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London's boroughs: borough by sector jobs, data and methodology

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Contents

1. Executive Summary

Over a number of years GLA Economics has developed a GLA London jobs series for 1971-2015[1], and a more detailed jobs series for 1998-2015[2]. There have been a number of difficult technical issues, and the accompanying reports have provided explanations on the methods used to address them. A significant gap in the evidence base has been a borough[3] by sector employee jobs series. This has constrained our understanding of the development of the London economy, and specifically how the shift from a manufacturing-based economy to a service-based economy has been reflected in different experiences across boroughs.

This working paper reports on the methodology used to develop such a series, and analyses what it says about how the London economy has evolved.

GLA Economics has reviewed possible approaches to develop a borough by sector series, both in terms of available data, and methodology. The chosen option is Iterative Proportional Fitting. A range of tests have been conducted to understand the impacts of this approach, and the properties of the derived series. As there is considerable uncertainty around these estimates, especially for earlier years, they are intended to inform decision-making rather than be definitive. The series is experimental, and available on the London Datastore[4].

In 1971 the largest sector of the London economy in terms of employee jobs was Manufacturing. Jobs in this sector had declined by over 85% by 2015, while Professional and real estate services[5] had become the dominant sector and employee jobs more than tripled over the same period. A pattern of shift in the sectoral structure of the London economy had become established by 1989 with decline in Construction, Manufacturing, Primary and utilities, Public administration, Transportation and storage, and Wholesale sectors, and growth in other sectors. These changes have been taking place gradually, and it was only by 2001 that the number of London employee jobs was higher than in 1971.

Developments at the borough level have been more convoluted, and many boroughs have faced mixed fortunes over the time period of study. The relative ranking as a share of employee jobs in both Manufacturing and Professional and real estate services across boroughs has changed. What has remained the same has been the strength of the jobs markets in central London, and in west London around Heathrow airport, and particularly Hillingdon. Inner London has seen the strongest growth in jobs in business services, and has been able to reap agglomeration economies from the clustering of sector jobs. This has been a driver of specialisation in these sectors. West London has a more diverse economy, and, in this geography, it is only in the last couple of years that jobs in business services have been higher than in the sectors which have been declining.

There are ten boroughs dispersed around London which had not recovered by 2015 the level of employee jobs in 1971. Jobs growth has been weakest in areas to the east of London. Across

[1] See, for example, The GLA's London Workforce Employment Series | London City Hall (2003), Working Paper 52: London's jobs history - a technical paper | London City Hall (2011), London labour market projections 2016 | London City Hall (2016, specifically Appendix 7), and London labour market projections 2017 | London City Hall (2017, see Appendix F). This series is for all jobs, both employee jobs and self-employed jobs

[2] See Working Papers 65, 66: London's sectors: detailed jobs data & method | London City Hall (2015)

[3] This paper, throughout, uses the term borough to refer to the 33 local authorities in London, although strictly speaking City of London is not a borough.

[4] At https://data.london.gov.uk/dataset/borough-by-sector-employee-jobs

[5] The analysis uses the GLA sector definitions of the London Jobs series, and not ONS section definitions

areas of London it is the same sectors where there has been falling jobs numbers, and it is in other sectors where there has been rising jobs numbers. What distinguishes the more successful areas is their ability to attract jobs in business services. For the outer boroughs, there is less evidence of strength across a number of business service sectors, but a number have been successful in creating jobs in administration and support services, and for others there has been jobs growth in another part of business services.

2. Introduction

This working paper presents the methodology and data used for a preliminary and provisional London borough by sector employee jobs series, and the results from the series generated.

In past publications GLA Economics has developed separate borough and sector series. These have been developed in related, but different, ways. This is, in part, because the ONS Workforce Jobs series, the principal data source for employee jobs, is a composite series from a number of survey data sources, and is only available for London and sectors. There is borough by sector survey data, which is an input into the Workforce Jobs series, but there are discontinuities because of changes in data recording and collecting practices. Consequently, there is no simple way of using the source data to estimate sector employee jobs by borough[6].

This paper reviews the available borough by sector survey data, considers the methodologies that might be adopted to produce a borough by sector employee jobs series, and the reasons for preferring Iterative Proportional Fitting. The paper explains the rationale for the choice of input data, and compares borough by sector results from applying the method of Iterative Proportional Fitting to these different datasets. This method has good statistical properties under certain conditions, and there is a review of how well these conditions are met.

Finally, it should be noted that GLA Economics has produced a range of analysis which considers the spatial distribution of jobs in London, and by sector – see, for example: Working Paper 85, A description of London's economy[7]; the Economic Evidence Base[8]; Working Paper 71, More residents more jobs? 2015 update[9]; and, Working Paper 68, Work and life in the CAZ, north part of the Isle of Dogs and fringes[10]. This analysis tends either to consider the spatial clustering of jobs by sector, or provide an analysis of borough trends. In contrast, this paper looks to consider the long-term relationship between sector trends in jobs, and relate this to borough trends over the period 1971-2015.

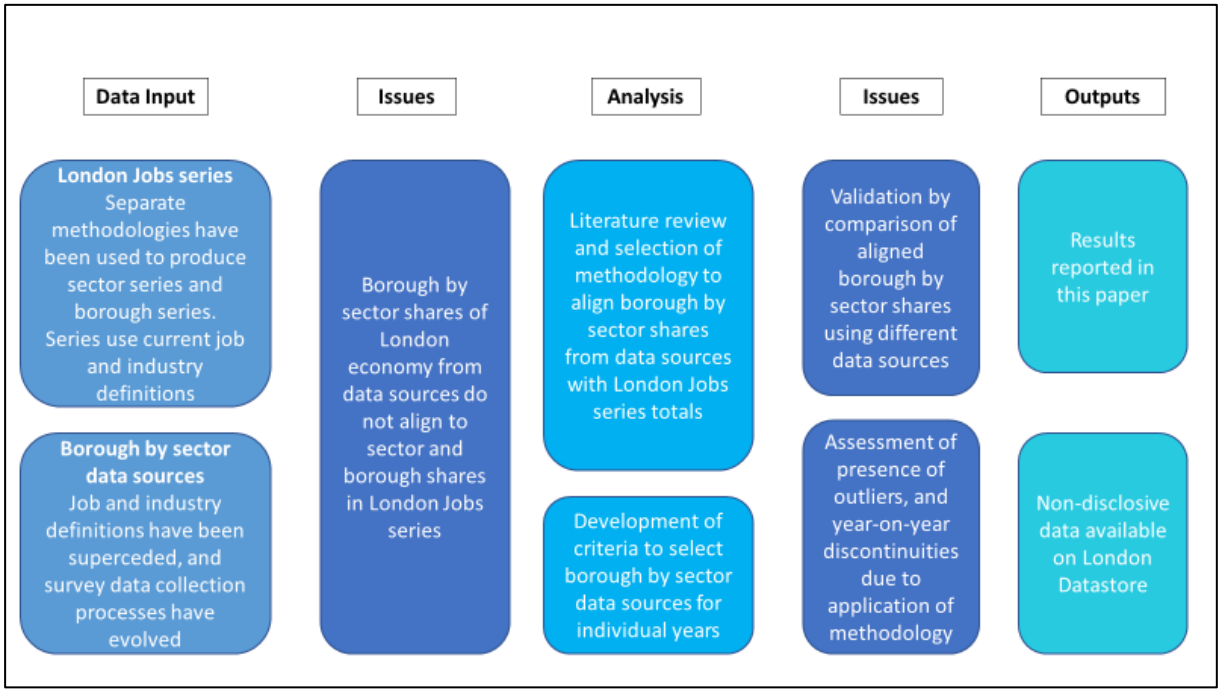
Section 3 provides an overview of the challenges involved in developing a borough by sector series, how these have been met, and how the results have been validated. More information is available in appendices. Appendix A covers data sources, properties, and definitions, while Appendix B sets out the development of a borough by sector series, and its validation. Section 4 gives the conclusions on the application of the methodology, section 5 reports the results, and the data is available on the London Datastore. More detailed analysis of results is at Appendix C.

[6] See Working Paper 52: London's jobs history - a technical paper | London City Hall (2011) for an expanded explanation, or in the methodology section of this publication
[7] See A description of London's economy | London City Hall
[8] See Economic Evidence Base for London 2016 | London City Hall
[9] See Working Paper 71: More residents more jobs? 2015 update | London City Hall
[10] See WP 68 Work & life in the CAZ, north part of the Isle of Dogs & fringes | London City Hall

3. Overview of approach to develop borough by sector series

This section provides an overview of the challenges involved in developing a borough by sector series, how these have been met, and how the results have been validated. Figure 1 provides a flowchart of the approach adopted to develop a borough by sector series, and the process is explained below. More detail on the data used, and the methods applied are in the appendices. Appendix A covers data sources, properties, and definitions, while Appendix B sets out the development of a borough by sector series, and its validation.

Figure 1: Flowchart of process to develop and validate borough by sector series



Source: GLA Economics

The GLA London Jobs series[11] for sectors and boroughs are the series to which a borough by sector series should align. GLA Economics has issued a number of publications explaining the development of the series[12]. It uses a number of data sources reported in a borough by sector format[13]. There are two reasons why this underlying data cannot be used directly to produce a borough by sector series consistent with the London Jobs series:

- **Borough by sector splits have not been preserved:** The data source for the most recent period for the London Jobs series for sectors is the ONS Workforce Jobs series, which is a composite series drawing on data from a number of surveys. So, the sector series for the London Jobs series has been produced on a different basis to the borough series. Some of the data sources which have contributed to these separate components

[11] The data for the series is available on the London Datastore
[12] See, for example, The GLA's London Workforce Employment Series | London City Hall (2003), Working Paper 52: London's jobs history - a technical paper | London City Hall (2011), London labour market projections 2016 | London City Hall (2016, specifically Appendix 7), and London labour market projections 2017 | London City Hall (2017, see Appendix F)
[13] It is important to note that the business survey data used in this analysis excludes the self-employed and does not therefore provide a complete picture of trends in London's labour market. Self-employment data are included in the amended BRES methodology but is limited to people that are registered for VAT or Pay-As-You-Earn (PAYE) schemes. Prior to BRES, self-employed people were not included in the business survey data sets.

of the London Jobs series have borough by sector data items. A consequence of the means of construction and development of the London Jobs series is that the borough by sector splits are not consistent

- **Changes in data definition and coverage over time:** The London Jobs series provides an estimate of jobs for each industry sector, borough, and year based on current definitions of a job and industry. Underlying data sources record jobs according to the definitions in place at the time of data collection. That is, there are discontinuities over time in job estimates from different sources, and changes over time might be because of methodological changes rather than changing business circumstances.

Appendix A discusses the properties of data that is available in a borough by sector format. This informs the selection of data used as input to produce a borough by sector series.

The next step was to review the literature to assess possible methodologies to align borough by sector shares from source data to the borough and sector shares of the London Jobs series. GLA Economics took the decision not to use survey microdata for this purpose because this increased significantly the complexity of the analysis, and did not necessarily improve the accuracy of estimates derived. Consequently, the method chosen was Iterative Proportional Fitting (IPF). The literature also indicates desirable properties of input data, and so provides a basis for coming up with selection criteria between possible input data sources, where more than one is available for a year. There are some potential undesirable consequences of the use of IPF mentioned in the literature, notably possible outliers where the derived borough by sector share differs significantly from the input value. For this purpose, there is a further issue where the borough by sector series has been created by combining data across years from a number of sources. That is, there is a risk of discontinuities in estimates year-on-year for methodological reasons, and which do not reflect changes in economic circumstances. **Appendix B** sets out more fully these steps in the development of a borough by sector series, and the validation processes adopted. **The conclusions on the implementation of the methodology are in the next section.** The series is experimental, and use of the data has not indicated that results are misleading, although the data should be used with care.

The data sources selected as input for the borough by sector series, and the years covered, are:

- 2009-15, the Business Register and Employment Survey (BRES)
- 1998-2008, the Annual Business Inquiry (ABI)
- 1991, 1993, 1995-7, the Annual Employment Survey (AES) (and is also available for 1998)
- Other years from 1971 onwards, the London Workplace Employment Series (LWES) (which is available from 1971-2005)

GLA Economics also used data from the:

- Inter-Departmental Business Register (IDBR) (which is available from 2001-15)
- Census of Employment (CofE) (which has borough by sector data for 1984, 1987, 1989, and1991)

4. Conclusions on implementation of the methodology

This working paper has provided a preliminary approach to develop a provisional borough by sector employee jobs data series for London for the years 1971-2015. IPF has been used for each of these years to produce this series, and to align borough and sector totals to those of the London Jobs series. This approach has been adopted as it places no restrictions on the data needed, and so overcomes data limitations, and is relatively straightforward to implement.

The estimates IPF produces can have good statistical properties[14]. This depends on the correlation between the control totals and the input data. The analysis uses borough by sector data series which have been used to produce the London Jobs series, namely the LWES, the AES, the ABI and the BRES. The associated borough and sector correlation coefficients are high, although at a sector level this was declining over time for the LWES in the 1980s. These series are also 'close' to control totals in the sense of 'distance' measures using absolute differences, or deviations.

The approach is one of a class of estimators used by national statistical agencies. It is computationally less complex, and the requirements of the data and analysis are also less. The academic literature does, though, indicate that there may be problems with the use of IPF in certain situations, and these are:

- Inconsistencies in control totals
- Correlated dimensions for control totals
- Sparse tables
- Measurement bias

The first three problems do not apply in this context. There is not an inconsistency as source data series contributed to the construction of the London Jobs series, boroughs and sectors are not correlated dimensions, and there are no zero entries for borough and sector jobs so the tables are not sparse.

Conceptually there may be an issue of measurement bias as the London Jobs series uses current definitions of a business, employee, industrial sector, and borough. These have not remained constant over time, and indeed survey methodology has become more sophisticated.

If this was significant it might require a large number of iterations for the IPF process, however in practice for each year it is less than 10.

Potential problems might also manifest in terms of mean adjustment or for individual borough and sectors. There is little evidence of significant mean adjustments as measured by mean absolute deviation, although there may be borough and sectors with comparatively large adjustments by this measure, and particularly for LWES data both in terms of the size of the adjustment, and the number of borough and sectors with a comparatively large adjustment. On the whole, it is more common for proportionately larger borough and sectors to have larger absolute adjustments, although there are smaller borough and sectors which have adjustments which are of a similar magnitude to the input value. As there is no means to estimate a

[14] The analysis of this section draws heavily on Brick, Montaquila and Roth (2003) https://ww2.amstat.org/sections/srms/Proceedings/y2003/Files/JSM2003-000472.pdf presented at the 2003 proceedings of the American Statistical Association https://ww2.amstat.org/sections/srms/Proceedings/y2003/Files/Search.pdf . Iterative Proportional Fitting is one form of raking.

"correct" borough by sector estimate it cannot be known to what extent the change through IPF is improving the estimate in every instance.

In aggregate, no significant problems have been identified in borough by sector estimates generated through IPF.

As borough by sector data is at a low level of disaggregation there may be significant year-on-year changes because a single, or small number of businesses, close or open up. Successive years which use different source data may also be a source of volatility because of the effects of changes in survey methodology, or simply because the same businesses are not sampled each year. There is also a risk of year-on-year volatility because IPF converges to one of many possible solutions. Evidence has not been found of significant adverse effects, although it is not possible to be definitive for each borough and sector in every year. IPF has had little impact for a large group of borough and sectors. Discontinuities where there is a significant change from the application of IPF in one year but not the next, or the reverse, are concentrated in the period 1990-95 when the preferred source data series alternates between LWES and AES in successive years, and to a lesser extent between 2008 and 2009 when there was a transition from ABI to BRES. It is possible, in these instances, that IPF may be offsetting to some extent differences in input borough by sector shares in London employee jobs arising from changes in survey methodology, rather than introducing distortion into the estimates.

In conclusion, the borough by sector employee jobs series should help to improve understanding of the London economy. A series of tests have been conducted to assess the robustness of the series both within and across years. This indicates that the process followed is statistically robust, but there remains considerable uncertainty around some estimates, especially for the earlier years of the series.

5. Results

5.1. Introduction

GLA Economics has produced a range of analysis which considers the spatial distribution of jobs in London, and by sector – see, for example: Working Paper 85, A description of London's economy[15]; the Economic Evidence Base for London[16]; Working Paper 71, More residents more jobs? 2015 update[17]; and, Working Paper 68, Work and life in the CAZ, north part of the Isle of Dogs and fringes[18]. This analysis tends either to consider spatial clustering of jobs by sector, or provide an analysis of borough trends (see, for example, Working Paper 85). Working Paper 71 concluded that there was not a significant relationship between employment and population density except in areas with low transport accessibility – while there are some areas predominantly in Outer London with a higher proportion of employment serving the local population.

