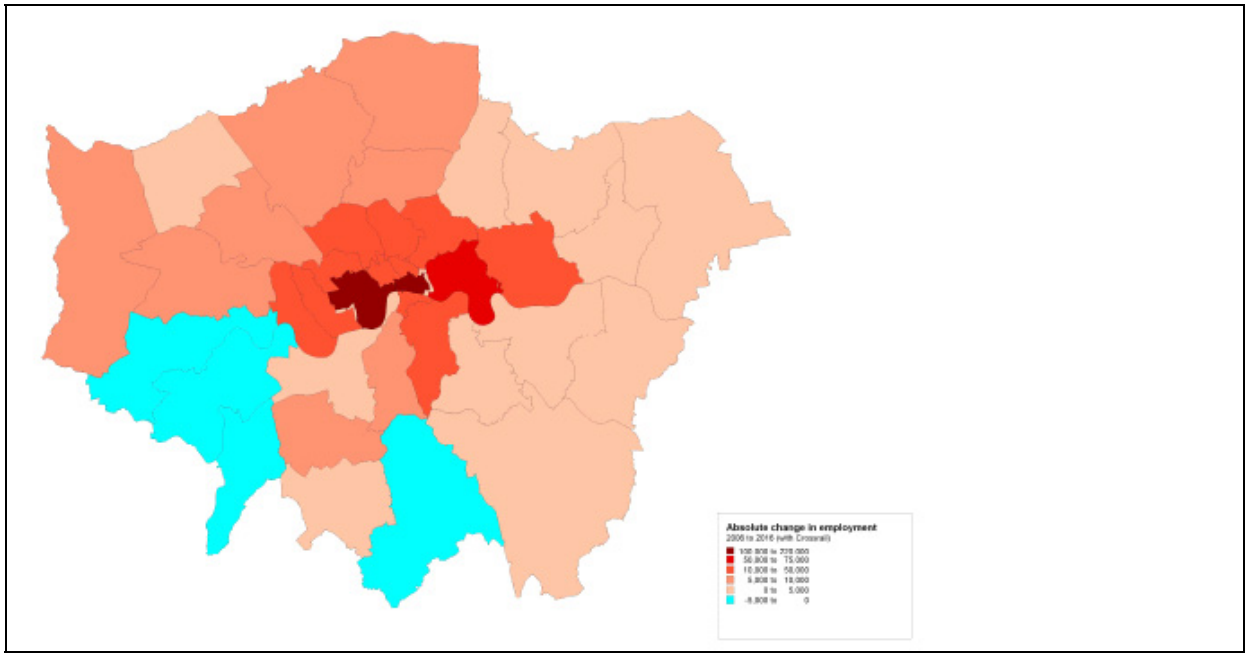
Figure S 3: Relative approach - capped



Results

Figure S4 below shows the change in the number of jobs by borough for 2016 (with Crossrail). The 2016 scenario estimate has an additional 712,000 jobs in Greater London compared to 2007. As accessibility levels drop in 2031, additional employment also drops in 2031 with only 435,000 more jobs in London compared to 2007. In 2016 most of the growth is concentrated in Central and East London. Highest growth occurs in the boroughs of Westminster, Camden, Tower Hamlets and City of London. South West London sees a fall in employment in 2016. These are the boroughs that do not benefit from transport infrastructure improvements, and see a fall in accessibility levels as highway congestion and rail crowding worsens. It is likely that additional infrastructure investment will take place from 2016 to 2031 to offset rail crowding and highway congestion. Therefore for forecasting purposes a more robust approach would be to freeze accessibility and hence employment levels to the 2016 (with Crossrail) scenario

Figure S 4: Absolute change in employment by borough 2006 -2016 with Crossrail



Conclusions

The forecasts summarised in this report constitute robust projections of future employment distribution based on changes in PT accessibility. However, it is important to stress that these forecasts are based on the assumption that the future location of employment is completely mobile and responds only to changes in transport accessibility patterns.

The forecasts should only be assessed in the context of a full consideration of the other factors and constraints influencing the location of employment in the GLA area, particularly historic trends and available site capacity. The GLA undertake this analysis before determining the final London Plan distributions.

1 Introduction

1.1 Background

1.1.1 Colin Buchanan (CB) was commissioned by GLA Economics in February 2009 to carry out a study investigating how employment growth might be distributed in London for future transport scenarios up to 2031. The study focussed specifically on the relationship between employment and public transport (PT) and highway (HW) accessibility in the Greater London area.

1.1.2 The GLA looks at three key drivers which influence the distribution of employment across London, as follows:

- **Historic trends** – reflecting past preferences of employers for locating in particular boroughs;
- **Site capacity** – reflecting the availability of business sites across London; and
- **Transport accessibility** – reflecting the need of most businesses to have good access to labour markets and clients.

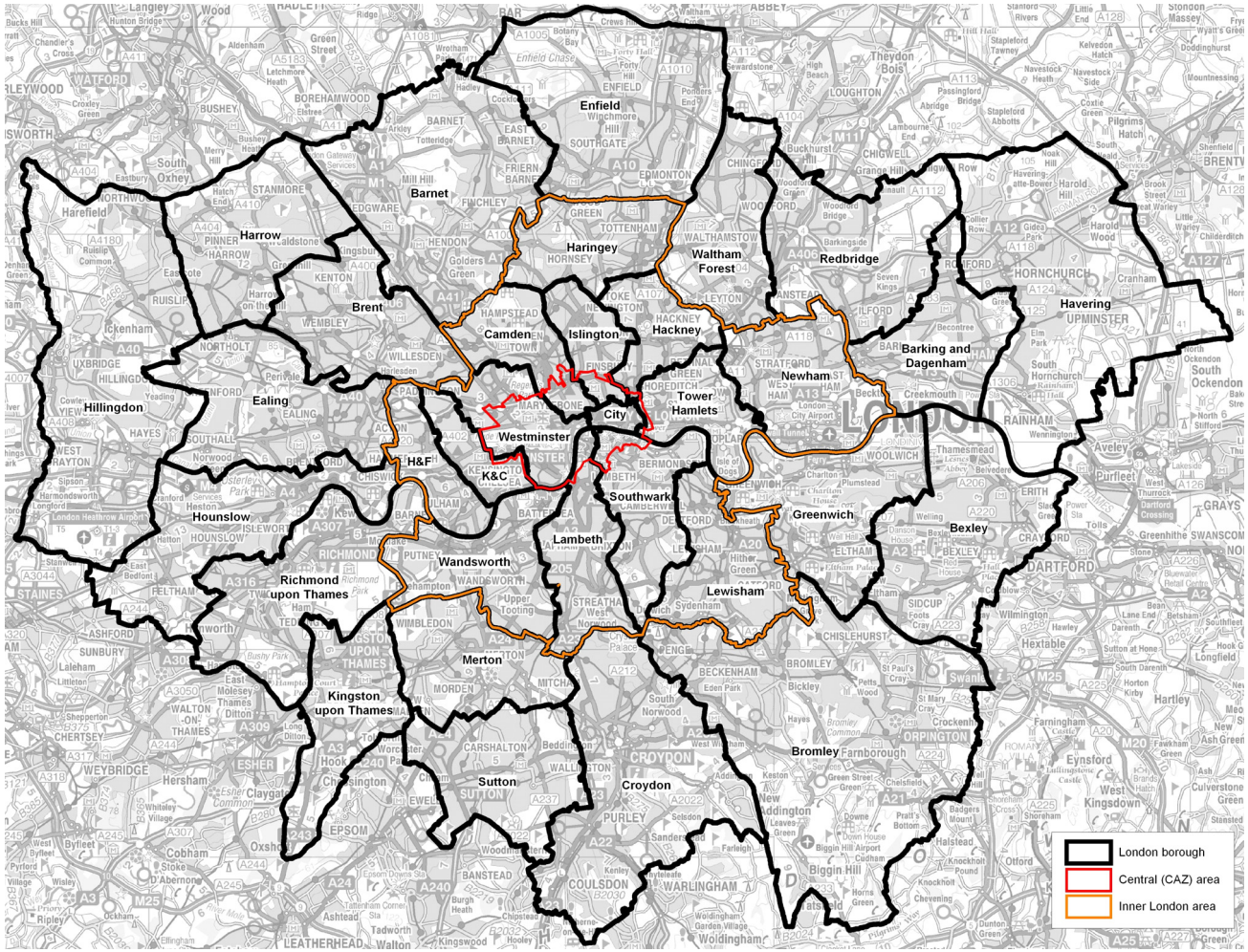
1.1.3 Previous research by CB[2] indicated a clear correlation between accessibility and employment density. The distribution of transport accessibility across London is set to undergo significant changes in the next decade, particularly with the introduction of two high capacity regional rail services: Thameslink and Crossrail. Such changes will impact on the future distribution of employment across the capital.

1.1.4 CB carried out an assessment of London employment accessibility for the GLA in 2002, and this study was commissioned to update the findings and improve where possible the methodology used of that work. The resulting future employment projections will be used by the GLA in combination with other research for a variety of purposes, including planning policy and business planning.

1.1.5 Employment projections were modelled for planned changes in accessibility in 2016 (without Crossrail), 2016 (with Crossrail), 2026 and 2031 primarily at a borough level, split between Central and the rest of London. Central London corresponds to the Central Activity Zone boundary. These four years correspond to the dates for which modelling of future journey times by Transport for London was undertaken. Projections for all other years were based on a linear interpolation of trends in modelled years. In most cases, borough boundaries were retained, with the exception of some boroughs that were located across the Central boundary and were consequently divided into two distinct areas. This resulted in a total of 41 split borough areas, as shown on the map in Figure 1.1.

[2] http://www.london.gov.uk/mayor/economic_unit/docs/ep-technical-paper-3.pdf

Figure 1.1: London boroughs split by Central, Inner and Outer London



1.2 Overview

1.2.1 The first stage of the study was to calibrate the base relationship between transport accessibility and development density. That relationship was then used to show how changing patterns of accessibility in the future might affect the distribution of employment. The base year was based on 2006 journey times taken from the London Transportation Model (LTS), and mid 2007 ONS population estimates.

1.2.2 The original 2002 work was based purely on PT accessibility, but this study incorporated comparable measures of highway as well as public transport accessibility. It was anticipated that a combination of the two would provide the best fit.

1.2.3 The central hypothesis was that employment density would be determined largely by access to labour supply. The greater the potential workforce available the greater the density of employment. It was also anticipated that there would be a clustering element, with employment attracted to areas that already had high employment densities. However, it was decided that future employment distribution forecasts should be based on a function of accessibility to population only, as predicting a variable using a function of itself would inevitably lead to the issue of circularity.

1.3 Report structure

1.3.1 The remainder of this report is structured as follows:

- Chapter 2 summarises the methodology for calibrating the base year relationship between accessibility and employment distribution in London, and details the key base year results between accessibility and employment distribution;
- Chapter 3 describes the future year accessibility forecasts and what drives the changes in patterns;
- Chapter 4 describes the impacts of the accessibility changes on employment patterns for the four future model years; and
- Chapter 5 draws out the key conclusions of the study.

2 Base year calibration

2.1 Introduction

2.1.1 CB undertook the work detailed in this report using PT and HW accessibility outputs from TfL's London Transportation Studies (LTS) model. LTS is a multi-modal London transport model that contains 1,285 zones, of which 879 are within the GLA area. The model uses measures of generalised time and generalised cost by mode between zones, in combination with input employment and population distributions by zone, to predict mode shares, link flows, crowding and journey times on both the PT and HW networks in London.

2.1.2 TfL supplied CB with matrices of zone-to-zone generalised time and generalised cost for the base year (2006), in addition to future year scenarios for 2016, 2026 and 2031. Table 2.1 indicates how generalised time and cost are calculated in LTS. All journey time data supplied was for a week-day AM peak period. With regards to PT, generalised time takes account of boarding, wait time and crowding penalties on top of clock time.

2.1.3 The crowding model used in LTS for PT increases 'in vehicle' time by a variable amount depending on the level of demand compared to capacity on each link. So a crowding 'penalty' of 1 is used for links which are uncrowded, meaning no additional uplift is applied to the value of time. A crowding penalty of 1.5 would mean that the level of crowding is such that 50% should be added to the value of time.

Table 2.1: LTS zone to zone measures of accessibility

LTS Journey Time Measure	Public Transport (PT)	Highway (HW)
Generalised time (GT) in minutes	* Total zone-to-zone journey (clock) time * Boarding penalty per board (2.5 minutes) * Waiting time factor (multiplier of 2.5) * Walk time factor (multiplier of 2) * 'In vehicle' crowding factor (variable, depending on level of crowding)	* Total zone-to-zone journey (clock) time (calculated using average road speed estimates, taking into account congestion constraints) * Parking search time
Generalised cost (GC) converted back into time	As for GT, plus the following: * Fares	As for GT, plus the following: * Journey purpose value of time * Vehicle operating costs * Toll costs

2.2 Base year calibration

2.2.1 The first stage was to determine the best relationships between accessibility and development density. A standard gravity model formula was used to calculate measures of PT and HW accessibility, as follows:

Accessibility to population = V * exp(-λ*T)

V = population

T = time from origin to destination (either GT or GC)

λ = constant

exp = exponential function

2.2.2 The gravity model calculates accessibility by taking into account both the journey time/cost and the number of jobs or people. The formula was applied both at a zone-to-zone and a borough-to-borough level. Accessibility to population was calculated for destination zones using total population in the origin zone.

2.2.3 The λ value represents a determination of the relative importance of short journey times when compared against longer journey times. A high λ value gives greater significance to shorter journey times when accessibility is calculated. A lower λ value implies that the impacts of accessibility changes are spread over a wider area.

2.2.4 Employment distributions were measured using density, which was calculated for each borough using GIS software. In order to make the calculations more accurate, TfL provided a GIS layer of metropolitan open 'non-developable' land such as green spaces

and parks, which was subtracted from area calculations to ensure that density levels were not distorted.

2.2.5 Once measures of accessibility had been calculated for all zone-to-zone movements, they were then summed by destination. The two measures were then compared with employment density. An automated iterative process was used to adjust the λ value in each case until the best fit had been achieved, measured in terms of R^2.

2.2.6 Numerous regressions were run during the calibration phase of the work to determine the optimal link between accessibility to population and employment density. The following tests were carried out:

- Combinations of HW and PT journey times;
- Comparisons of GT and GC;
- Using different measures of population and employment (economically active population, splitting between local and regional employment, blue collar and white collar employment).

2.2.7 It was not possible to determine different correlations for bus and rail access with employment density as separate journey time matrices for bus and rail were not available.

2.3 Initial testing

2.3.1 A number of different data sources were tested in order to determine the best fit relationship between accessibility and employment distribution.

2.3.2 In both cases, different combinations of employment, population and accessibility were tested.

- Employment was divided into categories (white collar/blue collar and 'employment-dependent'/'population-dependent'). 'Population-dependent' employment was intended to capture employment dependent on demand from the local population (primarily suburban) whereas 'employment-dependent' jobs were those dependent on regional, national and international demand and links (primarily Central London);
- Relationships tested with PT accessibility only;
- Relationships tested with HW accessibility only;
- Relationships tested with different combinations and weightings of PT and HW accessibility;
- PT and HW GT compared with PT and HW generalised cost;
- Accessibility time-bands (i.e. total population within 15/30/45 minutes PT) compared with gravity model formula approach.

2.3.3 A number of conclusions emerged from this initial phase of testing, as follows:

- The gravity model formula (with optimised λ value) was the most effective means of establishing strong relationships and worked better than the fixed GT isochrones;
- Splitting employment into different categories did not improve the overall fit, so total employment density was used as the measure for employment distribution;

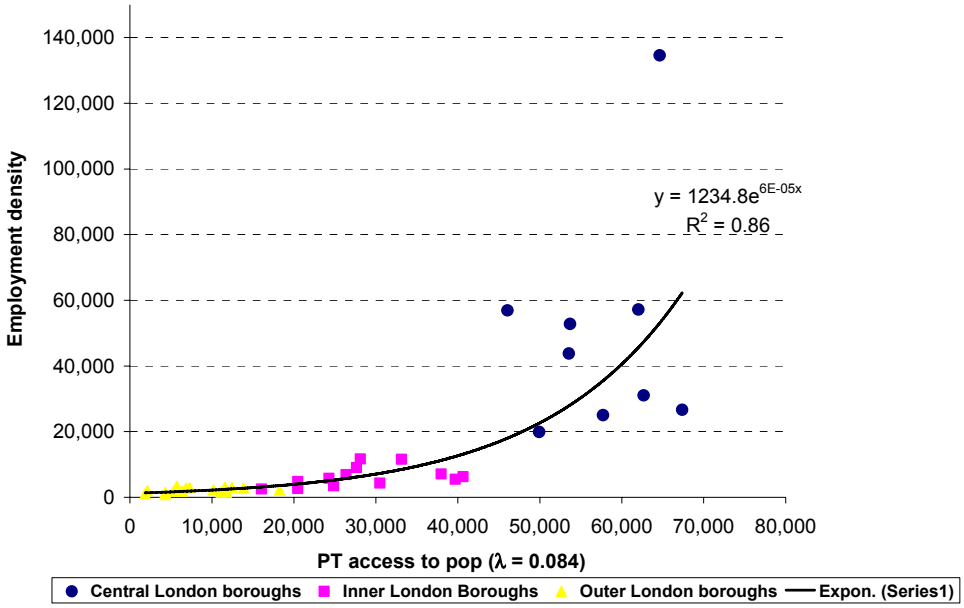
- There was no improvement to the relationship from using GC, therefore GT was used to measure accessibility;
- HW accessibility did not improve the relationship, but in fact made it worse. The result was that the best calibration was undertaken using PT accessibility only.