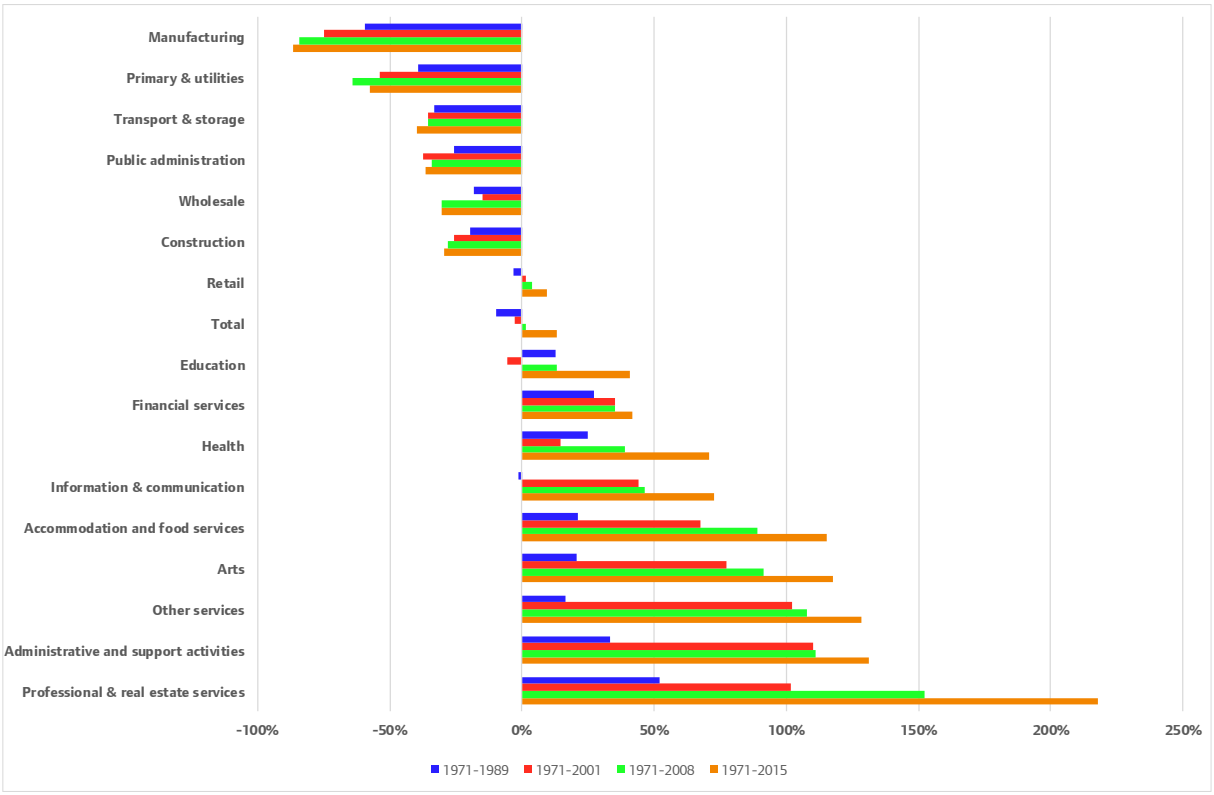
This paper looks to consider the long-term relationship between sector trends in jobs, and relate this to borough trends over the period 1971-2015 – it does not consider recent developments. The paper also relates its findings to those of other reports. As there is considerable uncertainty around some of these estimates, especially for the earlier years, the analysis is intended to inform decision-making rather than be definitive.

5.2. Sector trends in London employee jobs

The total number of jobs in London was lower at the cyclical peaks in 1989 and 2001 than it was in 1971, and it was only by the peak in 2008 that jobs were above their 1971 level. Since then jobs numbers have continued to grow. These trends have not been uniform across sectors. Six sectors have been in decline, namely Manufacturing; Primary and utilities; Transportation and storage; Public administration; Wholesale; and, Construction[19]. Manufacturing has seen the largest decline in proportionate terms, by 59% between 1971 and 1989, and by 86% over the extended period to 2015. The strongest growth is in Professional and real estate services which has more than tripled in size over this period, while each of Administrative and support activities, Other services, Arts, and Accommodation and food services have more than doubled. If a sector had contracted or expanded over the period 1971-1989 then this would also be the case over the longer time periods with the exceptions of Retail, and Information and communication which contracted between 1971 and 1989, and education which contracted over the thirty years to 2001, but expanded over other time periods, see Figure 2.

[15] See A description of London's economy | London City Hall
[16] See Economic Evidence Base for London 2016 | London City Hall
[17] See Working Paper 71: More residents more jobs? 2015 update | London City Hall
[18] See WP 68 Work & life in the CAZ, north part of the Isle of Dogs & fringes | London City Hall
[19] It should be noted that jobs in Construction have risen since 2011, and that the purpose of this paper is to identify longer term dynamics, which may not always reflect what has happened in the last few years.

Figure 2: Sector change in London employee jobs, 1971 – various years, percentage change



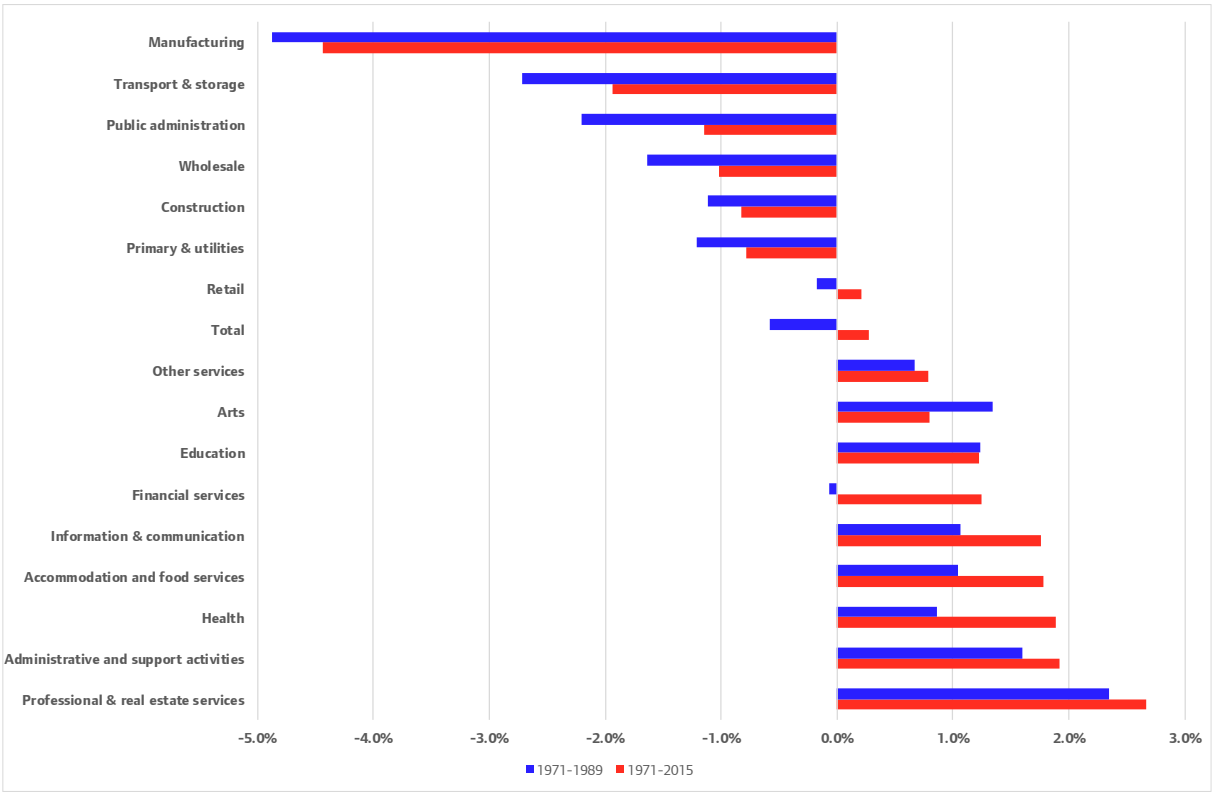
Source: GLA Economics calculations

In summary, while in 1971 Manufacturing accounted for 20% of jobs in London and Professional and real estate services made up 6%, by 2015 the share of Manufacturing had fallen to 3%[20], and that of Professional and real estate services had risen to 16%. Section 5.5 provides more analysis of sector changes by the relative size of sector groupings.

There is also a distinct pattern in the pace of growth of sectors. The rate of decline of declining sectors slowed over the period 1971-2015 compared to 1971-1989. While for growing sectors the rate of growth is higher for the longer period, with the exceptions of Arts, and (marginally) Education, see Figure 3. Over the entire period Manufacturing declined at an annual rate of 4.4% a year, while Professional and real estate services grew at an annual rate of 2.7%.

[20] This figure includes primary and utilities to avoid releasing disclosive data

Figure 3: Sector change in London employee jobs, 1971-1989 and 1971-2015, compound annual growth rate

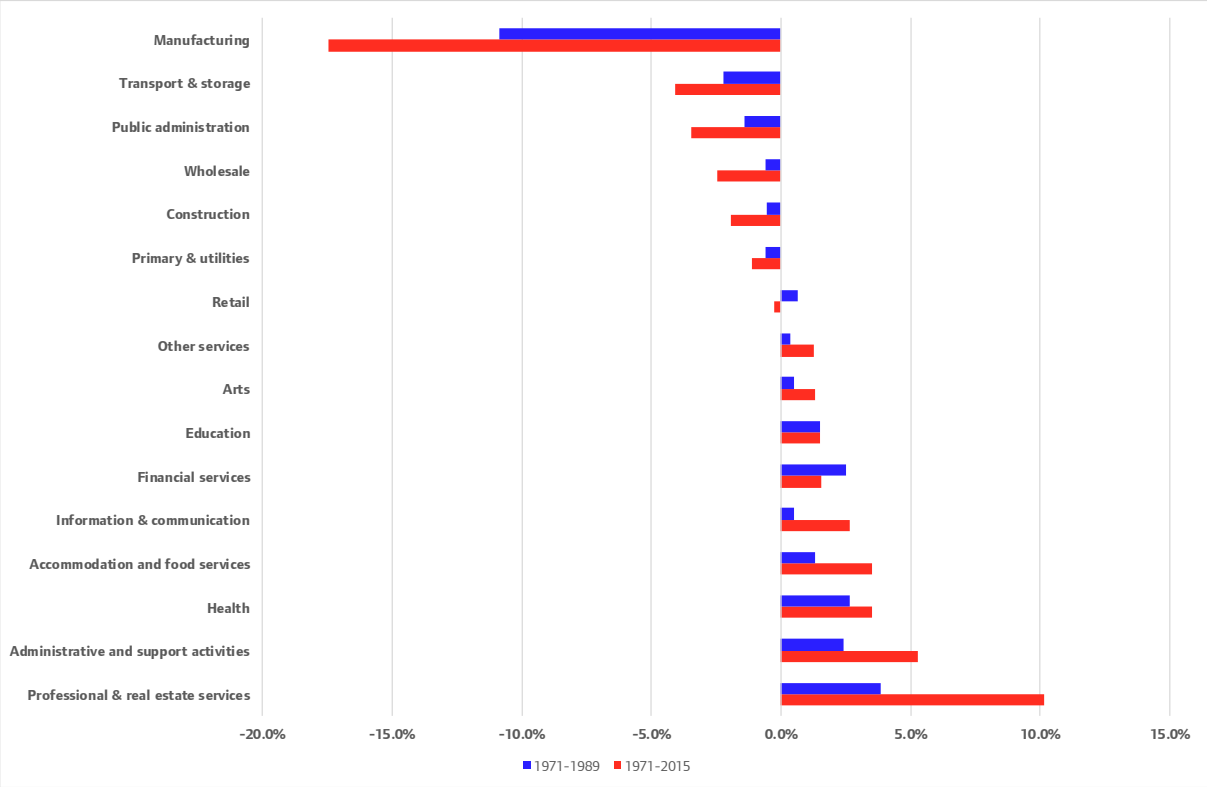


Source: GLA Economics calculations

Over the period 1971-2015 Manufacturing jobs have fallen by more than 700,000 while Professional and real estate service jobs have risen by a little over 500,000 jobs. Consequently, the share of manufacturing jobs in all jobs has fallen by more than the share of jobs of Professional and real estate services has increased[21], see Figure 4.

[21] The results for Financial services may appear confusing. The share of Financial services in London employee jobs increased over both 1971-1989 and 1971-2015, and by more in the earlier period. The share increased in the earlier period despite a fall in jobs (Figure 3) because the rate of decline was lower than that for jobs as a whole in London. The increase in share of London jobs in Financial services in the earlier period was larger than that for other sectors which experienced jobs growth such as Information and communication, and Accommodation and food services because the Financial services sector was of a larger absolute size, see Figure 4.

Figure 4: Change in sector share of London employee jobs 1971-1989 and 1971-2015, percentage points



Source: GLA Economics calculations
Note: sum across sectors for each time period is zero

Note that **Appendix C** presents a borough breakdown for each sector of:

- Compound annual jobs growth rate
- Change in borough share of sector jobs

That is, the counterpart of Figures 3 and 4 for boroughs within sectors. Later sections incorporate some of the findings from the detailed analysis in Appendix C.

5.3. Borough trends in London employee jobs

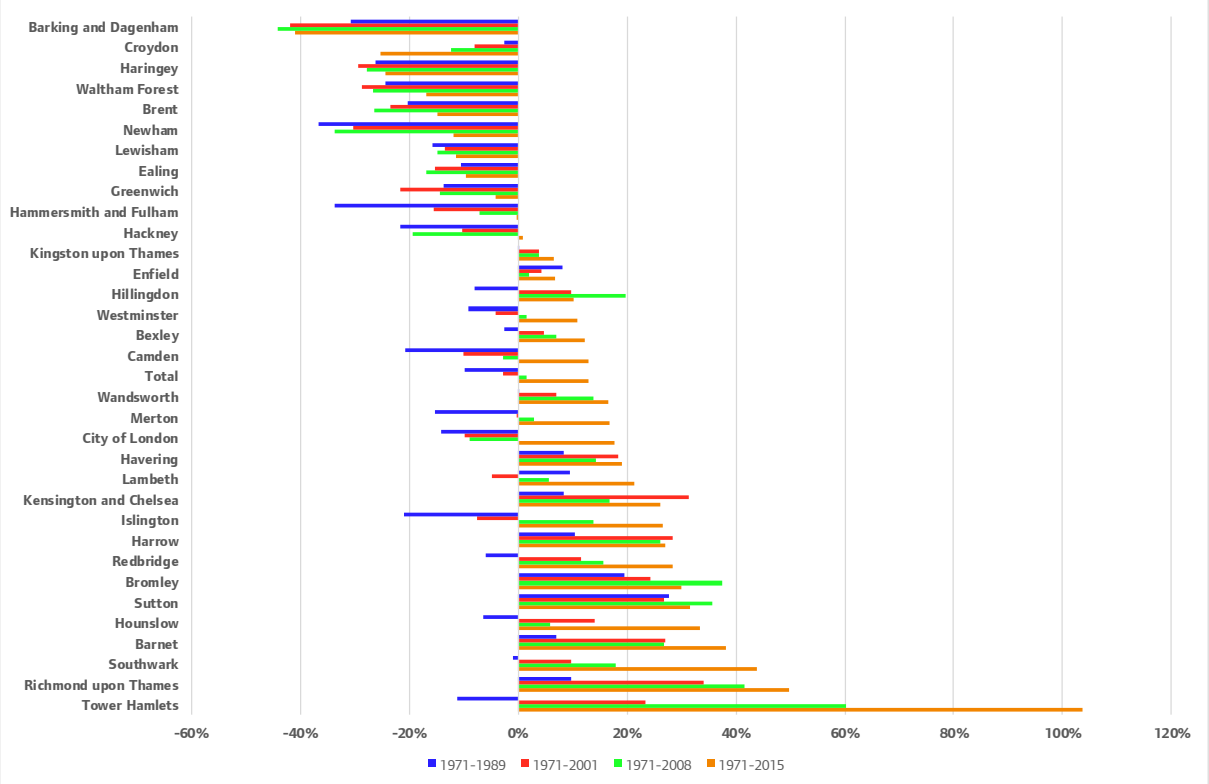
Figures 5 to 7 replicate Figures 2 to 4 for trends in borough jobs rather than sector jobs.