2.4 PT accessibility to population and employment density

2.4.1 Figure 2.1 sets out the best fit relationship between employment density and PT accessibility to population in 2006 by borough (split by Central/Inner/Outer zones). The bottom axis represents the accessibility index estimated from the gravity model with an optimised λ value of 0.08. The relationship identified is very strong, with the accessibility index explaining around 86% of employment density (R^2 of 0.86).

2.4.2 Three clusters clearly stand out: Inner London, Outer London and Central London boroughs. The relationship is exponential with employment density increasing rapidly at high levels of accessibility.

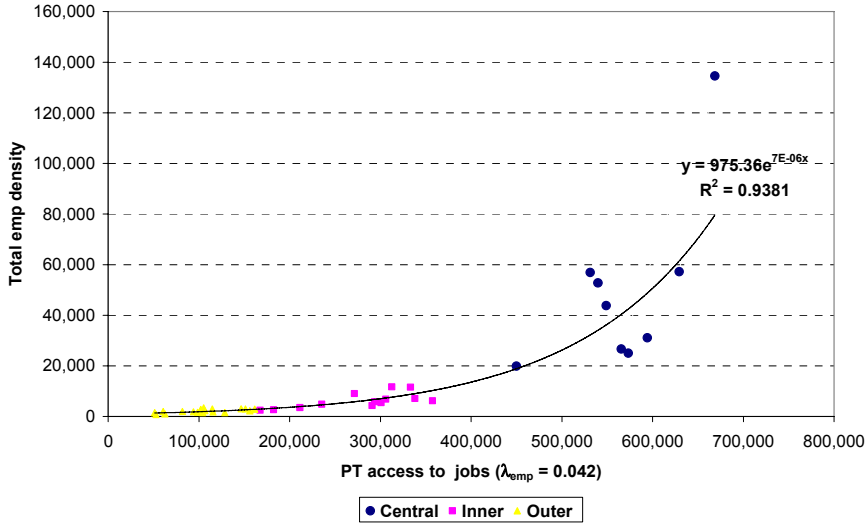
Figure 2.1: Employment density versus PT accessibility – borough level



2.4.3 Clustering of employment and agglomeration in big cities provides evidence of the importance to businesses of being close to other businesses. In order to take this into account, the relationship was also tested using access to employment.

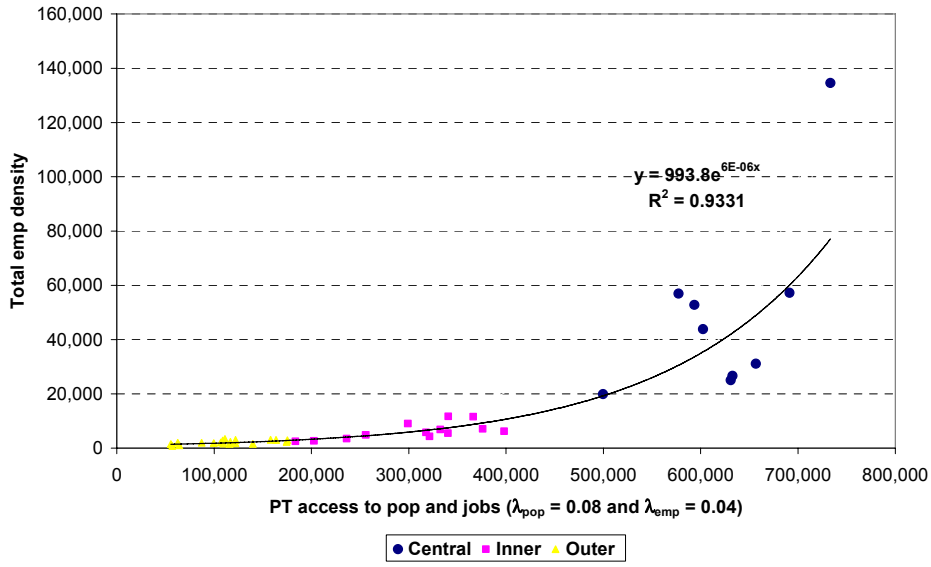
2.4.4 Figure 2.2 shows the best fit relationship between employment density and access to employment. The relationship is stronger using employment rather than population, with an R^2 of 0.94. However this relationship includes a certain level of circularity as employment is itself a function of employment, which will artificially increase the strength of the relationship.

Figure 2.2: Employment density versus access to employment



2.4.5 When combining both PT access to jobs and employment, the relationship is made stronger than with PT access to population only, with an R^2 of 0.93, as shown in figure 2.3.

Figure 2.3: Employment density versus access to population and employment



2.4.6 It is important to note however that while including a function of PT accessibility to jobs results in a slight improvement in the strength of the relationship between PT accessibility and employment density for base year 2006 data, it is difficult to use it for predicting future scenario distributions of employment.

2.4.7 This is fundamentally because of the issue of circularity evident in any attempt to predict a variable using a function of itself, but also because the relationships being tested are not dynamic in nature. This effectively leaves two options for including PT accessibility to jobs as a means of predicting future employment distribution, as follows:

- Future employment density = function of PT access to 2007 population and **PT access to 2007 jobs**
- Future employment density = function of PT access to 2007 population and **PT access to future GLA forecast jobs**

2.4.8 Following careful consideration, CB concluded that neither option would produce satisfactory results in terms of robust and defendable employment distribution forecasts.

2.4.9 In the case of the first option, using PT accessibility to 2007 jobs would create a bias against growth areas that have a low current level of employment, and result in an under-estimate of employment distribution in these areas. For example, the clustering of employment likely to occur around the Stratford Olympic sites would be under-estimated since there is relatively little employment located in this area in 2007. This issue would be exacerbated by the calibration work described previously, which indicated the increased significance of shorter journey times for access to other jobs.

2.4.10 The second option was rejected on the grounds that making future employment distribution forecasts using a set of existing forecasts derived from a methodology based on different parameters would not be statistically sound. The complexities of using one set of employment forecasts to predict another would make a full understanding of the results more problematic.

2.4.11 It was therefore decided that future employment distribution forecasts should be based on a function of PT accessibility to population. The slight increase in the strength of the relationship with the inclusion of PT accessibility to jobs for the base year data was not sufficient to offset the issues that would arise when attempting to incorporate PT accessibility to jobs.

2.5 Conclusions

2.5.1 The relationship between PT accessibility and development density is very strong both in explaining the distribution of employment in Greater London. The analysis suggests that variations in accessibility explain over 85% of those distributions.

2.5.2 The results were slightly surprising, in that we initially expected that highway accessibility would play an important role in determining development densities outside Central London. The reasons as to why this did not become the case seem to be that highway accessibility is distributed much more evenly than PT accessibility and yet employment is not distributed evenly.

2.5.3 Our rationalisation of the findings is as follows:

1. The cluster of employment in Central London is almost entirely dependent on public transport access;
2. Hence the distribution of population is heavily dependent on public transport access to Central London;
3. Other non-Central London employment is largely population related i.e. largely service sector jobs and the distribution of those and of the people that work in them are hence determined by (1) and (2) above; and
4. Public transport accessibility is hence the prime driver for all development density in London.

2.5.4 There are clearly certain examples where this is not the case. The relationship is a general one and cannot be expected to explain every area in London. There are some

clusters of employment based on highway accessibility, notably on the M4 corridor and around the M25. At a London-wide level however it is public transport accessibility which seems to be the key driving force behind variations in development density.

3 Future year accessibility changes

3.1 Introduction

3.1.1 For each future year, LTS projections were used to calculate changes in the accessibility index for each borough. The calibration phase of the work identified the best measures of accessibility (with optimised λ values) with which to predict employment density using 2006 journey times and 2007 ONS population estimates.

3.1.2 The next stage of the work was to produce new accessibility indices with future year journey time forecasts, based on LTS model outputs. TfL provided GTs by LTS zone for 2016 without Crossrail, 2016 with Crossrail, 2026 and 2031 in order to forecast future changes in accessibility. LTS journey time data for future years is dependent on a series of assumptions regarding future transport provision, as summarised in Table 3.1. Details of the proposed schemes included in forecast years can also be found in Appendix A of this report. Transport provision for future years reflects the situation at the date of the scenario testing (January 2009).