There is a diverse picture in terms of borough trends in jobs growth for the periods 1971-1989, 1971-2001, 1971-2008, and 1971-2015 (see Figure 5). This contrasts with Figure 2 where there was a settled picture of decline or growth across sectors. There are ten boroughs which have not recovered the level of jobs seen in 1971, namely: Barking and Dagenham; Brent; Croydon; Ealing; Greenwich; Hammersmith and Fulham; Haringey; Lewisham; Newham; and, Waltham Forest. With the exception of Croydon each of these boroughs has seen some jobs growth in the most recent period, that is the loss of jobs between 1971 and 2015 is less than for 1971 and earlier periods. In another ten boroughs, there has been jobs growth for the four time periods in Figure 5, that is: Barnet; Bromley; Enfield; Harrow; Havering; Kensington and Chelsea; Kingston upon Thames; Richmond upon Thames; Sutton; and, Wandsworth. Strongest jobs growth over the entire period 1971-2015 has been in Tower Hamlets (where jobs have more

than doubled). This has been followed, in descending order of growth, by Richmond upon Thames; Southwark; Barnet; and, Hounslow.

Despite mixed fortunes across parts of the period of 1971-2015, boroughs with a part in the Central Activities Zone (CAZ) have grown strongly in the period 2008-2015 (as a comparison between the bars for 1971-2008 and 1971-2015 reveals). These boroughs are: Camden; Hackney; Islington; Kensington and Chelsea; Lambeth; Southwark; Tower Hamlets; Wandsworth; and, Westminster. It was only since 2008 that employee jobs in the City of London exceeded the 1971 level, and only around 2001 when this happened for Westminster.

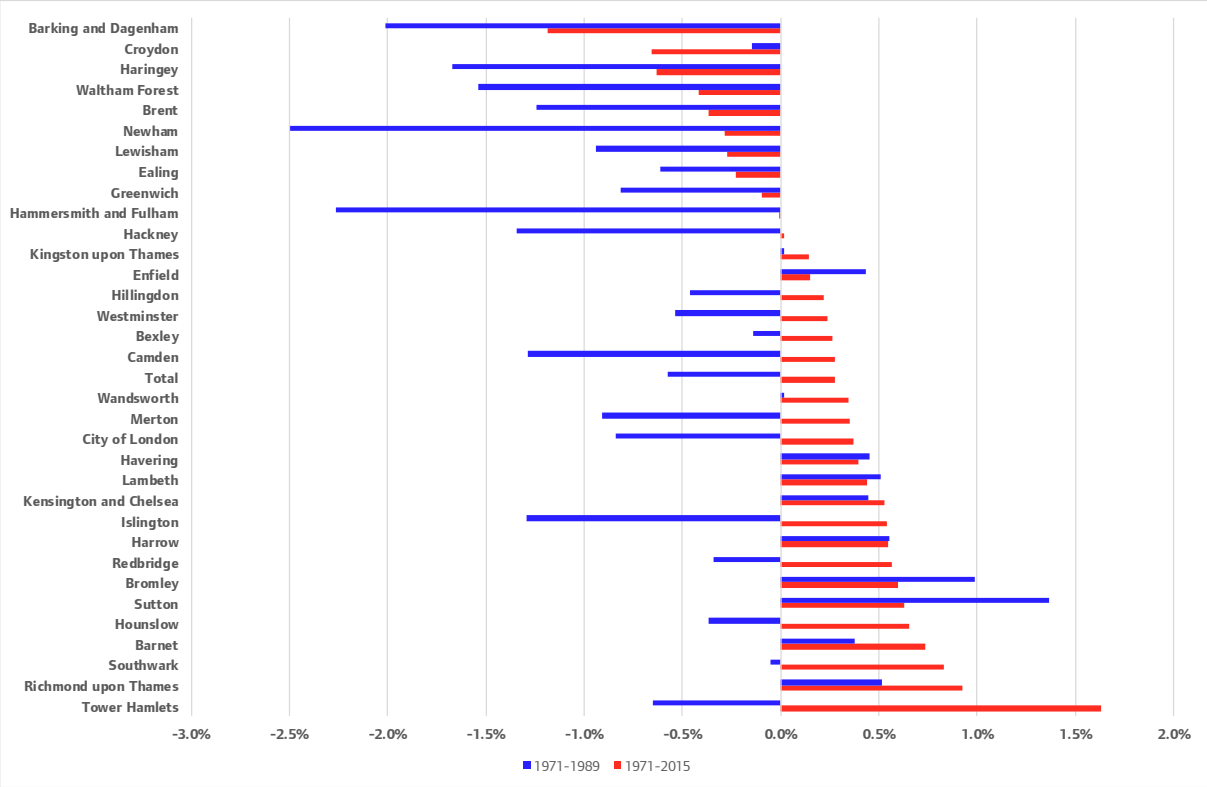
Figure 5: Borough change in London employee jobs, 1971 – various years, percentage change



Source: GLA Economics calculations

Figure 6 replicates Figure 3, by providing the compound annual growth rate in borough jobs for the periods 1971-1989, and 1971-2015. As with Figure 3, the jobs growth rate has improved over the longer period across most boroughs, and for some there has been a recovery in jobs after earlier job losses. Job performance worsened with time in seven boroughs: Bromley; Croydon; Enfield; Harrow (if, marginally); Havering; Lambeth; and, Sutton.

Figure 6: Borough change in London employee jobs, 1971-1989 and 1971-2015, compound annual growth rate

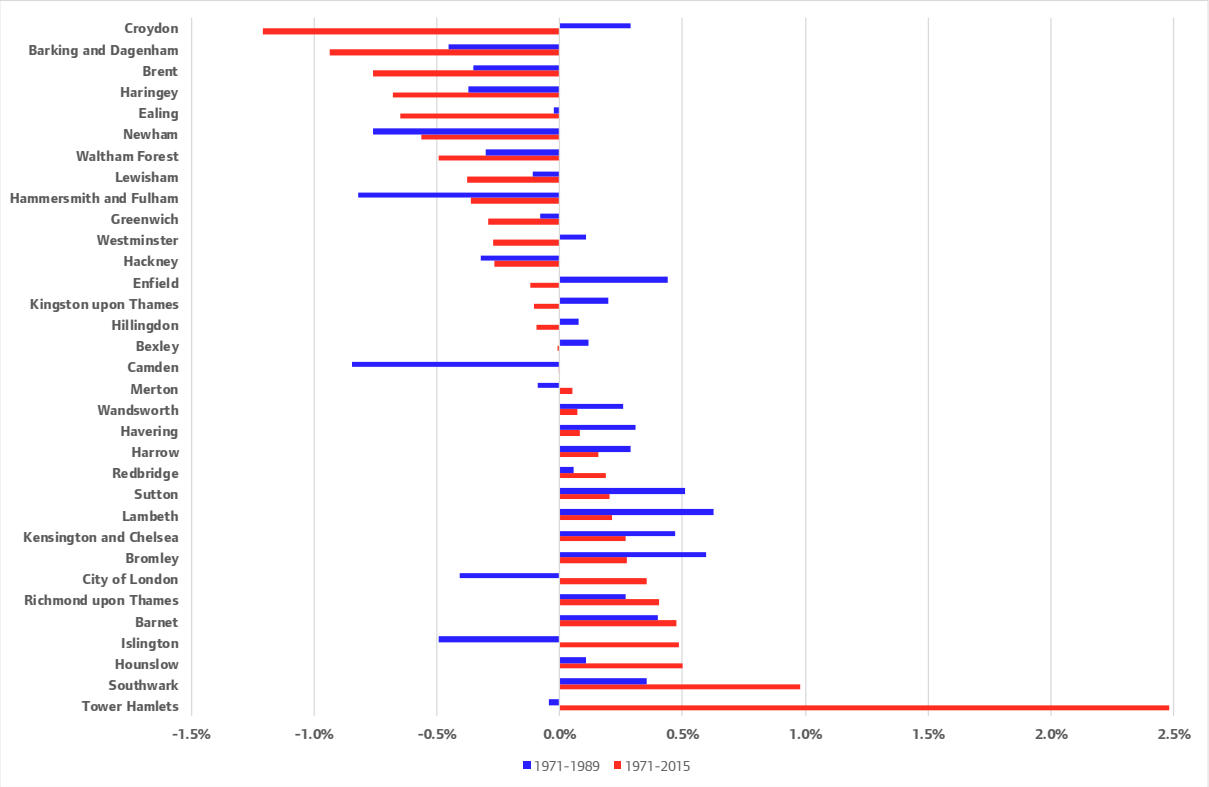


Source: GLA Economics calculations

Figure 7 shows the change in borough share of employee jobs for the periods 1971-1989 and 1971-2015. There are similarities with the changes in sector share in Figure 4 in that typically boroughs with a gain in share over the period 1971-1989 also had a gain between 1971 and 2015, and vice versa. It is not, though, the case for a number of boroughs that the changes have become more magnified over time. Indeed, to take the borough with the largest reduction in share of jobs over the entire period, Croydon, and the borough with the largest increase, Tower Hamlets, over the shorter period 1971-1989 Croydon gained share[22] and Tower Hamlets lost share.

[22] Despite losing jobs over this period the rate of job loss was less than that for London as a whole, and so Croydon increased its share of jobs.

Figure 7: Change in borough share of London employee jobs 1971-1989 and 1971-2015, percentage points



Source: GLA Economics calculations
Note: sum across sectors for each time period is zero

In conclusion, there is not a simple explanation of the economic development of boroughs as there is for sectors. Many boroughs have had a mixed experience of jobs growth, which contrasts with more consistent sector trends. Previous GLA Economics research has suggested that population growth in a borough is at most a partial explanation of jobs growth, not least because of the extensive transport connections in London[23].

GLA Economics has conducted research on the CAZ (combined with the Northern Isle of Dogs[24] and its fringes)[25] which reports that the top five sectors of employment were: Professional services; Financial services; Information and communication technologies; Administration and support services; and, Accommodation and food services. This has a clear read across to the growth sectors in the London economy. The report also provides evidence that there is distinct geographical clustering of jobs in these sectors.

5.4. Borough impact of changes in sector distribution of employee jobs

The last section explored jobs growth for individual boroughs, but it did not consider the relative share of London jobs by borough, and therefore the importance of changes within boroughs to the London jobs total. This section and the next section do this.

[23] See Working Paper 71: More residents more jobs? 2015 update | London City Hall
[24] This area is in Tower Hamlets, one of the boroughs with a part in the CAZ
[25] See WP 68 Work & life in the CAZ, north part of the Isle of Dogs & fringes | London City Hall

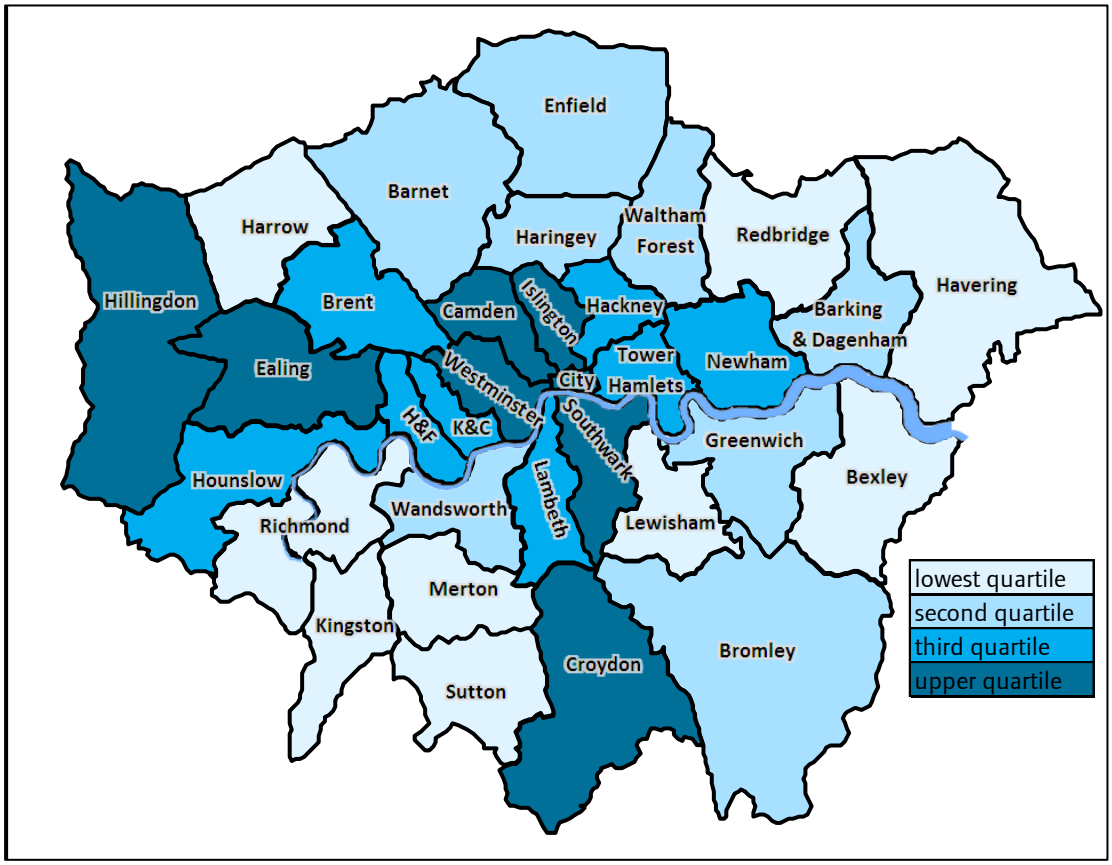
This section reports change in the borough distribution of sector jobs, for 1971, 1989, and 2015 for the London economy as a whole, the Manufacturing sector, and Professional and real estate services[26]. It examines the boroughs by quartile share of London jobs, which provides a visual indication of how the distribution of jobs across boroughs has changed as the London economy has become more service-based. What this approach does not do is indicate where jobs in a sector are concentrated in a relatively small number of boroughs.

For each of the periods 1971-1989, and 1971-2015 Manufacturing jobs fell in all boroughs[27] (Figure C.3), while jobs increased in all boroughs in Professional and real estate services[28] (Figure C.19), so the maps below capture how the change in trend has been distributed across boroughs[29].

In 1971 boroughs with above average shares of jobs passed from Newham in the east, through the central areas, and out to Hillingdon, and from the centre down to Croydon. By 1989 boroughs in the upper half of the ranking had shifted slightly westwards, and north – Hackney and Newham had dropped out while Barnet and Enfield had entered. There is a similar look to the ranking for 2015 except Enfield has moved down, and Hammersmith and Fulham has moved into the upper half. A number of boroughs have remained in the upper quartile of the ranking in each of 1971, 1989 and 2015: Camden, City of London, Hillingdon, Islington, Southwark, and Westminster – that is the centre of London, and the area around Heathrow airport has been important for jobs throughout the period, see Maps 1-3.