Table 3.1: Public transport provision

Public Transport Provision Assumptions	2006	2016 (With Crossrail)	2026	2031
Heathrow Express to terminal 5	x	✓	✓	✓
Channel Tunnel Rail Link (CTRL) domestic and international	x	✓	✓	✓
North London Railway Service Level Commitment Phases 1 - 2 (East London Line/North London line / West London line except E London Line ext Phase 3)	x	✓	✓	✓
HLOS (network Rail) commitments (rail capacity increases on South West London, Southern, Thameslink, South Eastern, Great Eastern, c2c, West Anglia, London Midland)	x	✓	✓	✓
Crossrail 1	x	✓	✓	✓
Full PPP (Public Private Partnership) improvements on Jubilee	✓	✓	✓	✓
Full PPP upgrades (except on Jubilee)	x	✓	✓	✓
Hammersmith and City stop at Wood lane	x	✓	✓	✓
PPP upgrade on Bakerloo	x	x	✓	✓
Piccadilly line extension to Terminal 5	x	✓	✓	✓
Underground Reliability - Global Effect increase	✓	✓	✓	✓
Underground reliability - individual line effect - RailPlan	x	✓	✓	✓
DLR bank to Lewisham and Poplar to Stratford 3-car upgrade	x	✓	✓	✓
DLR extension to Woolwich	x	✓	✓	✓
DLR Stratford international	x	✓	✓	✓
2016/2017 bus frequency improvements	x	✓	✓	✓
Bus reliability decreases	x	✓	✓	✓
Boarding alighting improvements 2001	✓	✓	✓	✓
Development area buses – Thames Gateway	x	✓	✓	✓
East London Transit Phase 1	x	✓	✓	✓
Greenwich Waterfront Transit Phase 1	x	✓	✓	✓

3.1.3 It is clear from Table 3.1 that almost all the changes are assumed to be in place by 2016 with little changing thereafter apart from the predicted changes in employment.

3.2 Changes in PT accessibility indicators

3.2.1 In order to estimate the accessibility index, PT GTs for future years were combined with 2007 population. This means that access is determined only by changes in the provision of transport infrastructure, and does not take into account any changes in the distribution of population distribution. The sole effects of transport investment on employment density are therefore made visible.

3.2.2 Changes in the accessibility index are in absolute terms rather than relative, which means that an increase in accessibility in one borough will not affect the accessibility levels in other boroughs.

3.2.3 Table 3.2 shows the index of PT accessibility to population by borough for 2016 (without Crossrail), 2016 (with Crossrail), 2026 and 2031, with 2006 as the base. The figures in green highlight an increase in accessibility levels of over 10% compared to the base, and numbers in red show levels of accessibility that are lower than 2006 levels.

3.2.4 Accessibility patterns differ significantly by borough. Certain boroughs see increases in their levels of accessibility, such as Hillingdon (over 20% from 2006 to 2031), Barnet (a little less than 20% increase) and Newham. Hillingdon has the highest increase in accessibility, explained by infrastructure improvements with the Piccadilly line extension to Terminal 5 and Heathrow Express to Terminal 5 as well as Crossrail that are not included in the 2006 measure of accessibility.

3.2.5 On the other hand, four boroughs see a constant fall or stagnation in their levels of accessibility for all modelled years. These boroughs are Richmond upon Thames, Kingston upon Thames, Hounslow and Croydon. Any improvements in rail services to those boroughs are cancelled by increases in rail crowding and congestion reducing bus speeds.

3.2.6 A general trend however can be observed: a large number of boroughs see a peak in accessibility with the 2016 with Crossrail scenario, and a fall in accessibility in 2026 and 2031. This is due to two factors:

- The LTS model does not allow for any transport infrastructure investment from 2016 onwards; and
- The LTS model assumes an increase in highway congestion and rail crowding. If no investment is planned to counter these effects, bus speeds and hence journey times will increase as well as rail GT, hence leading to a fall in overall accessibility levels.

3.2.7 The LTS model only includes transport infrastructure investment that has been approved by TfL. As congestion and crowding worsen, TfL will respond with new infrastructure investment schemes that are not included in the LTS scenarios. It should therefore be assumed that the drop in accessibility levels after the 2016 with Crossrail scenario will to a certain extent be offset by future investments that have not been accounted for in this analysis.

Table 3.2: Change in the accessibility index by borough (base 100 = 2006)

Borough	2016 (without Crossrail)	2016 (with crossrail)	2026	2031
Barking and Dagenham	106	108	106	106
Barnet	**119**	**119**	**119**	**119**
Bexley	102	104	104	106
Brent	108	109	**113**	**113**
Bromley	105	105	104	106
Camden	**110**	**114**	**112**	**111**
City of London	107	**113**	109	106
Croydon	**97**	**97**	**98**	**98**
Ealing	102	109	108	109
Enfield	105	**110**	107	108
Greenwich	103	107	104	105
Hackney	107	**111**	107	105
Hammersmith and Fulham	109	**111**	108	108
Haringey	106	108	105	104
Harrow	110	**110**	**113**	**115**
Havering	**99**	106	104	105
Hillingdon	**114**	**122**	**120**	**123**
Hounslow	**97**	**98**	**97**	**97**
Islington	108	**111**	108	107
Kensington and Chelsea	108	109	106	105
Kingston upon Thames	**97**	**96**	**95**	**96**
Lambeth	103	105	104	102
Lewisham	103	104	102	103
Merton	109	110	109	110
Newham	**113**	**118**	**114**	**113**
Redbridge	**97**	103	101	101
Richmond upon Thames	**95**	**94**	**93**	**93**
Southwark	102	105	102	100
Sutton	104	104	104	106
Tower Hamlets	107	**112**	107	105
Waltham Forest	100	102	100	**100**
Wandsworth	102	102	101	101
Westminster	106	110	109	108

3.2.8 The percentage changes in the access to population from 2006 to 2016 (with and without Crossrail), 2026 and 2031 are set out in Figures 3.1 to 3.4. The 2016 without Crossrail scenario shows a fall in PT access to population in Outer North East and Outer South East London. These are the boroughs that will benefit the least from any transport infrastructure improvement. The highest increases take place in North West London, which highlight the access improvements created by Thameslink.

3.2.9 When including Crossrail, improvements in accessibility shift towards Central London and the Crossrail corridor. Boroughs along the corridor now see a rise in their accessibility levels. The boroughs that benefit the most from Crossrail are (in order of increase) Hillingdon, Havering, Ealing, Redbridge; the City of London and Newham.

3.2.10 Looking at outputs for 2026 and 2031, although accessibility levels on the whole are around 6% higher than in 2006, these drop by 2-3% in comparison to 2016 with Crossrail levels. In the 2031 scenario, the biggest improvements take place along the North West – East/South East London corridor. The PPP changes are also important but are smaller on individual lines and to/from individual locations.

Figure 3.1: % change in PT access to population 2006 to 2016 (without Crossrail)

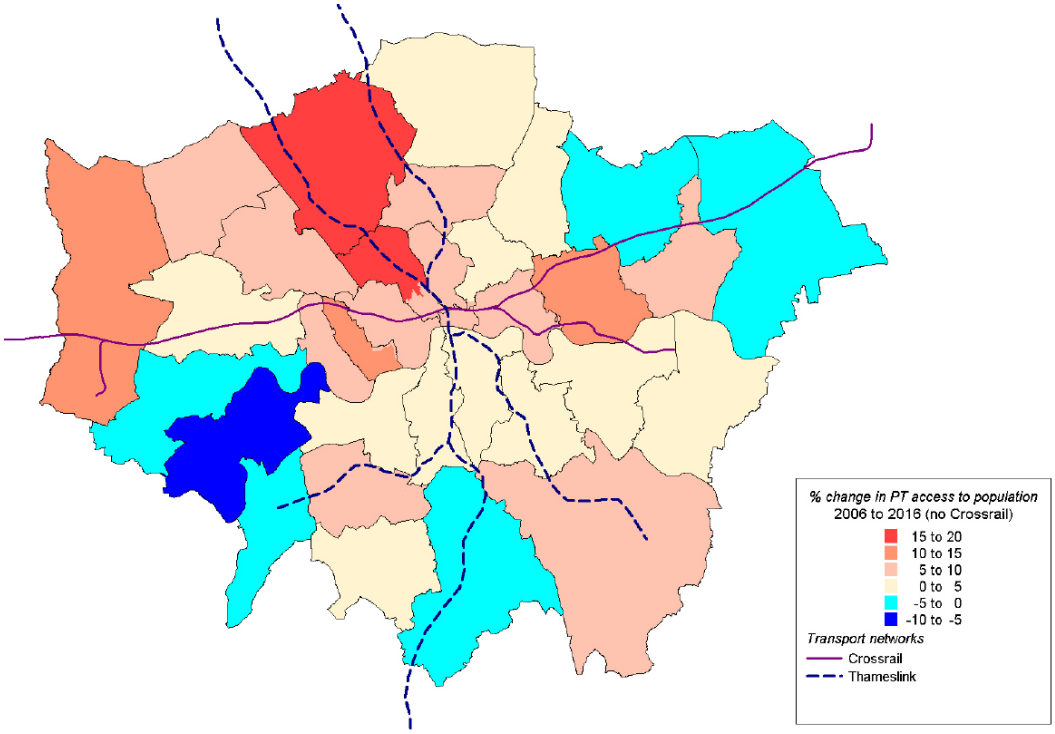


Figure 3.2: % change in PT access to population 2006 to 2016 (with Crossrail)