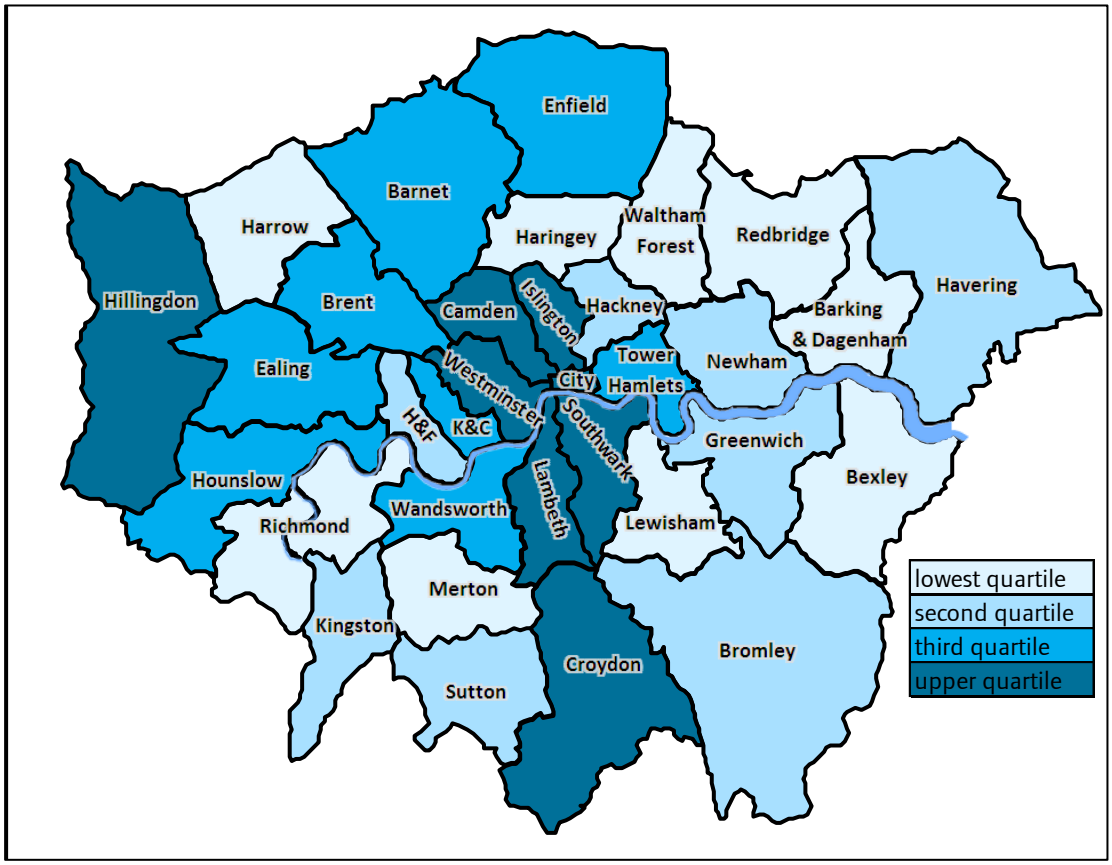
[26] Manufacturing was the largest sector in 1971, and Professional and real estate services was the largest sector in 2015
[27] Except Kensington and Chelsea for the period 1971-1989
[28] Except Camden and Islington for the period 1971-1989
[29] These findings are also the case in terms of absolute job numbers except there has been a decline in professional and real estate service job numbers for 1989-2015 for a few boroughs: Barking and Dagenham; Bromley; Croydon; Havering; and, Sutton

Map 1: Borough distribution by quartile of share of London employee jobs, 1971



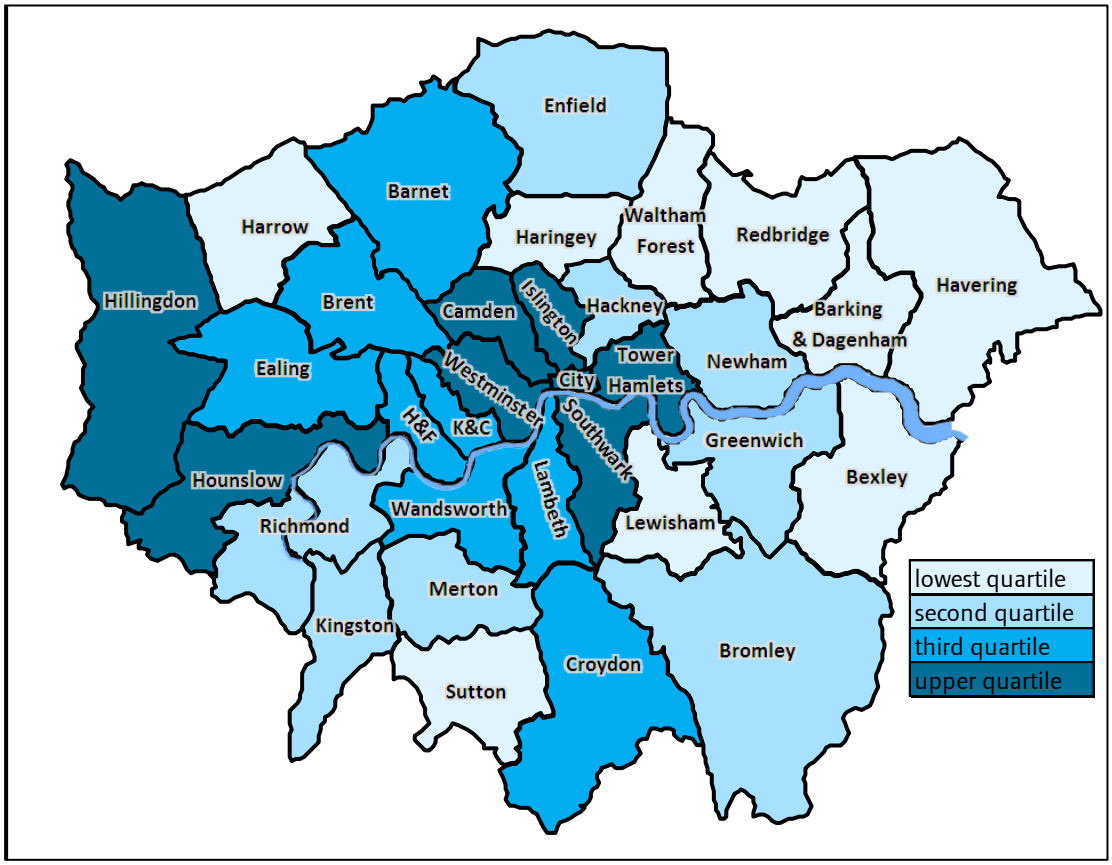
Source: GLA Economics calculations

Map 2: Borough distribution by quartile of share of London employee jobs, 1989



Source: GLA Economics calculations

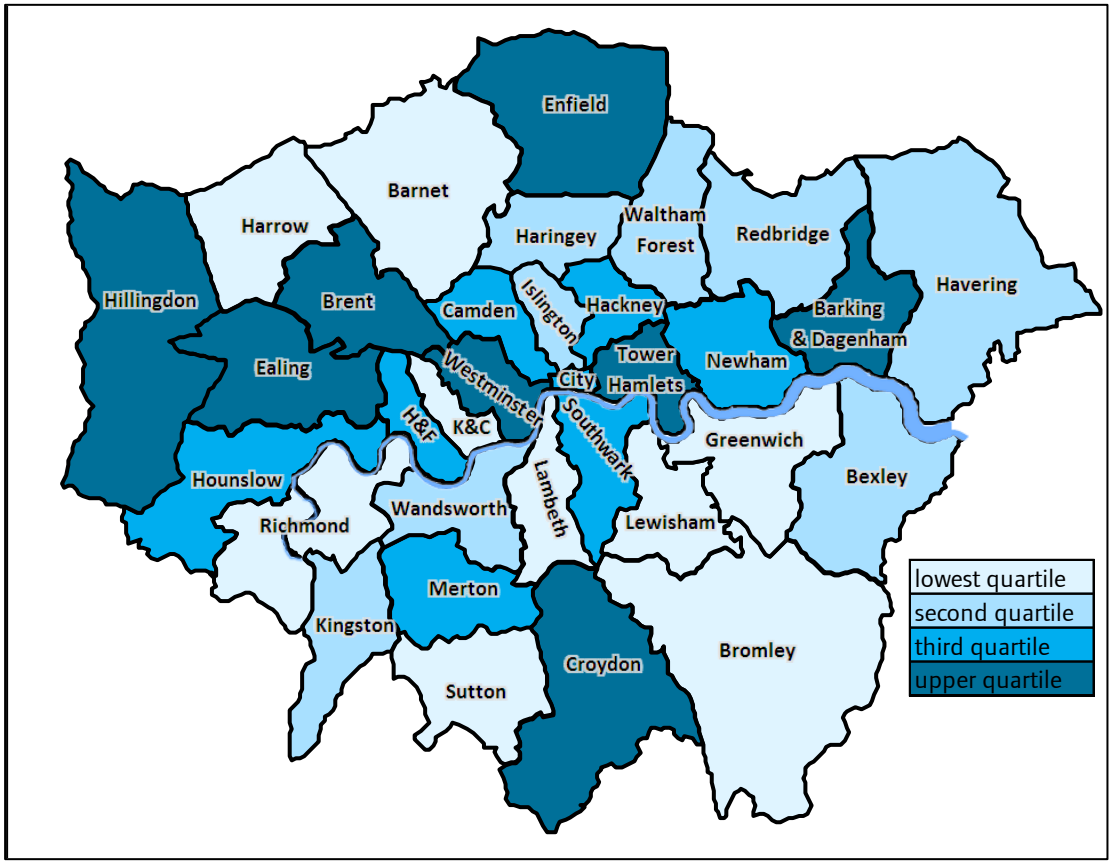
Map 3: Borough distribution by quartile of share of London employee jobs, 2015



Source: GLA Economics calculations

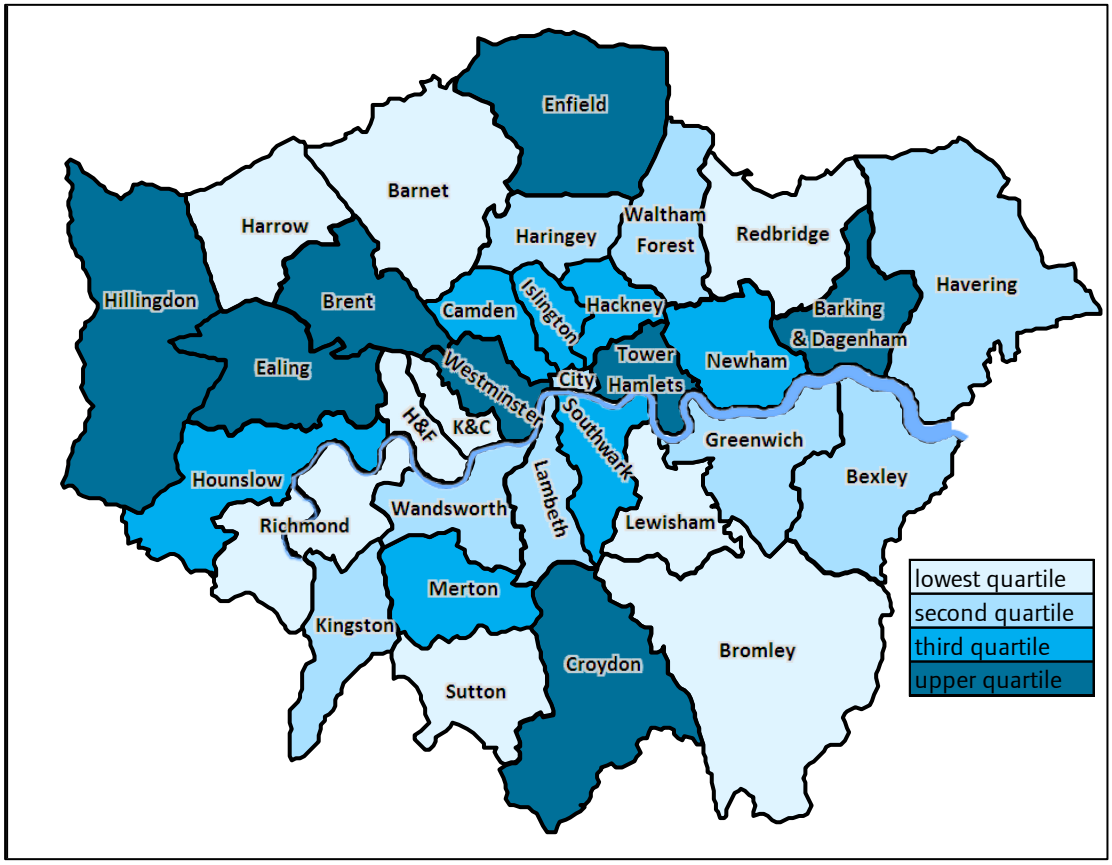
In 1971 there was a mixed relationship for boroughs between being in the upper quartile of the ranking for Manufacturing jobs and all jobs. In both were Croydon, Ealing, Hillingdon and Westminster, while Barking and Dagenham, Brent, Enfield and Tower Hamlets were in the upper quartile of the ranking for Manufacturing jobs only. Six of these eight remained in the upper quartile for Manufacturing jobs in 2015, with Croydon and Tower Hamlets dropping out, and Bexley and Newham coming in. Notably, Westminster remains in the upper quartile for Manufacturing jobs. In 1971 and 1989 boroughs in the upper half of the ranking tended to be on a North-South or East-West axis through the centre of London. By 2015 this had shifted to boroughs north of the river (with the exception of Bexley), see Maps 4-6.

Map 4: Borough distribution by quartile of share of London Manufacturing employee jobs, 1971



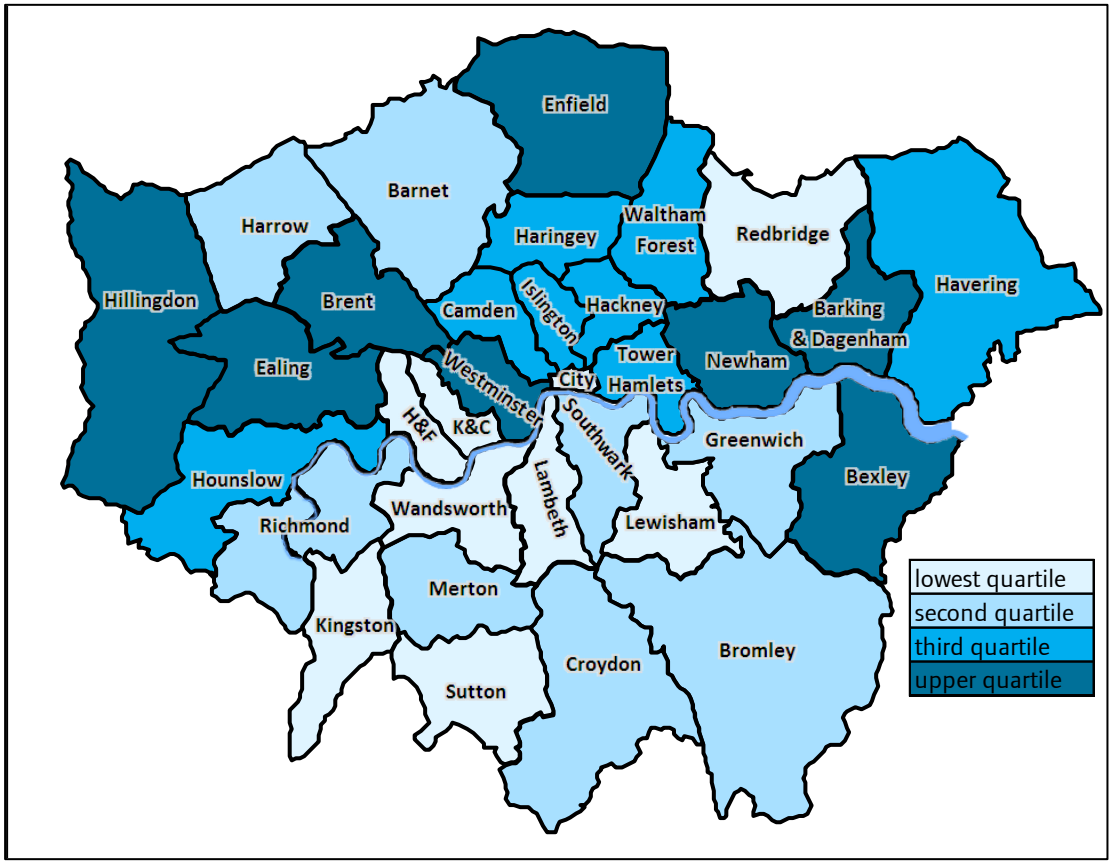
Source: GLA Economics calculations

Map 5: Borough distribution by quartile of share of London Manufacturing employee jobs, 1989



Source: GLA Economics calculations

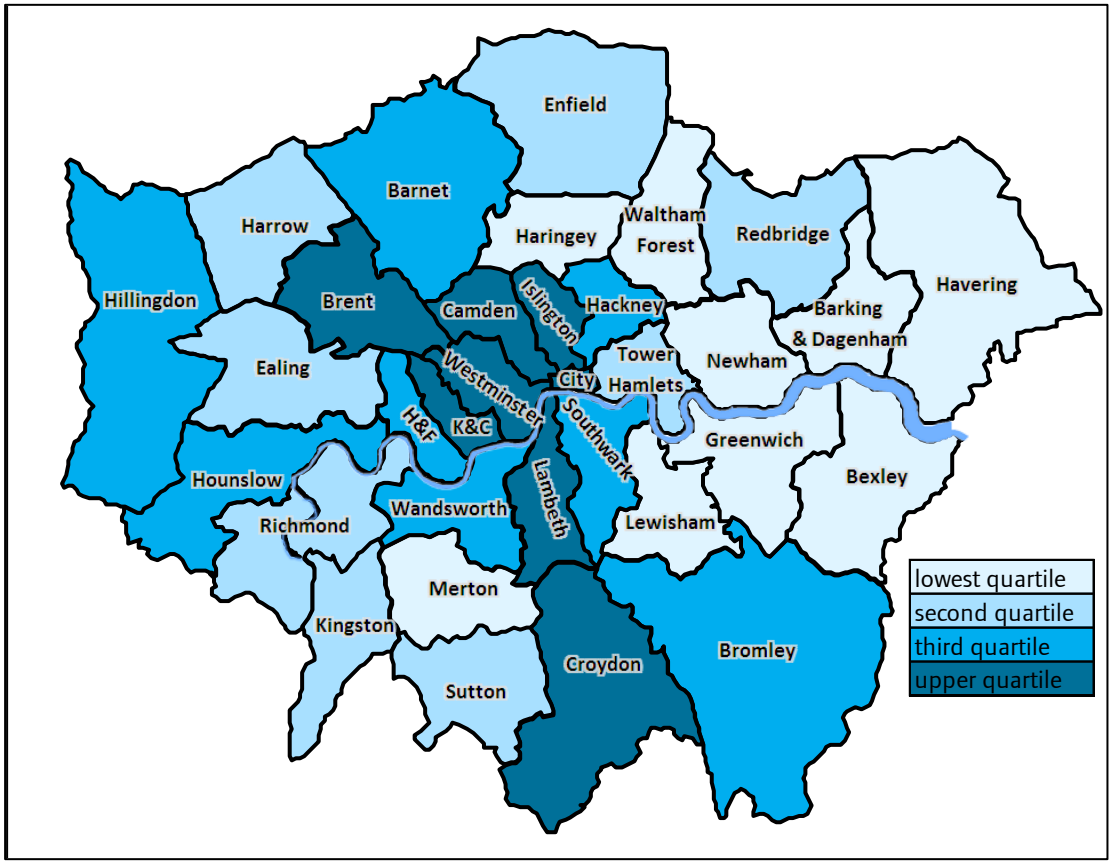
Map 6: Borough distribution by quartile of share of London Manufacturing employee jobs, 2015