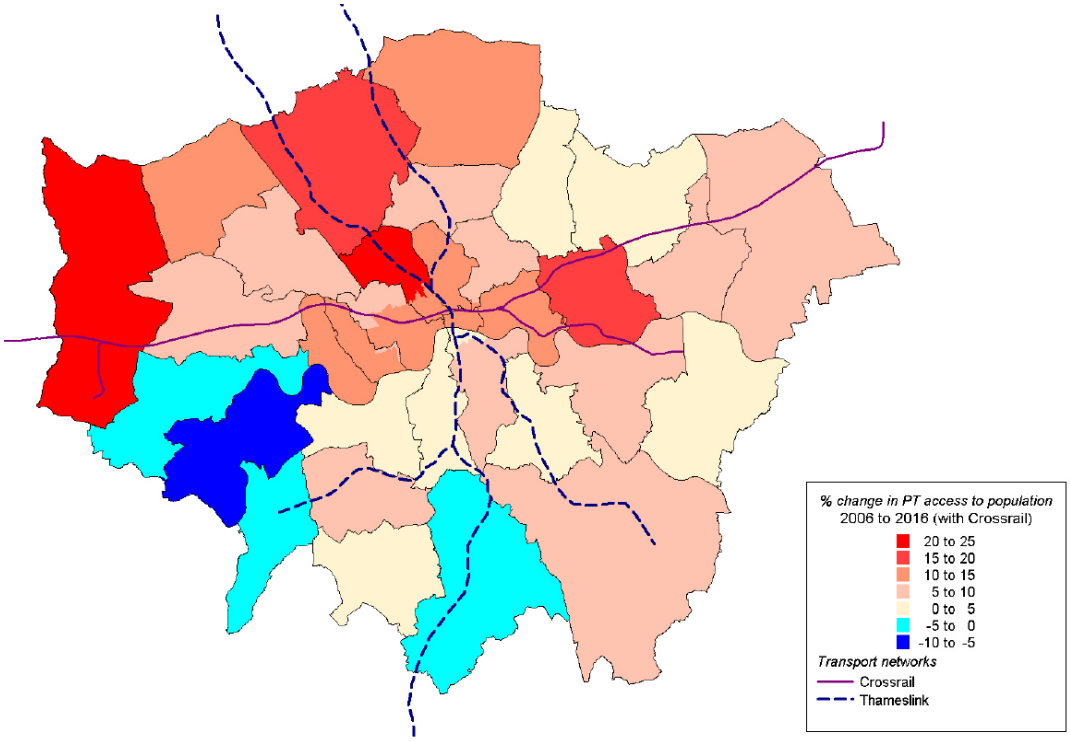


Figure 3.3: % change in PT access to population 2006 to 2026

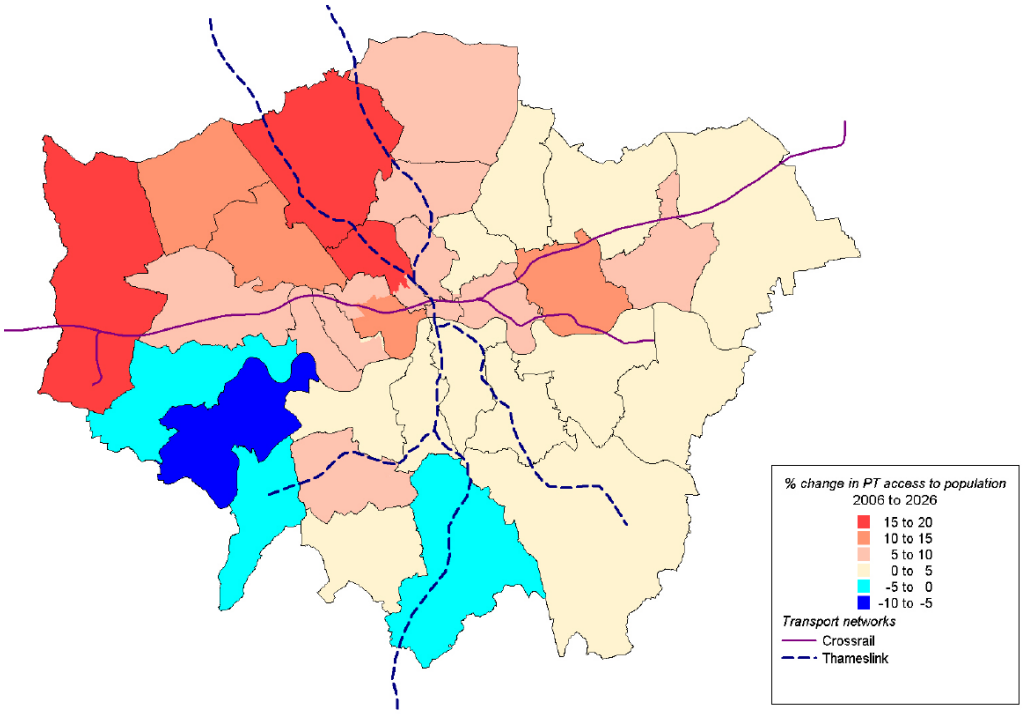
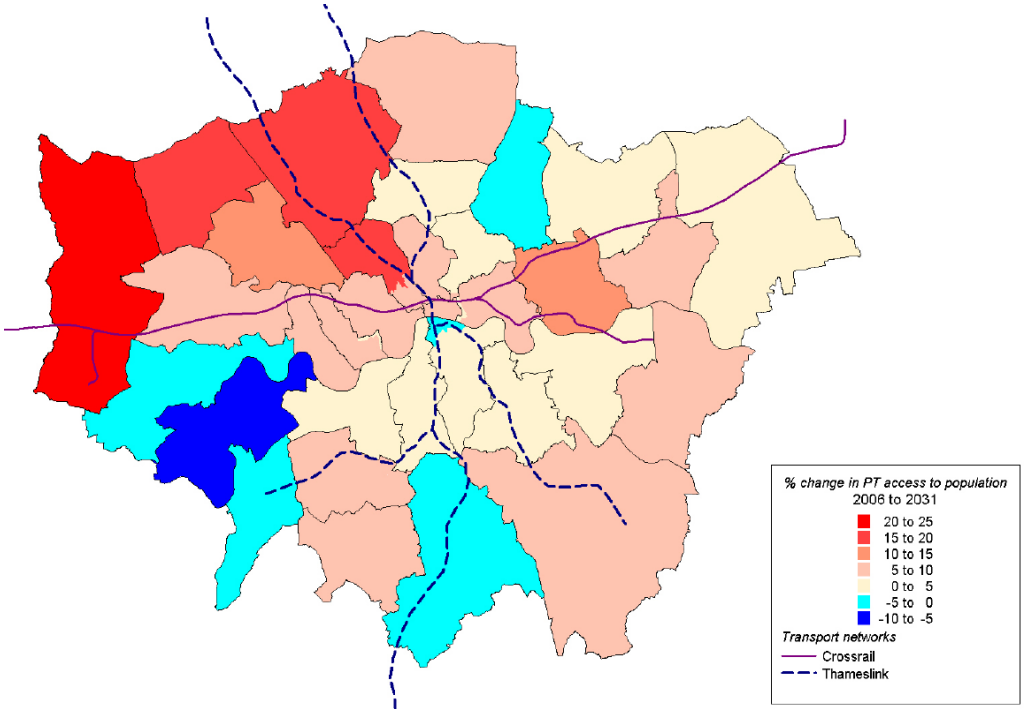


Figure 3.4: % change in PT access to population 2006 to 2031



4 Distribution of employment

4.1 Method

4.1.1 Employment projections are made for each borough (split by Central/Inner where appropriate) by considering the best fit relationship described in Chapter two to forecast employment levels for future levels of PT access. It is important to note that the forecasts presented in this chapter focus solely on how transport access influences employment growth. Distribution and growth of employment are also determined by other factors such as availability of office space and historic trends that will be taken into account by GLA in the triangulation process.