Source: GLA Economics calculations

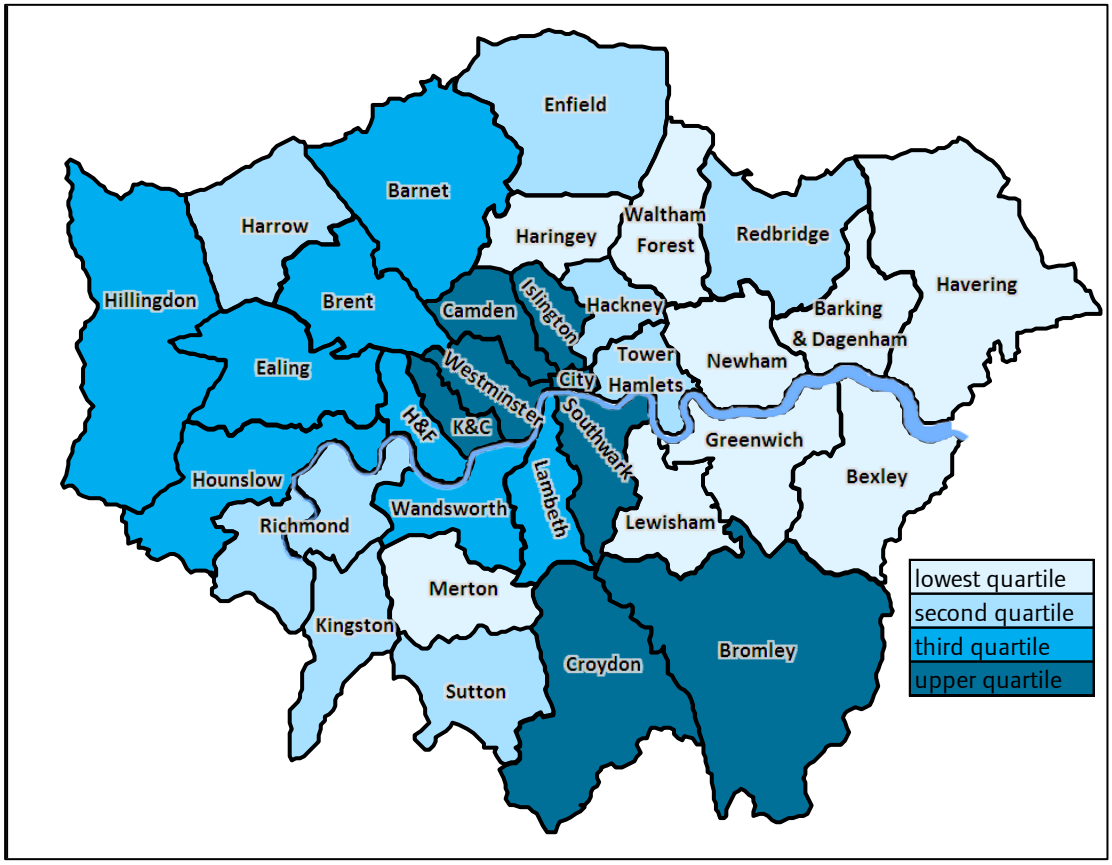
The Professional and real estate services sector has also shifted across London over time. In 1971, there was little presence amongst boroughs in the east in the upper half of the ranking of shares of jobs, and, if anything, there has been a westwards shift. Bromley was in the upper half of the ranking in 1971, and the upper quartile in 1989, but had slipped out of the upper half by 2015. Central boroughs all accounted for places in the upper quartile of the ranking in 2015. In 1971 Brent and Croydon also featured in the upper quartile, see Maps 7-9.

Map 7: Borough distribution by quartile of share of London Professional and real estate services employee jobs, 1971



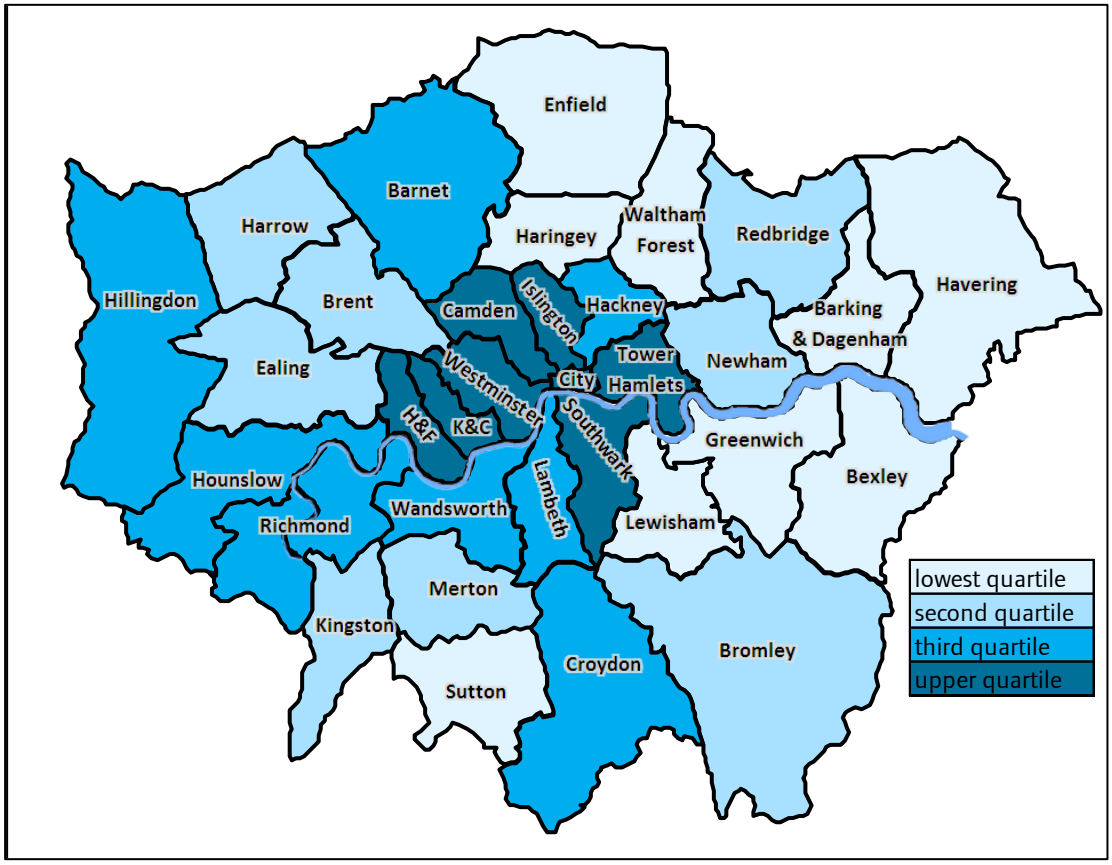
Source: GLA Economics calculations

Map 8: Borough distribution by quartile of share of London Professional and real estate services employee jobs, 1989



Source: GLA Economics calculations

Map 9: Borough distribution by quartile of share of London Professional and real estate services employee jobs, 2015



Source: GLA Economics calculations

The London Labour Market Projections 2016 reports[30] that the London economy has become more specialised in a relatively small number of sectors: Financial services; Information and communication technologies; and, Professional and real estate services. These sectors accounted for 53% of London's output[31] in 2014, up from 42% in 1997. These are also sectors which have a disproportionate share of UK jobs in London.

Consistent with this finding, the analysis of this section indicates that employee jobs have become more concentrated in the central areas of London, and that this is associated with the rise of the Professional and real estate services sector. In contrast, there was not the same clustering of Manufacturing jobs in 1971. Boroughs which had a large share of jobs in Manufacturing did not necessarily have a large share of all jobs in London across sectors. Areas important to Manufacturing with other strengths such as Hillingdon with Heathrow airport, or central areas have continued to thrive while others have not.

5.5. Sub-regional trends in employee jobs by sector groups

This sub-section provides an overview of borough by sector trends by aggregating across boroughs and sectors to see what further messages might be drawn out about how the sector development of London's economy has played out across boroughs. The classification of sub-

[30] See London labour market projections 2016 | London City Hall
[31] As measured by Gross Value Added

regions has been developed by the ONS, and the grouping of sectors has been produced for this paper.

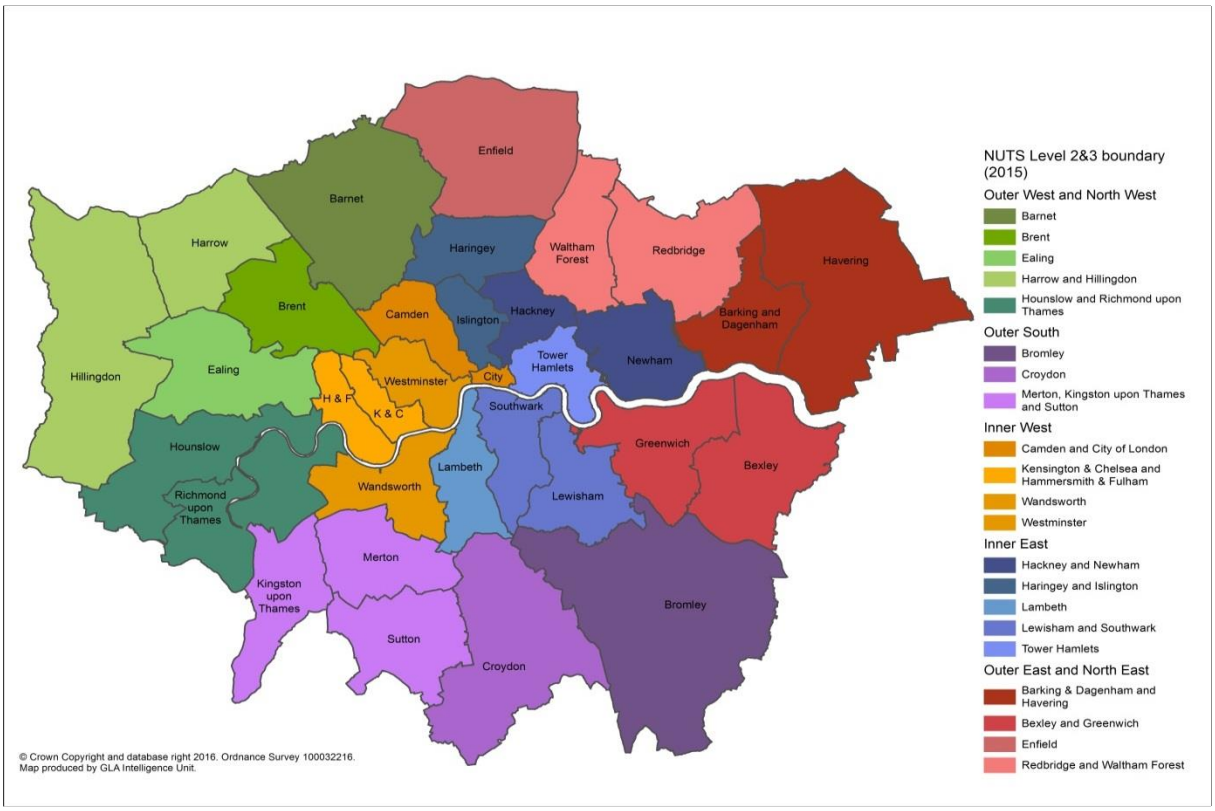
The ONS has developed the Nomenclature of Territorial Units for Statistics (NUTS) 2010 arrangement for sub-regions of the UK. Under this convention, Greater London corresponds to NUTS-1, NUTS-2 divides inner London into two sub-divisions and outer London into three sub-divisions, with NUTS-3 splitting these sub-divisions further into individual boroughs or local authority groupings. Boroughs with a part in the CAZ are in one of the inner London sub-divisions, although these sub-divisions also include other boroughs. Table 1 provides the NUTS-2 classification of boroughs, and Map 10 shows how this translates into NUTS-3 areas.

Table 1: Classification of London's statistical sub-regions

Inner London		Outer London		
Inner London – West	**Inner London – East**	**Outer London – West and North West**	**Outer London – East and North East**	**Outer London – South**
Camden	Hackney	Barnet	Barking and Dagenham	Bromley
City of London	Haringey	Brent	Bexley	Croydon
Hammersmith and Fulham	Islington	Ealing	Enfield	Kingston upon Thames
Kensington and Chelsea	Lambeth	Harrow	Greenwich	Merton
Wandsworth	Lewisham	Hillingdon	Havering	Sutton
Westminster	Newham	Hounslow	Redbridge	
	Southwark	Richmond upon Thames	Waltham Forest	
	Tower Hamlets			

Source: Office for National Statistics

Map 10: London's five NUTS-2 sub-regions for statistical purposes



Source: GLA Intelligence Unit

This paper uses a classification of four non-standard sector groups:

- Business services – these sectors provide services which support businesses, but support may not be associated with a tangible commodity
- Customer services – these are sectors which individuals might use in their leisure time
- Declining sectors – these are the sectors which have been identified in Figures 2 and 3 as having been in decline in London over the period 1971-2015
- Local public services – this is Education and Health, which individuals might access near where they live

Table 2 sets out how these sector groups correspond to GLA sectors.

Table 2: Grouping of London's sectors

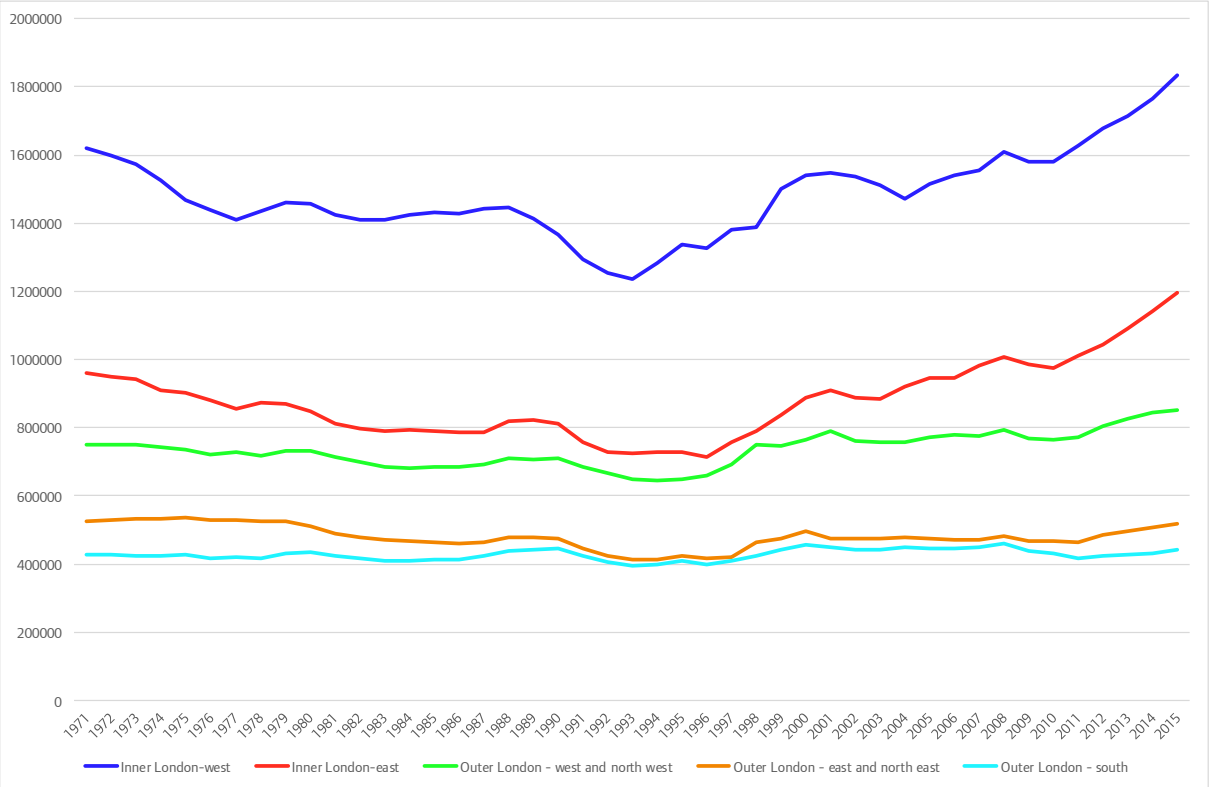
Sector grouping	Individual sectors
business services	administration and support services
	financial services
	information and communication technologies
	other services
	professional and real estate services
customer services	accommodation and food services
	arts
	retail
declining sectors	construction
	manufacturing
	primary and utilities
	public administration
	transportation and storage
	wholesale
local public services	education
	health

Source: GLA Economics

In 1971 jobs in the inner London areas exceeded those in outer London areas, and jobs in Inner London – west were over 50% higher than in Inner London – east. This remained the case in 2015. Outer London – west and north west had the next highest number of jobs in 1971. These three sub-regions have also grown the fastest since 1971. Inner London – east has a quarter more jobs[32], while job numbers have increased by 13% in the other two sub-regions over the years to 2015. In comparison, jobs in Outer London – east and north east had not recovered to their 1971 level by 2015, while in Outer London – south jobs rose by 4%.