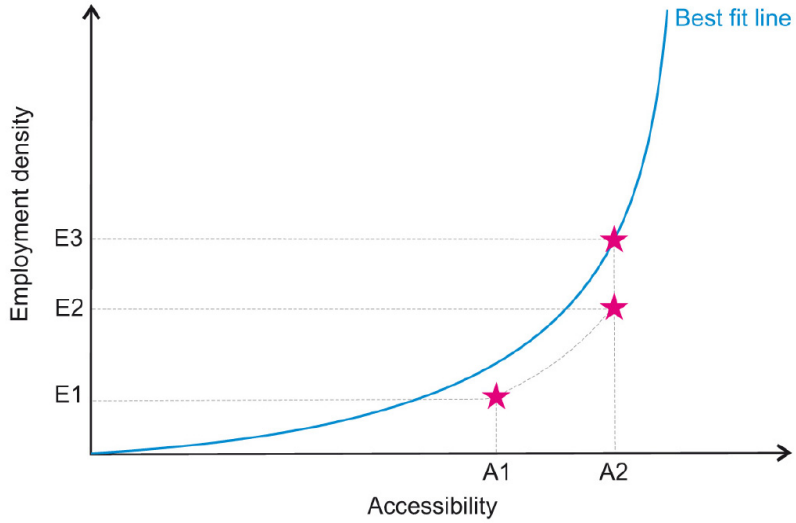
4.1.2 The approach used to forecast future employment is very similar to the method used in the previous work undertaken for the GLA in 2004.

4.2 Distribution of employment – scenarios

4.2.1 When distributing employment, two different approaches can be applied:

- The **absolute approach**: this assumes that all boroughs in time converge towards the accessibility-density relationship. So those boroughs that are currently situated under the best fit curve will in time make up the differential and in future have higher levels of employment density for given accessibility indices. This is illustrated in Figure 4.1 below, where an increase in accessibility from A1 to A2 will produce new employment levels at point E3;
- The **relative approach**: this assumes that boroughs keep their differentials with the best fit curve. This means that for a certain level of accessibility, if employment in a borough is 10% below what is expected, then this difference will remain with changes in accessibility. In Figure 4.2 this relates to a change in employment levels from point E1 to E2.

Figure 4.1: Absolute and relative change

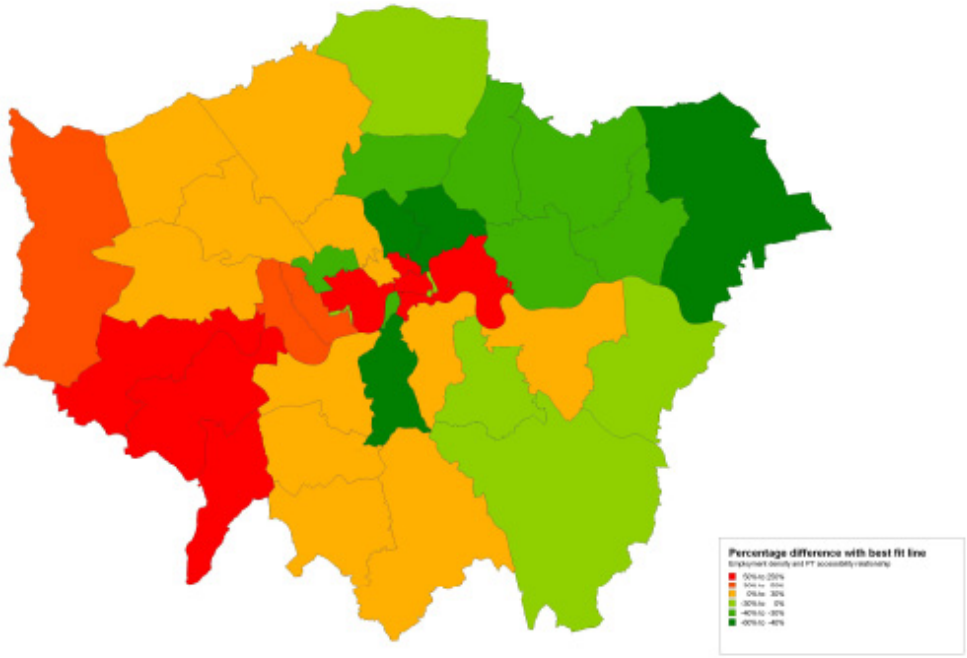


4.2.2 The approaches give significantly different results. With the absolute approach, boroughs that are under the best fit curve observe high increases in employment with higher

accessibility levels, whilst boroughs with employment levels above the best fit curve will either see much smaller increases in employment levels, and depending on where they are situated along the curve, employment might fall. However it would seem illogical to assume such a situation as it is counterintuitive for employment to fall with better PT access. It is more realistic to assume that certain boroughs will always have higher employment levels than expected, and therefore apply the relative approach.

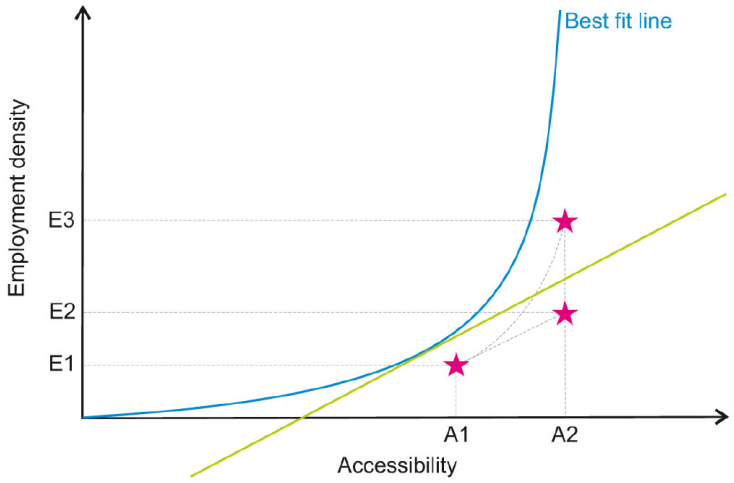
4.2.3 Figure 4.2 sets out the percentage difference between existing employment levels and employment levels as predicted by the best fit line for each borough. It shows that, with current accessibility levels, West and Central London have employment levels that are higher than expected, whilst East London and Lambeth have lower levels of employment than expected. The relative approach assumes that these differentials will remain in future years.

Figure 4.2: Differentials in employment density compared with the best fit line



4.2.4 Another issue with the relative approach is that following the exponential function leads to large increases in employment for those boroughs with already high accessibility levels. In order to scale the results back to more realistic levels, it was assumed that above certain levels of accessibility, employment would increase in a linear rather than exponential fashion. This is illustrated in Figure 4.3 where accessibility growth from A1 to A2 leads to employment levels shown by point E2 rather than E3. The capped employment growth was applied at accessibility levels that separate central London clusters with Inner and Outer London boroughs.

Figure 4.3: Relative change - capped



4.3 Employment growth by borough

4.3.1 Employment distribution for future years was forecast using the approach explained above. Table 4.1 sets out employment figures by borough for each modelled year. Figures 4.4 and 4.5 highlight the change in the number of jobs by borough for 2016 (with Crossrail) and 2031, compared to 2006.

4.3.2 The 2016 with Crossrail scenario enables an additional 712,000 jobs in Greater London compared to 2007 levels. As accessibility levels drop in 2031, additional employment also drops with only 435,000 more jobs in London compared to 2007. In 2016 most of the growth is concentrated in Central and East London. Highest growth occurs in the boroughs of Westminster, Camden, Tower Hamlets and City of London. South West London sees a fall in employment in 2016 and 2031, as well as Croydon and Waltham Forest. These are the boroughs that do not benefit from transport infrastructure improvements, and see a fall in accessibility levels as highway congestion and rail crowding worsens.

4.3.3 It is likely that additional infrastructure investment will take place from 2016 to 2031 to offset rail crowding and highway congestion. Therefore for forecasting purposes a more robust approach would be to freeze accessibility and hence employment levels to the 2016 (with Crossrail) scenario.

4.3.4 Due to the use of the relative capped approach, these forecasts do not allow for any boroughs to catch up on their lag in terms of employment for certain levels of accessibility. This may not be the case for a number of boroughs such as Newham for example, where significant development is currently taking place and the differential with the best fit curve is likely to reduce. This will need to be taken into account when interpreting the employment forecasts.

Figure 4.4: Absolute change in employment 2006 to 2016 (with Crossrail)

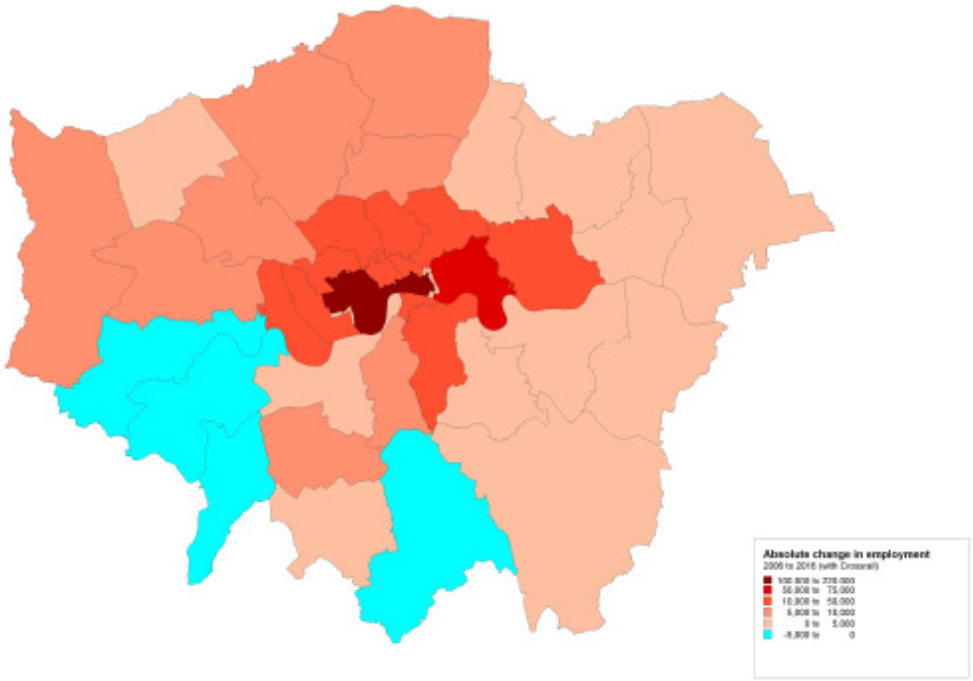


Figure 4.5: Absolute change in employment 2006 to 2031

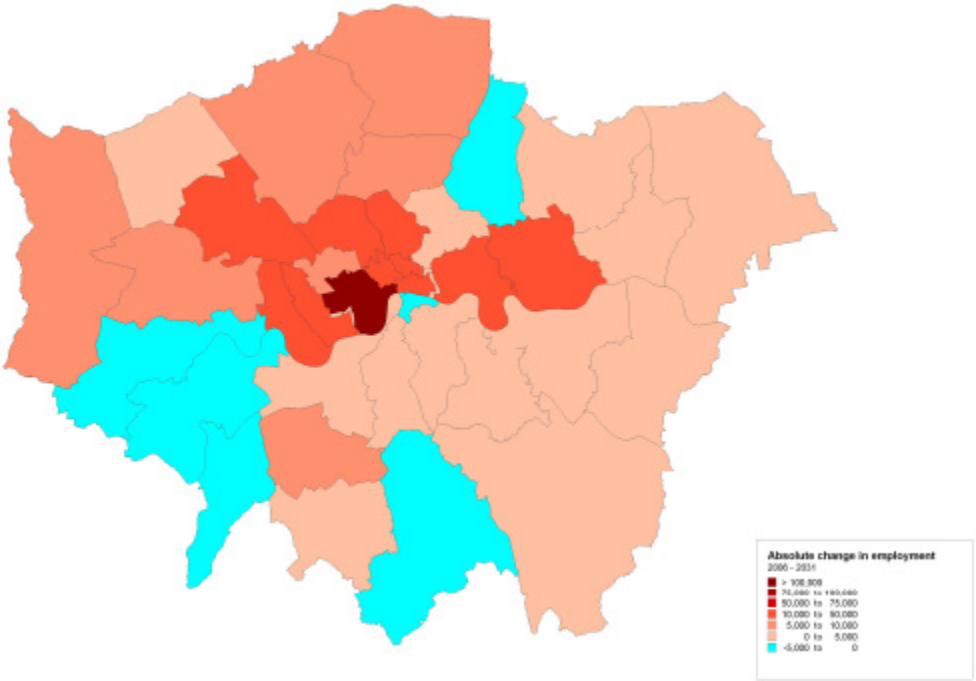


Table 4.1: Employment projections by borough

Employment Totals	2007	2011 (extrapolated from 2007 and 2016)	2016	2017 (2016 With XR)	2026	2031
Barking and Dagenham	51,039	52,066	53,092	53,866	53,051	52,979
Barnet	133,549	138,308	143,067	143,435	143,031	143,210
Bexley	75,092	75,279	75,465	75,808	75,753	76,118
Brent	110,489	114,187	117,884	118,493	122,194	122,827
Bromley	130,854	131,182	131,511	131,487	131,336	131,610
Camden	289,907	319,378	348,850	374,024	360,007	351,059
City of London	378,981	405,870	432,758	479,722	446,677	427,472
Croydon	149,689	149,012	148,335	148,358	148,566	148,775
Ealing	138,894	140,011	141,128	147,528	146,646	147,199
Enfield	109,568	111,196	112,824	116,996	114,763	115,002
Greenwich	80,476	81,131	81,786	83,808	82,393	82,697
Hackney	92,165	96,326	100,488	107,148	100,320	97,711
Hammersmith and Fulham	131,502	141,971	152,440	155,757	149,193	148,574
Haringey	84,605	88,189	91,774	94,494	91,109	89,828
Harrow	82,171	83,495	84,818	84,984	85,853	86,461
Havering	84,835	84,687	84,540	86,009	85,609	85,767
Hillingdon	203,009	204,651	206,293	208,507	207,892	208,702
Hounslow	133,824	132,938	132,051	132,618	131,941	132,250
Islington	192,776	211,456	230,136	246,172	231,092	225,703
Kensington and Chelsea	128,730	142,613	156,496	162,449	148,292	146,685
Kingston upon Thames	86,835	86,233	85,631	85,511	85,113	85,427
Lambeth	136,593	140,520	144,447	147,063	144,669	142,753
Lewisham	76,410	77,610	78,810	79,521	78,082	78,473
Merton	81,350	84,147	86,945	87,161	86,768	87,238
Newham	82,639	89,334	96,029	102,909	97,884	96,687
Redbridge	76,286	75,455	74,623	77,665	76,571	76,583
Richmond upon Thames	92,268	91,414	90,561	90,427	90,088	90,224
Southwark	217,075	222,790	228,505	238,930	226,795	219,203
Sutton	72,821	73,258	73,694	73,718	73,760	74,062
Tower Hamlets	206,092	219,893	233,694	261,694	237,793	229,148
Waltham Forest	68,497	68,590	68,684	69,910	68,600	68,146
Wandsworth	127,252	128,365	129,479	130,340	127,978	128,262
Westminster	610,322	667,695	725,068	832,140	821,901	754,530
TOTAL	**4,716,597**	**4,929,251**	**5,141,905**	**5,428,653**	**5,271,722**	**5,151,366**

5 Summary and conclusions

5.1 Limits of the approach

5.1.1 It is important to stress that the projections of employment distribution resulting from using the methodology previously described only take into account changes in accessibility. There is no consideration of historic trends and site capacity, meaning that the projections can be considered as theoretical 'potential' changes based on future transport improvements, and based on the assumption that jobs are mobile and respond fully to changes in accessibility. The forecasts are also based on the assumption that the base 2006 relationship between employment density and PT accessibility is optimal, which may not in reality be the case.

5.1.2 As noted in the introduction of this report, historic trends and site capacity are the other factors that form the "triangulation process" used to forecast employment for the London Plan.

5.1.3 In addition, the methodology described here aims to establish an optimal relationship between employment and accessibility, but it does not determine the direction of causation between these factors. In reality, there is likely to be some circularity to the relationship, with employment and population growth resulting in improvements to accessibility, which in turn is likely to lead to further employment growth. The relationship is complex and has been simplified for the purposes of this study in order to make clear projections. Highway accessibility has also not been included in the equation.

5.2 Summary of results

5.2.1 This study has updated the previous relationship between accessibility and employment density. A gravity model based formula to determine indices of accessibility was applied to each LTS zone and then aggregated to borough level. A strong relationship between the PT accessibility to population index and employment density was identified.

5.2.2 Tables 5.1 and 5.2 show the boroughs with the highest and lowest projected proportional growth in employment from 2006 to 2016 (with Crossrail). The percentage change in employment is concentrated in Central and East London (as shown previously in Figure 4.4). This is because they will benefit directly from significant infrastructure investment such as Thameslink and Crossrail, and also have poor existing levels of PT accessibility. In contrast, Table 5.2 indicates that proportional growth in employment to 2031 is lowest for boroughs in the South and South West of Greater London.

Table 5.1: Five boroughs with highest projected growth in employment (2006 to 2031)

Borough	2007	2016 (With XR)	% Change (2016 Over 2006)
Westminster	610,322	832,140	36%
Camden	289,907	374,024	29%
Islington	192,776	246,172	28%
Tower Hamlets	206,092	261,694	27%
City of London	378,981	479,722	27%

Table 5.2: Five boroughs with lowest projected growth in employment (2006 to 2031)

Borough	2007	2016 (With XR)	% Change (2016 Over 2006)
Bromley	130,854	131,487	0%
Croydon	149,689	148,358	-1%
Hounslow	133,824	132,618	-1%
Kingston upon Thames	86,835	85,511	-2%
Richmond upon Thames	92,268	90,427	-2%

5.3 Conclusions and recommendations

5.3.1 The forecasts summarised in this report constitute robust projections of future employment distribution based on changes in PT accessibility. However, it is important to stress that these forecasts are based on the assumption that the future location of employment is completely mobile and responds only to changes in transport accessibility patterns. The forecasts should only be assessed in the context of a full consideration of the other factors and constraints influencing the location of employment in the GLA area, particularly historic trends and available site capacity.