[32] This sub-region includes Lewisham and Newham which had fewer jobs in 2015 than 1971, and Hackney which only had slightly more.

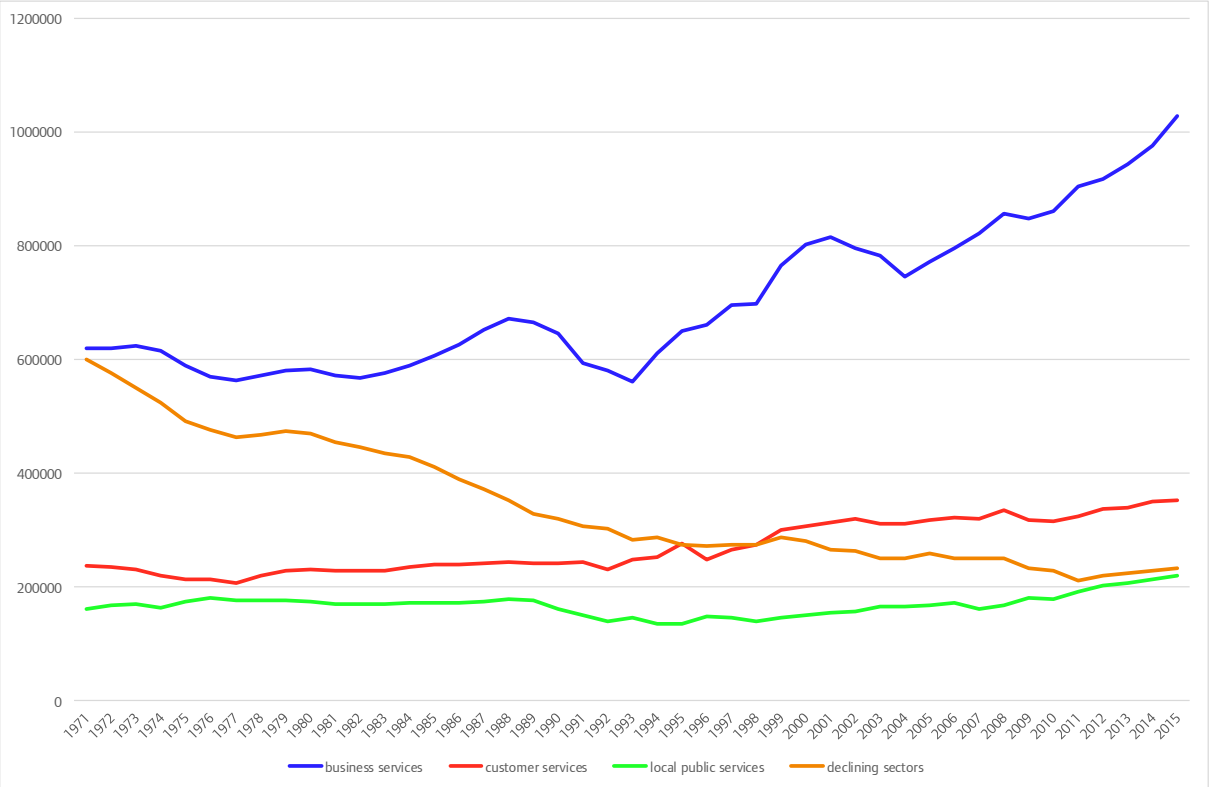
Figure 8: Employee jobs trends for London NUTS-2 sub-regions 1971-2015



Source: GLA Economics calculations

Across the period 1971-2015 Inner London – west has had more jobs in each of the sector groupings than each of the other sub-regions. The exception is the declining sectors from 2000 onwards when job numbers were higher in Outer London – west and north west. For every year jobs in business services have been higher than those in the declining sectors. Both groupings had around 600,000 jobs in 1971. Jobs in business services have increased by around two thirds over the period. While Westminster's share of Professional and real estate service jobs is by far the largest across boroughs, it has fallen from 28% to 20% of jobs between 1971 and 2015 (see Figure C.20 in Appendix C). There has been a corresponding drop in jobs of nearly two thirds in the declining sectors. This includes a fall in jobs in Public administration even though Westminster's share of London's jobs has risen from 19% to 28% (see Figure C.24 in Appendix C). Figure 9 looks at the trends in Inner London – west in more detail.

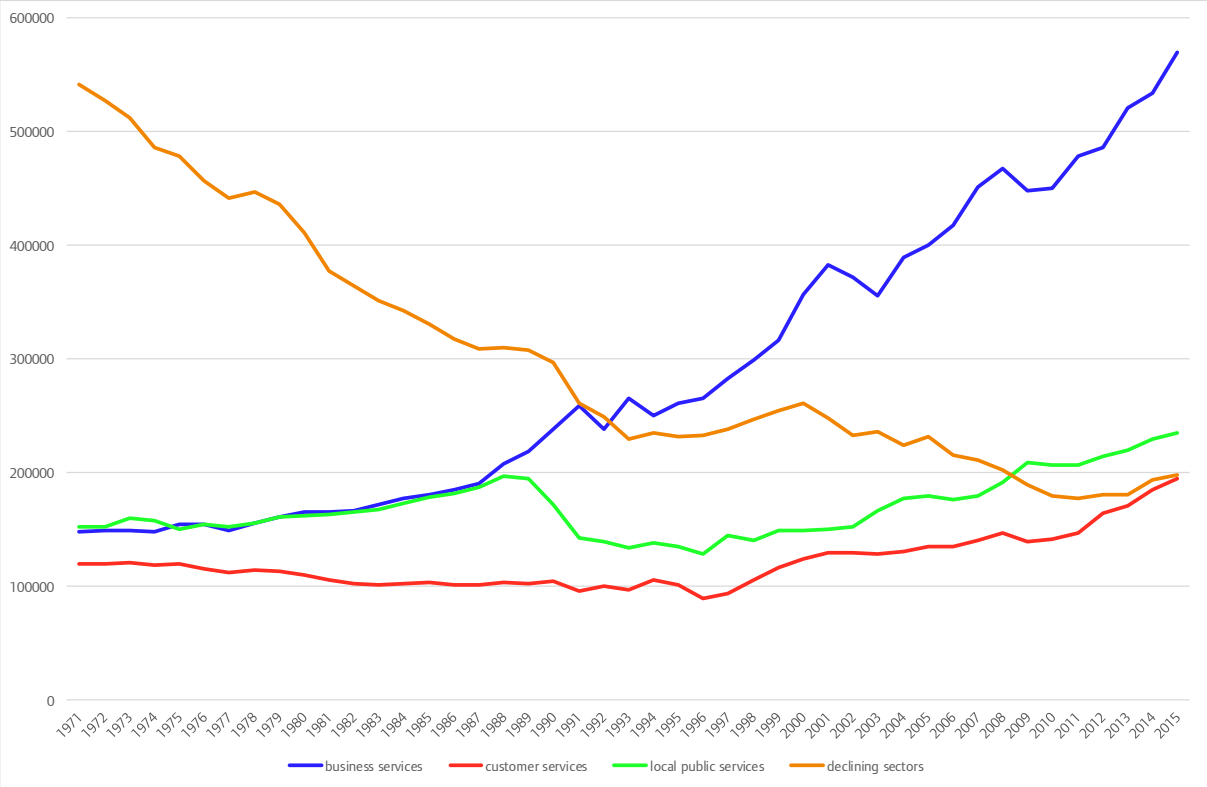
Figure 9: Employee jobs trends for Inner London – west by sector grouping 1971-2015



Source: GLA Economics calculations

For Inner London – east in 1971 there were 560,000 jobs in the declining sectors, and the other sector groupings had around 100-150,000 jobs. There are clear parallels with Inner London - west. The declining sectors have seen a similar fall in jobs in absolute terms, and business services have seen a similar growth in jobs in absolute terms over the years to 2015. The business services sector has nearly quadrupled in size. It is noticeable that growth in the Financial services sector has been in Tower Hamlets (see Figures C.17 and C.18 in Appendix C). This sub-region has also seen the strongest growth in customer services. Newham and Tower Hamlets have seen strong growth in Retail services both in absolute terms, and relative to other boroughs (see Figures C.9 and C.10 in Appendix C), and Tower Hamlets has also enjoyed growth by both measures in Accommodation and food services (Figures C.13 and C.14 in Appendix C). Figure 10 looks at the trends in Inner London – east in more detail.

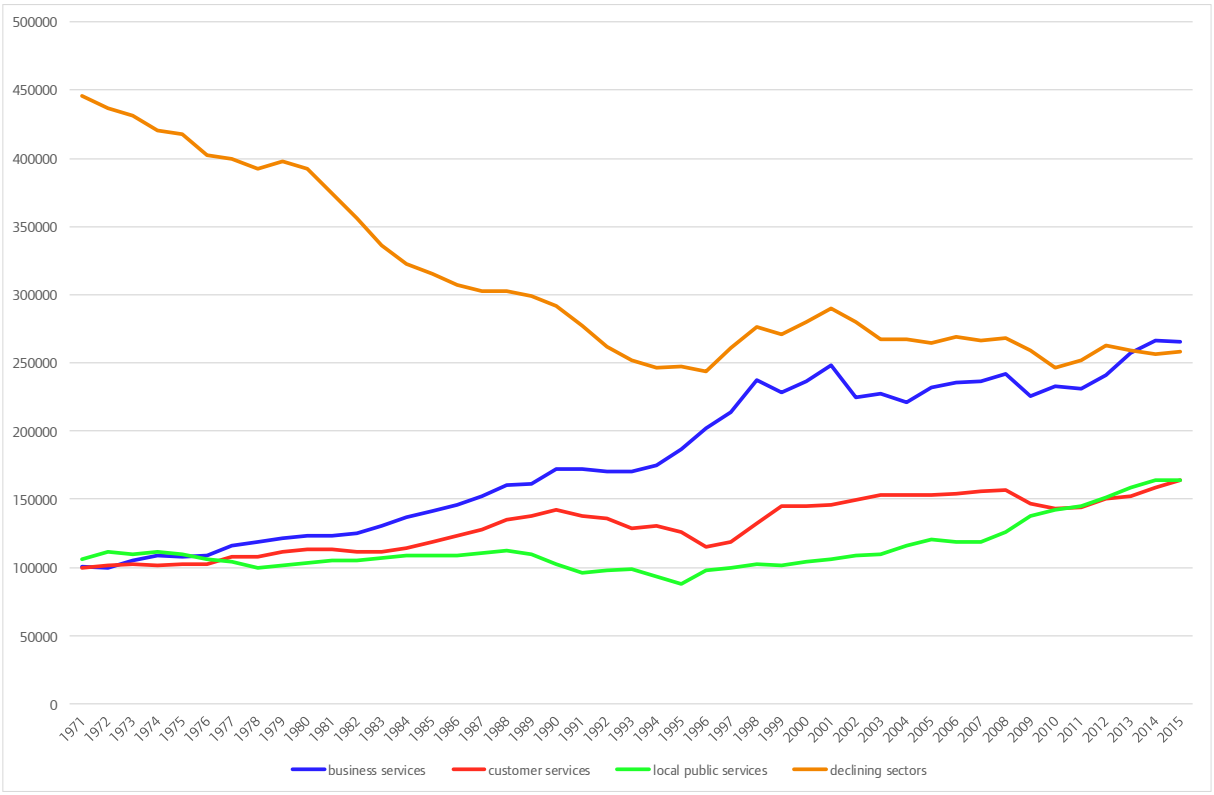
Figure 10: Employee jobs trends for Inner London – east by sector grouping 1971-2015



Source: GLA Economics calculations

As with the Inner London sub-regions there has been a fall in jobs of 200,000 in the declining sectors in Outer London – west and north west between 1971 and 2015, see Figure 11. As with Inner London there has been growth in jobs in the other sector groups, but in contrast it was only in 2014 that jobs in business services exceeded jobs in the declining sectors. Amongst the declining sectors Hillingdon and Hounslow have a longstanding strength in Transportation and storage through the location of Heathrow airport, and there has been both jobs growth, and a noticeable shift in the share of London jobs in this sector to these boroughs (Figures C.11 and C.12 in Appendix C). Information and communication technologies has also been a sector for jobs growth for this sub-region (Figures C.15 and C.16 in Appendix C). While there has been healthy jobs growth in this area of London it does not specialise in certain industry sectors in the same ways as Inner London.

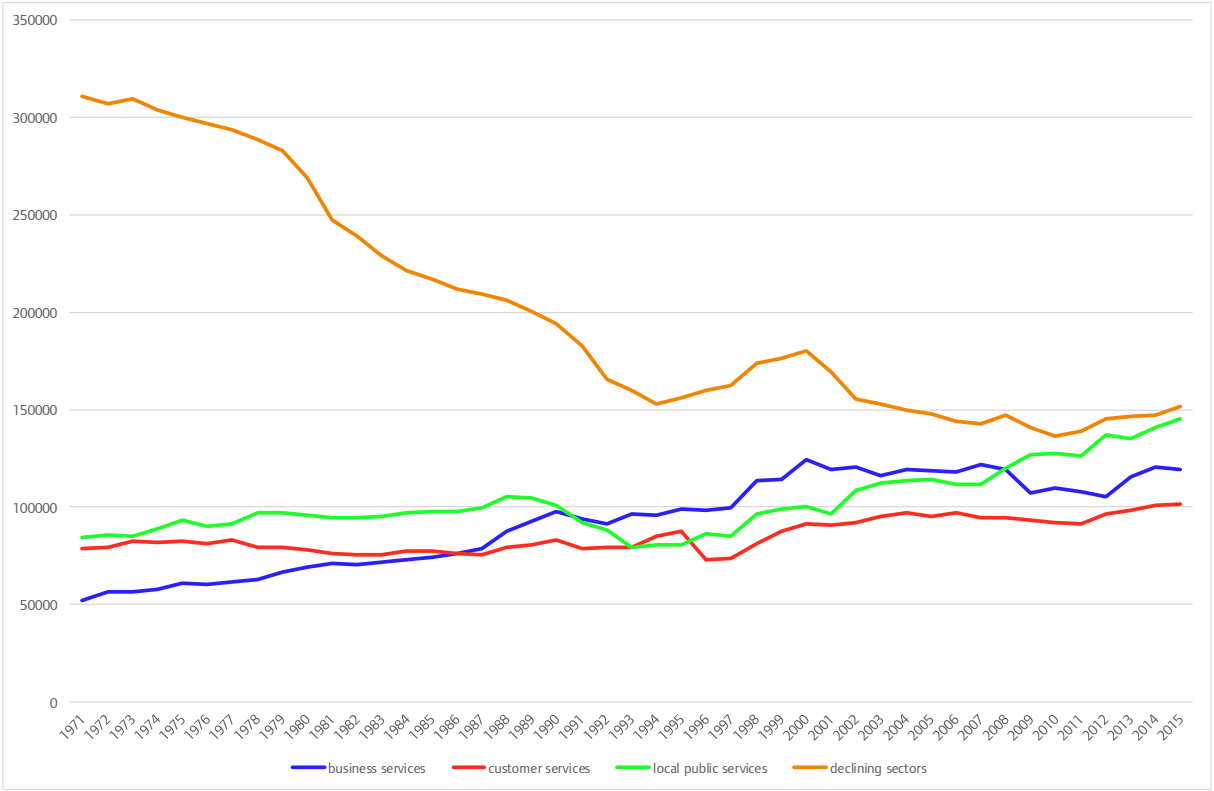
Figure 11: Employee jobs trends for Outer London – west and north west by sector grouping 1971-2015



Source: GLA Economics calculations

Outer London – east and north east has the distinguishing feature that in 2015 jobs in the declining sectors are still greater than those in other sector groupings, see Figure 12. Jobs in this sector grouping have more than halved since 1971 to around 150,000 in 2015. Also like other sub-regions there has been jobs growth in the other sector groupings but this has not been sufficient for overall job numbers in 2015 to be higher than in 1971.

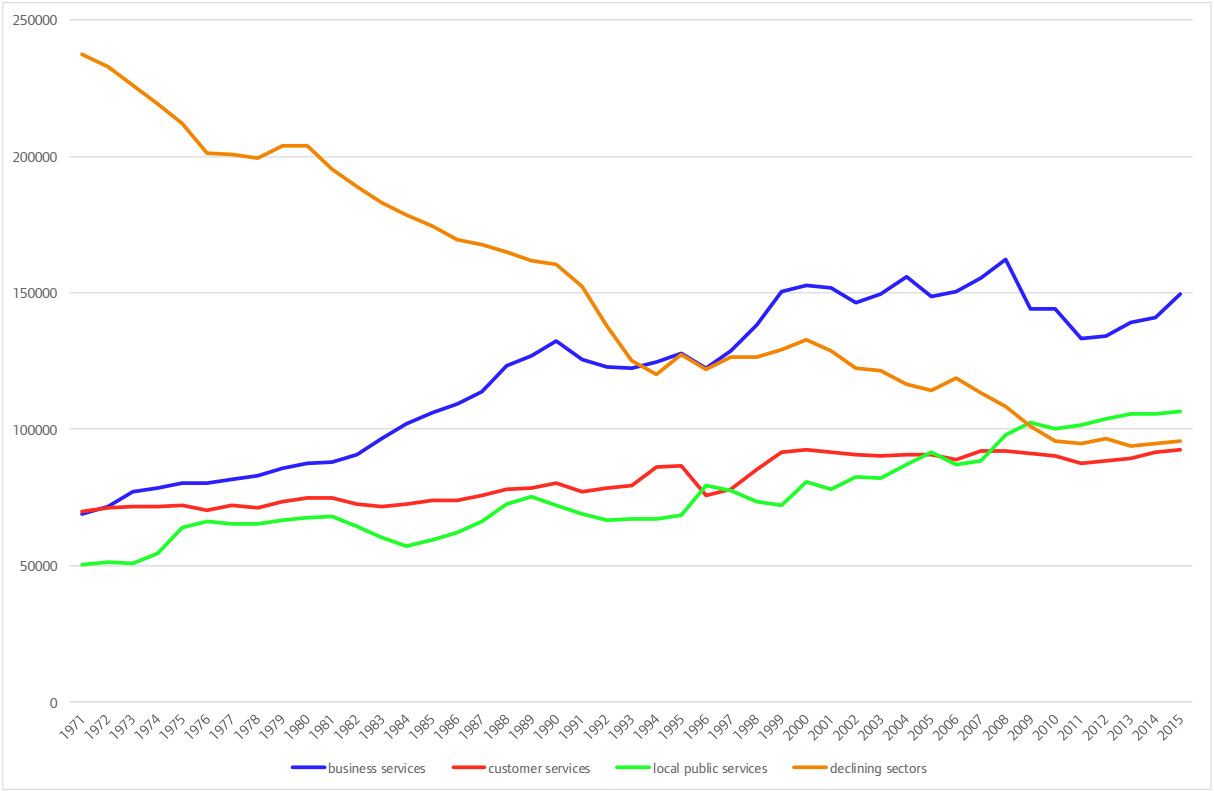
Figure 12: Employee jobs trends for Outer London – east and north east by sector grouping 1971-2015



Source: GLA Economics calculations

Jobs in Outer London – south tell a similar story to most of the rest of London in that there are fewer jobs in the declining sectors, and more jobs in the other sector groupings. This jobs growth has been sufficient to ensure that the total number of jobs was higher in 2015 than 1971.

Figure 13: Employee jobs trends for Outer London – south by sector grouping 1971-2015



Source: GLA Economics calculations

In summary, each of the five statistical sub-regions of the London economy has a similar jobs story of falling job numbers in declining sectors, and rising numbers in business services, customer services, and local public services. The inner London and west London jobs markets have been stronger than other areas over the entire period of study from 1971-2015. Inner London has benefited from specialising in business services and the clustering of sector jobs. While there has been growth in business service jobs elsewhere there is less of a clear pattern of specialisation, and it is in administration and support services that it is most visible that there is relative strength in outer boroughs (Figures C.21 and C.22 in Appendix C). What characterises the west London jobs market is the presence of Heathrow airport, and the jobs market is more diverse with jobs in the declining sectors and professional services broadly equal in numbers. Weak jobs growth in east London reflects low growth in jobs in business services.

Appendix A. Data sources, properties, and definitions

A.1. Introduction

This appendix sets out the properties of sources of borough by sector data that might be used as input for the development of a borough by sector series aligned with the London Jobs series. There are four parts:

- An overview of the approach to the construction of the London Jobs series (section A.2)
    - Defining employee jobs (section A.2.1)
    - Construction of the sector employee London Jobs series (section A.2.2)
    - Construction of the borough employee London Jobs series (section A.2.3)
    - Conclusion on construction of the employee London Jobs series (section A.2.4)
- Descriptions of the available borough by sector data sources (section A.3)
- Changes in data practices over time (section A.4)
    - Changes in the Standard Industrial Classification over time (section A.4.1)
    - Data collection methodology changes over time (section A.4.2)
    - Changes in the definition of an employee, and survey coverage of businesses over time (section A.4.3)
- Summary of business survey data which closes this section (section A.5)

Where possible each element of the third part provides an indication of the magnitude of the changes.

This explains:

- the differences between the London Jobs series, and borough by sector data sources
- why differences in estimates of borough by sector shares over time and across sources might be methodological in nature, rather than changing business circumstances
- and how discontinuities in a borough by sector time series might arise from underlying source data

Finally, it should be noted that part of Appendix B is to consider the choice of source data for borough by sector shares which is consistent with the London Jobs series. The analysis in this appendix is thus part of the input into those decisions.

A.2. Construction of the London employee jobs series 1971-2016

A.2.1. Defining employee jobs

The definition of an employee job for the GLA London Jobs series follows that used in the ONS Workforce Jobs series.

Workforce jobs in this analysis relate to the number of jobs in London, whether or not they are taken by London residents. In essence, the figures discussed here refer to jobs located in London not employees living in London, as some jobs will be held by people who live outside London. Jobs is also not the same as people, as some people may have more than one job[33].

[33] Jobs are recorded for the registered address of the business. This may not be the place of work for field staff.

Workforce Jobs in ONS publications are defined as follows:

Workforce jobs = employee jobs + self-employed jobs + HM Forces + Government supported trainees

In London, employee and self-employed jobs account for over 99% of the total Workforce Jobs. Given this, GLA Economics have excluded HM Forces and Government supported trainees from their analysis and for consistency these components are not included in the London Jobs series. Additionally, this analysis does not include self-employed jobs as there is no survey data source to produce robust results of borough by sector self-employed jobs[34].

The Workforce Jobs series is a composite series, and does not come from a single survey. The business survey employee data described in the next section is one source for the employee series, and the Annual Population Survey (APS) is the principal source for the self-employed jobs series[35].

A complete regional Workforce Jobs series consisting of both employee and self-employed jobs was introduced in July 2010, with the earliest data point for London available for 1996. The employee job series extends back to 1981. The WFJ data presented in this paper cover 1981 to 2015 and are based on the 4-quarter annual (calendar year) average in each of the industry sectors.

A.2.2. Construction of the sector employee London Jobs Series

A.2.2.1. GLA London Jobs series 1971-2016

The London Jobs series is the same as the Workforce Jobs series for London and sector employee jobs for the years 1981-2016[36]. GLA Economics backcast this series to 1971 for employment by splicing with the London Workforce Employment Series[37]. Subsequently, there was a slight refinement to the methodology to produce separate employee and self-employment jobs series[38].

The Workforce Jobs series, and within it employee jobs, are available by sector. Both GLA sector and ONS section definitions follow the SIC2007 classification. GLA sectors are a slight re-organisation of ONS sections.

The GLA sector primary and utilities combines four ONS sections:

- A: Agriculture, forestry and fishing
- B: Mining and quarrying
- D: Electricity, gas, steam, and air conditioning supply
- E: Water supply: sewerage, waste management and remediation activities

[34] The Labour Force Survey is ONS's preferred survey for self-employed jobs. Sample sizes are sufficient to produce robust estimates for London by sector or borough, but not borough by sector.
[35] See Revisions to workforce jobs: Dec 2016 - Office for National Statistics for an indication of the range of data used in the WFJ series, and how it it is used
[36] Data for wholesale and retail as separate sectors is only available back to 1996. Appendix F of London Labour Market Projections 2017 explains how this is backcast to 1971 for employee jobs.
[37] See London labour market projections 2016 | London City Hall, specifically Appendix 7
[38] See London labour market projections 2017 | London City Hall, specifically Appendix F

The GLA sector professional, scientific and technical activities and real estate combines two ONS sections:

- L: Real estate activities
- M: Professional, scientific and technical activities

The GLA also has separate Wholesale (including motor trades, and repair of motor vehicles) and Retail sectors which splits ONS section G (consisting of Wholesale and Retail Trade, repair of motor vehicles). The ONS provides Workforce Jobs data to support this apportionment for employee and self-employed jobs[39].

The published borough by sector series combines together the sectors of primary and utilities, and manufacturing. This is because results for some boroughs of employee jobs in the primary and utilities sector are potentially disclosive. That is employee numbers in certain businesses might be identifiable, and it would be contrary to assurances provided as part of the data collection process to publish this information. A later section discusses the reasons for this choice.

A.2.3. Construction of the borough employee London Jobs Series[40]

ONS does not publish a local authority level Workforce Jobs series. For a consistent jobs series at the borough level the ONS recommends the Jobs Density total jobs measure. This data is available for the years from 2000[41]. The Jobs Density measure is an indicator of local labour demand and is defined as the number of filled jobs in an area divided by the number of working age people resident there. The jobs measure used in the calculation of jobs density is all Workforce Jobs, and so includes self-employed jobs as well as employee jobs.

GLA Economics reviewed the use of Jobs Density data in 2011[42], and concluded that due to its relatively short run the series should not be used explicitly for a borough jobs series, but it would act as a sense-check. Job Density data has not been put to additional use to derive a borough by sector series as jobs data is not available for employees only, nor by sector.

Instead in 2011 GLA Economics developed a borough employee job series back to 1981[43] which made a series of adjustments to available preferred ONS business survey data sources, and constrained the London jobs total to the Workforce Jobs employee jobs total for each year. GLA Economics backcast this series to 1971 for employees by splicing it with the London Workforce Employment Series[44].

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[39] The most recent data is at Employee and self-employed jobs in divisions of industry section G in the Greater South East, 1996 to 2016 - Office for National Statistics

[40] The historic data series used in this paper is up to 2015. Since the completion of the analysis for this working paper ONS has published BRES data for 2016, see UK business register and employment survey (BRES) - Office for National Statistics. This used a broader sampling frame of the business survey population than previous surveys, and included for the first time PAYE non-VAT businesses. It also provided results with this sampling frame for 2015 – for more information see later in this section. The latest published London Jobs series does not include this data in estimating borough splits for 2015 and 2016, and so for consistency this data not been included in this analysis.

[41] The data is available on NOMIS, www.nomisweb.co.uk, and ONS published a methodology note in the August 2003 Labour Market Trends, Labour Market Trends (discontinued)- August 2003, Volume 111, No. 8 - ONS

[42] See Working Paper 52: London's jobs history - a technical paper | London City Hall for a discussion

[43] See Working Paper 52: London's jobs history - a technical paper | London City Hall for an explanation of the methodology

[44] See London labour market projections 2016 | London City Hall (2016, specifically Appendix 7)

A.2.4. Conclusion on construction of the employee London Jobs Series

In conclusion, the GLA London sector employee jobs series, and GLA London borough employee jobs series have been developed from the same business survey data, but different processes have been followed to produce numbers consistent with the ONS Workforce Jobs series for London employee jobs. So, a borough by sector series cannot be produced by applying a single calibration factor to the underlying business survey data. Appendix B.2 discusses possible alternatives.

A.3. Business borough by sector source data

This section sets out available borough by sector data. These sources have been used in the analysis of the next section to support the selection of the input borough by sector data. It is from the selected data that borough by sector shares are derived consistent when aggregated with the London Jobs series for sectors and boroughs. ONS has been running business surveys since 1971. Borough by sector data is available from 1984. These are the ONS preferred data sources for industry level data at local geographies:

A.3.1. Business Register and Employment Survey (BRES) 2009 onwards

BRES is the current ONS business survey of employee jobs and replaced the Business Register Survey and the Annual Business Inquiry – part 1[45]. It has the two purposes of collecting data to update local unit information and business structures on the Inter-Departmental Business Register (IDBR) and to produce annual employment statistics. An important difference with the Annual Business Inquiry is that surveyed businesses (enterprises) are requested to report jobs for each workplace (local unit)[46].

A.3.2. Annual Business Inquiry/1 (ABI/1) 1998 – 2008

The Annual Business Inquiry (ABI) replaced the Annual Employment Survey (AES). It integrated a number of business surveys which enabled the derivation of meaningful productivity estimates as business (enterprise) output and employee estimates were derived from a single source[47]. The development of the ABI relied on the implementation of the Inter-Departmental Business Register (IDBR) during 1994 and 1995, for a survey sampling frame. The IDBR had not been available for earlier business surveys. This improved the data collection methodology, and process to aggregate survey results to employee estimates[48] - the sub-section on data collection methodology changes over time draws out the implications for this work. The AES had collected data at the level of local units (workplaces), and this data collection method did not continue in the ABI. Instead, the ABI collected data from reporting units (which might be the entire business (enterprise)), and apportioned employee job estimates to local units (workplaces).

[45] For more information see Business Register and Employment Survey - Office for National Statistics
[46] This approach has the strength that enterprises should report jobs where they are located. While field staff may have a base at a certain local unit the place of work may change for administrative reasons rather than changes in a job. Also individuals working in small offices may still be attributed to headquarters. See, London labour market projections 2017 | London City Hall (specifically Appendix F), for discussion of practical implications.
[47] For more information on the development of the Annual Business Inquiry see [ARCHIVED CONTENT] Economic Trends (discontinued) , No. 564, November 2000 - ONS
[48] For an explanation of the changes see https://www.nomisweb.co.uk/articles/ref/ABI_lmt_may2000.pdf

A.3.3. Annual Employment Survey (AES) 1991, 1993, 1995-98

A.3.4. Census of Employment (CofE) 1984, 1987, 1989, 1991

The data for these surveys is available on NOMIS. Associated publications would have been paper-based, and GLA Economics has not been able to find any online documentation.
The ONS also makes borough by sector data available from another source:

A.3.5. Inter-Departmental Business Register[49] (IDBR) data from 2001 onwards, latest data 2015

This is a comprehensive list of UK businesses used by the government for statistical purposes. It covers 2.6 million businesses (enterprises) in all sectors of the UK economy, other than very small businesses (those without employees and with turnover below the tax threshold). It provides the sampling frame for BRES. Employee data is updated on the IDBR from various sources including BRES. The source data for this analysis is from ONS issues of user requested data[50].

GLA Economics also has available the:

A.3.6. London Workplace Employment Series (LWES)[51] 1971-2005

This was the GLA's own set of data for measuring the number of jobs in London. It has been superceded by the GLA London Jobs series.

All sources used in this working paper report for current borough boundaries, except for LWES. This does not take account of the transfer of Heathrow airport from Hounslow to Hillingdon in 1994[52].

A.4. Changes in data practices over time

The London Jobs series provides an estimate of jobs for each industry sector, borough, and year based on current definitions of a job and industry. Underlying data sources record jobs according to the definitions in place at the time of data collection. That is, there are discontinuities over time in job estimates from different sources, and changes over time might be because of methodological changes rather than changing business circumstances.

Further, over time the data has been collected from a number of surveys, and each has its own methodology. While data collection processes at any one time may reflect best practice the availability of new technology, notably IT, has meant they have improved. In parallel the structure of the economy has changed, and the standards adopted to classify it have evolved.