5.3.2 In addition, the forecasts detailed in this report are based entirely on PT accessibility, and it is recommended that a new assessment is carried out using updated highway outputs from the LTS B6 MTE model, which at the time of writing is in development. An assessment using updated highway outputs will help to fully understand the impact of highway accessibility on the distribution of employment.

Appendix A – Modelled changes in transport

Scheme/Assumption Summary	2006	2017	2026	2031
NATIONAL RAIL				
NR: 2007 Timetable Update	✓	✓	✓	✓
Heathrow Connect: London Paddington - Hayes & Harlington (refer to XR1)	✓	x	x	x
Heathrow Express to Heathrow Terminal 5	x	✓	✓	✓
Integrated Kent Franchise (London Rail version) service pattern	x	✓	✓	✓
CTRL Domestic (in conjunction with Integrated Kent Franchise)	x	✓	✓	✓
CTRL International (all to St. Pancras, none to Waterloo)	x	✓	✓	✓
North London Railway Service Level Commitment Phases 1 - 2 (East London Line/North London line / West London line except E London Line ext Phase 3)	x	✓	✓	✓
High Level Output Statement (HLOS Network Rail) Commitments				
South West London (inner)	x	✓	✓	✓
South West London (lengthened to 10 cars)	x	✓	✓	✓
Southern (inners+ELL)	x	✓	✓	✓
Southern (outers and Thameslink)	x	✓	✓	✓
West Anglia stage 1 (increased 12 car services)	x	✓	✓	✓
West Anglia (stage 2/2a)	x	✓	✓	✓
South Eastern (additional 12 car trains)	x	✓	✓	✓

Great Eastern Inner Upgrades	x	✓	✓	✓
Great Eastern Outer Upgrades	x	✓	✓	✓
c2c (incl Tilbury loop platforms extended to 12 cars)	x	✓	✓	✓
London Midland (previously Silverlink County) increased to 12 car trains	x	✓	✓	✓
Thameslink programme +GN adjustments (stage 1)	x	✓	✓	✓
Thameslink Programme Phase 2 (London Rail Alternative 24tph)	x	✓	✓	✓
Crossrail 1 (Abbey Wood Scheme) 24 train p/hour in peak with ten cars (Heathrow Connect Removed) + Additional Stop at Woolwich	x	✓	✓	✓
UNDERGROUND				
Full PPP Improvements to 2006 (upgrade to Jubilee)	✓	✓	✓	✓
Full PPP Upgrades to 2011 (Waterloo & City, Jubilee, Victoria, Northern)	x	✓	✓	✓
Full PPP line upgrades on W&C, Jubilee, Victoria, Northern, Piccadilly, Sub Surface (District & Circle, Met, inc Extended Circle)	x	✓	✓	✓
Hammersmith & City stops at Wood Lane (White City)	x	✓	✓	✓
PPP Upgrade to Bakerloo Line (Post 2016 effects)	x	x	✓	✓
Piccadilly Line extension to Heathrow Terminal 5	x	✓	✓	✓
Northern Line Phase 2 improvements	x	x	x	x

DLR				
DLR - 2006 Timetable	✓	✓	✓	✓
DLR Bank-Lewisham 3-car Upgrade	x	✓	✓	✓
DLR Poplar to Stratford 3-car upgrade	x	✓	✓	✓
DLR extension to Woolwich	x	✓	✓	✓
DLR Stratford International - Canning Town/North London Line to Stratford Lea Valley & CTRL travelator	x	✓	✓	✓
BUS				
Bus : 2006 Bus Allocation Timetable (29/10/05)	✓	✓	✓	✓
2016/17 Bus frequency inc. cf. 2006 (8% all periods)	x	✓	✓	✓
Boarding alighting improvement cf 2001 (10%)	✓	✓	✓	✓
Development Area Buses - Thames Gateway	x	✓	✓	✓
TRANSITS				
East London Transit (Phase 1a only)+A60	x	✓	✓	✓
East London Transit Phase 1b (Barking Rivership Loop)	x	✓	✓	✓
Greenwich Waterfront Transit (Bus scheme Abbey Wood-North Greenwich) Phase 1	x	✓	✓	✓
HIGHWAY				
£8 (at 2007 prices) CCZ Congestion Charging	✓	✓	✓	✓
Thames Gateway Bridge £1 Toll = (Car £1.26, LGV 1.71, OGV £2.75) at 2007 prices	x	x	x	x
Highway capacity reductions (10% cf 2001 - 2006)	✓	✓	✓	✓

Highway capacity reductions (2% cf 2006)	x	✓	✓	✓
FARES				
Rail, LU & DLR fares are 2.7% cf 2001 (0% cf 2006)	✓	x	x	x
Rail, LU & DLR fares are 12% cf 2001	x	✓	✓	✓
Rail fares are RPI+1 ~3.7% pa over 8 year period 2009/2010 to 2016/2017	x	✓	x	x
Rail fares RPI 2016 - 2026	x	x	✓	✓
Bus fares are -4.5% cf 2001	✓	x	x	x
Bus fares are -2% cf 2001	x	✓	✓	✓
RELIABILITY				
Bus Reliability improvement cf 2001 (25%)	✓	x	x	x
Bus Reliability decrease 36% cf 2006	x	✓	x	x
Bus Reliability decrease 50% cf 2006	x	x	✓	✓
LU Reliability - Global Effect Increase 10% cf 2001	✓	✓	✓	✓
LU Reliability - Individual Line Effect - RailPlan	x	✓ (0.98)	✓ (0.98)	✓ (0.98)
OTHERS				
Fuel Price Increase by 12.5% (Petrol) and 11.4% (Diesel) cf 2001	✓	tbc	tbc	tbc
POLICY				
Soft TDM (Travel Demand Management) (2% reduction in car trips & 0% PT)	x	✓	✓	✓
Walking	x	✓	✓	✓
Cycling	x	✓ (200%)	✓ (200%)	✓ (200%)

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Nếu bạn muốn có văn bản tài liệu
này bằng ngôn ngữ của mình, hãy
liên hệ theo số điện thoại hoặc địa
chỉ dưới đây.

Greek

Αν θέλετε να αποκτήσετε αντίγραφο του παρόντος εγγράφου στη δική σας γλώσσα, παρακαλείστε να επικοινωνήσετε τηλεφωνικά στον αριθμό αυτό ή ταχυδρομικά στην παρακάτω διεύθυνση.

Turkish

Bu belgenin kendi dilinizde
hazırlanmış bir nüshasını
edinmek için, lütfen aşağıdaki
telefon numarasını arayınız
veya adrese başvurunuz.

Punjabi

ਜੇ ਤੁਹਾਨੂੰ ਇਸ ਦਸਤਾਵੇਜ਼ ਦੀ ਕਾਪੀ ਤੁਹਾਡੀ ਆਪਣੀ ਭਾਸ਼ਾ ਵਿਚ ਚਾਹੀਦੀ ਹੈ, ਤਾਂ ਹੇਠ ਲਿਖੇ ਨੰਬਰ 'ਤੇ ਫ਼ੋਨ ਕਰੋ ਜਾਂ ਹੇਠ ਲਿਖੇ ਪਤੇ 'ਤੇ ਰਾਬਤਾ ਕਰੋ:

Hindi

यदि आप इस दस्तावेज की प्रति अपनी
भाषा में चाहते हैं, तो कृपया निम्नलिखित
नंबर पर फोन करें अथवा नीचे दिये गये
पते पर संपर्क करें

Bengali

আপনি যদি আপনার ভাষায় এই দলিলের প্রতিলিপি
(কপি) চান, তা হলে নীচের ফোন্ নম্বরে
বা ঠিকানায় অনুগ্রহ করে যোগাযোগ করুন।

Urdu

اگر آپ اِس دستاویز کی نقل اپنی زبان میں
چاھتے ھیں، تو براہ کرم نیچے دئے گئے نمبر
پر فون کریں یا دیئے گئے پتے پر رابطہ کریں

Arabic

إذا أردت نسخة من هذه الوثيقة بلغتك، يرجى
الاتصال برقم الهاتف أو مراسلة العنوان
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Gujarati

જો તમને આ દસ્તાવેજની નકલ તમારી ભાષામાં
જોઈતી હોય તો, કૃપા કરી આપેલ નંબર ઉપર
ફોન કરો અથવા નીચેના સરનામે સંપર્ક સાધો.

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