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[49] Inter-Departmental Business Register (IDBR) - Office for National Statistics

[50] The main source data is Workplaces and Employees in London Local Authorities by industry and size, 2001 to 2015 - Office for National Statistics. This does not provide estimates for Primary and Utilities which might have been disclosive. These have been imputed using borough employee estimates from [ARCHIVED CONTENT] Release Edition Reference Tables - ONS for 2001-8, Workplaces and employees in London's Creative Industries 2009 to 2014 by small area breakdown and 2014 by size of enterprise - Office for National Statistics for 2009-14, and Breakdowns of business activity in the Greater South East: 2015 - Office for National Statistics for 2015, and making a small adjustment for activities of households as employers, and activities of extra-terristorial organisations. – these are the other activities for which there is not a sector breakdown

[51] The GLA's London Workforce Employment Series | London City Hall (2003)

[52] Full details of all London borough and Greater London boundary changes can be found here: http://www.lgbce.org.uk/__data/assets/pdf_file/0016/11419/627-the-boundaries-of-greater-london-and-the-london-boroughs.pdf

Consequently, there are some important differences from data recording practices to note between business surveys, and within the years that a particular survey was in place. This may mean that year-on-year changes in data items may reflect in part changes in data recording, and not just changes in the functioning of the labour market. These changes can be classified as:

- Standard Industrial Classification (SIC) changes over time, used to record the industry sector of jobs
- Data collection methodology changes over time
- Changes in the definition of an employee, and survey coverage of businesses over time

The GLA London Jobs series for sector employee jobs and borough employee jobs has been developed in a way which seeks to smooth over discontinuities which might have been caused by these changes, and produce consistent series over time. This section summarises the major changes over the period 1971-2015.

A.4.1. Standard Industrial Classification (SIC) changes over time

A Standard Industrial Classification was first introduced in the UK in 1948 for use in classifying business establishments and other statistical units by the type of economic activity in which they are engaged. The classification provides a framework for the collection, tabulation, presentation and analysis of data, and its use promotes uniformity. Over time new products, processes and industries emerge and for that reason the SIC system needs to be updated periodically. Modelling work covered by this paper is affected by several changes in SIC; there were updates to the standard in 1980, 1992, 2003 and 2007[53].

A.4.1.1. Change from SIC 1980 to SIC 1992

Changes to NACE[54], the European Union's classification system for economic activities, were published in February 1989 that required the UK to introduce an update to the Standard Industrial Classification (SIC). As a part of the introduction of the SIC 1992 framework, the national divisions (sections, or sectors, in current terminology), groups, classes, and sub-classes were revised.

A.4.1.2. Change from SIC1992 to SIC2003

Further changes to NACE were published in January 2003 that required the UK to introduce an update to the SIC to maintain consistency. As a part of the introduction of the SIC 2003 framework, the national sub-classes and classes were revised.

As a result of the change from SIC 1992 to SIC 2003, business survey data for some industry sectors at the sub-class level (5-digit SIC level) were missing data between 1998 and 2002. This discontinuity[55] in these industry codes arose mainly from codes being split into several SIC 2003 codes. Change in the economic or industry structure was the key driver of disconnect between

[53] See [ARCHIVED CONTENT] UK Standard Industrial Classification of Economic Activities (UK SIC): Archive - ONS for more background. A classification takes time to implement. While, for example, SIC2007 was published in 2007, it was taken onto the IDBR and refined during 2008, implemented in surveys in 2009-10, and finally implemented fully in National Accounts in September 2011.

[54] NACE is Nomenclature statistique des Activités economiques dans la Communauté Européene, see Glossary:Statistical classification of economic activities in the European Community (NACE) - Statistics Explained

[55] Discontinuity in this case refers to a change in the way industry level information is classified, which in turn implies that the change in definitions between the two SIC frameworks results in missing information in some industry sub-classes.

the methodologies or SIC frameworks in some cases. However, this should not be a significant issue for this analysis, which has not used data below the 2-digit SIC level.

One of the more significant changes from SIC 1992 to SIC 2003 was in the treatment of head offices. Under the SIC 1992 framework, head offices were classified to the principal activity of the enterprise to which they belonged e.g. employment in the head office of a manufacturing company would be classified as employment within manufacturing, even though they did not engage in any manufacturing activities[56]. Under the SIC 2003 system these employees would be classified separately into a new single code "7415: Management activities of holding companies". This would re-classify these activities to the Professional services section. Statistics derived from enterprise-level data for jobs are not significantly affected by this change but data based on local units (i.e. individual sites of enterprises), such as regional data, can be more affected by this reclassification[57] - this might affect borough trends, for example. BRES is the first business survey which collects data at a local unit level, and this provides the basis for all other estimates – the later section on data collection methodologies provides more background.

A.4.1.3. Change from SIC 2003 to SIC 2007

The publication of SIC 2007 marked a significant change in the SIC and this change was particularly relevant for London as it resulted in a greater breakdown of Business services data, an important sector for London's economy. Not only is the service sector better captured by SIC 2007, a number of new sections were included into the new structure[58].

Working Paper 52 by GLA Economics published in 2011[59] outlined how these changes in SIC affected the total employee estimates at a section level between the two surveys, and for convenience, Table A.1 summarises these differences.

[56] Economic Statistics and the Standard Industrial Classification (SIC) 2003.
[57] The scale of this change following the reclassifications of head offices and its impact on local units and employment is further outlined as a part of the ONS analysis included in 'Economic Statistics and the Standard Industrial Classification (SIC) 2003'
[58] UK Standard Industrial Classification of Economic Activities 2007 (SIC 2007), Structure and explanatory notes, ONS.
[59] See Working Paper 52: London's jobs history - a technical paper | London City Hall

Table A.1: Differences in London employee estimates by section between SIC 2003 and SIC 2007

ABI SIC 2003 in 2008			ABI SIC 2007 in 2008		
	Sections	**Employees**		**Sections**	**Employees**
A	Agriculture, hunting and forestry	4,500	**A**	Agriculture, forestry and fishing	1,500
B	Fishing	0			
C	Mining and quarrying	3,300	**B**	Mining and quarrying	3,300
D	Manufacturing	178,200	**C**	Manufacturing	122,400
E	Electricity, gas and water supply	6,900	**D**	Electricity, gas, steam and air conditioning supply	6,600
			E	Water supply; sewerage, waste management and remediation activities	16,300
F	Construction	122,500	**F**	Construction	140,500
G	Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods	570,900	**G**	Wholesale and retail trade; repair of motor vehicles and motor cycles	565,500
H	Hotels and restaurants	303,000	**I**	Accommodation and food service activities	302,900
I	Transport, storage and communications	307,400	**H**	Transportation and storage	236,900
			J	Information and communication	295,100
J	Financial Intermediation	331,900	**K**	Financial and insurance activities	333,200
K	Real estate, renting and business activities	1,116,200	**L**	Real estate activities	79,200
			M	Professional, scientific and technical activities	473,000
			N	Administrative and support service activities	451,400
L	Public administration and defence; compulsory social security	223,500	**O**	Public administration and defence; compulsory social security	223,500
M	Education	309,600	**P**	Education	313,200
N	Health and social work	390,400	**Q**	Human health and social work activities	387,700
O	Other community, social and personal services activities	300,300	**R**	Arts, entertainment and recreation	114,300
			S	Other service activities	102,100
P	Activities of private households as employers and undifferentiated production activities of private households	0	**T**	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	0
Q	Extraterritorial organisations and bodies	0	**U**	Activities of extraterritorial organisations and bodies	0
	Total	4,168,600		**Total**	4,168,600

Source: ABI SIC 2003 and ABI SIC 2007

A.4.2. Data collection methodology changes over time

Over the period of time covered by the London Jobs series 1971-2016 the underlying data has come from a number of surveys, and each has its own methodology. While data collection processes at any one time may reflect best practice the availability of new technology, notably IT, has meant they have improved. This has brought about discontinuities in job estimates from different sources, or even over the lifetime of a single survey. This sub-section provides an indication of the nature of some of these discontinuities. The consequence is that when this source data is used to derive a borough by sector series differences over time might be because of methodological changes rather than changing business circumstances.

Working Paper 66[60] estimated the size of the discontinuity in the transition from ABI to BRES, and also when there was a change in methodology in the ABI.

In 2008 to 2009, the transition to BRES[61] resulted in improved employee jobs estimates. The previous business survey ABI/1 collected employee information at the reporting unit level (i.e. in most cases this would mean at the head office level) that was aggregated to produce national estimates. Regional estimates were obtained by apportioning these national estimates on to regions. In contrast, BRES collects data at the local unit/workplace level and calculates national and regional estimates by aggregating these local unit data on to regional and national level removing the potential inaccuracies arising from the apportioning method.

The move from ABI/1 to BRES resulted in several improvements in the business survey data but resulted in a discontinuity in the time series[62]. According to the ONS analysis, in 2008 the London employee estimate based on BRES data is approximately 84,000 or around 2 per cent higher than the estimate based in ABI/1. This is the largest discrepancy in employee job estimates in absolute terms across all Government Office Regions[63]. Working Paper 66 by GLA Economics[64] published in 2015 outlined how these changes in SIC affected the total employee estimates at a section level between the two surveys, and for convenience, Table A.2 summarises these differences.

[60] See Working Papers 65, 66: London's sectors: detailed jobs data & method | London City Hall
[61] The first phase of improvements associated with the introduction of BRES was implemented in 2006 when changes to ABI/1 were introduced.
[62] The key changes affecting the survey were: Questionnaire design in the main affecting the data accuracy of smaller businesses; sample design with stratification by SIC division and by employment size bands; changes to how validation and quality assurance takes place; change in the way employment information was collected resulting in improved regional and industrial breakdowns. For further information, see The Office for National Statistics, Discontinuity analysis of the move from the Annual Business Inquiry to the Business Register Employment Survey, December 2010.
[63] In percentage terms, the discrepancy between the two survey methodologies is the largest in the North East.
[64] See Working Papers 65, 66: London's sectors: detailed jobs data & method | London City Hall

Table A.2: Difference in employee estimates between ABI/1 and BRES in London by industry, 2008[65]

SECTION LEVEL (1-DIGIT)	Published	Published	Value	%
Industry	ABI SIC 2007	BRES SIC 2007	Difference	Difference
Section level	2008	2008	2008	2008
A : Agriculture, forestry and fishing	1,500	1,400	-100	-6.7%
B : Mining and quarrying	3,300	3,300	0	0.0%
C : Manufacturing	122,400	131,100	8,700	7.1%
D : Electricity, gas, steam and air conditioning supply	6,600	6,800	200	3.0%
E : Water supply; sewerage, waste management and remediation activities	16,300	15,400	-900	-5.5%
F : Construction	140,500	149,400	8,900	6.3%
G : Wholesale and retail trade; repair of motor vehicles and motorcycles	565,500	566,000	500	0.1%
H : Transportation and storage	236,900	236,900	0	0.0%
I : Accommodation and food service activities	302,900	311,900	9,000	3.0%
J : Information and communication	295,100	308,400	13,300	4.5%
K : Financial and insurance activities	333,200	349,200	16,000	4.8%
L : Real estate activities	79,200	75,600	-3,600	-4.5%
M : Professional, scientific and technical activities	473,000	495,700	22,700	4.8%
N : Administrative and support service activities	451,400	451,700	300	0.1%
O : Public administration and defence; compulsory social security	223,500	222,900	-600	-0.3%
P : Education	313,200	313,700	500	0.2%
Q : Human health and social work activities	387,700	387,700	0	0.0%
R : Arts, entertainment and recreation	114,300	117,500	3,200	2.8%
S : Other service activities	102,100	107,800	5,700	5.6%
Total	4,168,600	4,252,400	83,800	2.0%

Source: ABI/1 and BRES, ONS.

Looking at the difference in the employee estimates by industry in London (Table 2), the greatest discrepancy is in the Professional, scientific and technical activities sector (driven by changes to division 70: Head offices and management consultancy activities), with BRES estimates around 22,700 higher (or 4.8 per cent) than ABI/1 employee estimates. The second most significant discrepancy is in Financial and insurance activities (driven by division 66: Activities auxiliary to financial services and insurance activities) with the BRES estimate around 16,000 higher than ABI/1 estimates for employee jobs (equivalent to around a 4.8 per cent difference).

These industry differences for London are broadly in line with the national estimates[66]; a more detailed discussion of the impact of the survey change from ABI/1 to BRES in London is included in the analysis by GLA Economics outlined in Current Issues Note 30[67].

Table A.3 provides the analysis of Table A.2 broken down by borough. As can be seen this change in data collection methodology has also had proportionately different impacts across boroughs. It is mainly central boroughs which have had a proportionately larger uplift in jobs: City of London is 5.2% higher (16,300 jobs), Westminster 3.6% higher (21,500 jobs), Southwark 3.2% higher (5,400 jobs), Kensington and Chelsea 3.1% higher (3,400 jobs), Camden 2.7% higher (7,400 jobs), Hammersmith and Fulham 2.6% higher (3,100 jobs), Newham 2.5% higher (1,700 jobs), and Islington 2.2% higher (4,100 jobs). In contrast, jobs estimates declined for Bromley and Redbridge, by 1.4% and 4.3% respectively.

[65] BRES in 2008 only included a sub-sample of businesses also sampled for ABI to trial the methodology and provide a comparison with ABI results.
[66] Discontinuity analysis of the move from the Annual Business Inquiry to the Business Register Employment Survey, ONS.
[67] GLA Economics, Current Issues Note 30: The new Business Register Employment Survey: Changes in London's jobs, 2008 and 2009 compared.

Table A.3: Difference in employee estimates between ABI/1 and BRES in London by borough, 2008

Borough	ABI	BRES	value difference	% difference
Barking and Dagenham	45,500	45,800	300	0.7%
Barnet	110,700	112,900	2100	1.9%
Bexley	65,100	65,200	100	0.2%
Brent	94,000	95,000	1000	1.0%
Bromley	107,500	106,000	-1500	-1.4%
Camden	275,800	283,200	7400	2.7%
City of London	311,800	328,100	16300	5.2%
Croydon	130,500	130,800	300	0.2%
Ealing	112,200	113,800	1500	1.4%
Enfield	92,500	93,700	1200	1.3%
Greenwich	67,800	68,600	700	1.0%
Hackney	81,900	83,200	1300	1.5%
Hammersmith and Fulham	117,800	120,900	3100	2.6%
Haringey	61,700	62,200	500	0.8%
Harrow	66,800	67,900	1100	1.6%
Havering	71,300	72,600	1400	1.9%
Hillingdon	188,600	189,900	1300	0.7%
Hounslow	121,600	123,400	1800	1.5%
Islington	187,700	191,800	4100	2.2%
Kensington and Chelsea	110,400	113,800	3400	3.1%
Kingston upon Thames	76,000	76,700	700	1.0%
Lambeth	126,900	128,300	1500	1.1%
Lewisham	61,100	61,800	700	1.2%
Merton	65,900	66,900	1000	1.6%
Newham	69,900	71,600	1700	2.5%
Redbridge	69,100	66,100	-3000	-4.3%
Richmond upon Thames	72,700	73,400	700	0.9%
Southwark	172,200	177,700	5400	3.2%
Sutton	68,900	69,100	200	0.3%
Tower Hamlets	204,000	207,600	3700	1.8%
Waltham Forest	56,300	57,300	1000	1.7%
Wandsworth	107,900	109,100	1200	1.1%
Westminster	596,200	617,600	21500	3.6%
London	4,168,400	4,251,900	83600	2.0%

Source: ABI/1 and BRES, ONS

Working Paper 52[68] also examines these industry changes, and reports that weaknesses in the AES data collection methodology had led to under-reporting of 500,000 employee jobs nationally. Investigations indicated that contacts at reporting offices had been filling in pre-

[68] See Working Paper 52: London's jobs history - a technical paper | London City Hall

printed forms only and not additional blank forms for new sites or where the reporting unit had taken on greater responsibility[69].

There are some years when it is possible to compare estimates of London employee jobs from more than one data source, Table A.4. This reinforces the point that estimates of employee jobs numbers have increased with improvements in survey methodology introduced with successive surveys from CofE to AES to ABI to BRES. The LWES is broadly consistent with aggregate ABI numbers, and higher than CofE and AES which is consistent with the expectation that the back series would need to have been updated with the introduction of ABI (as LWES continued until 2005). IDBR is lower than other ONS sources available at the same time namely ABI and BRES which would be expected as data is only updated as it becomes available, and is not imputed.

[69] For more information see https://www.nomisweb.co.uk/articles/ref/ABI_lmt_may2000.pdf

Table A.4: Comparison of survey London employee job estimates, various years

	1984	1991	1998	2001	2008	2009	2015
LWES	3,731,000	3,517,000					
CofE	3,457,000	3,246,000					
difference	274,000	270,000					
% difference	7.9%	8.3%					
LWES		3,517,000	3,750,000				
AES		3,253,000	3,623,000				
difference		263,000	127,000				
% difference		8.1%	3.5%				
CofE		3,246,000					
AES		3,253,000					
difference		7,000					
% difference		0.2%					
ABI			3,764,000				
AES			3,623,000				
difference			141,000				
% difference			3.9%				
LWES			3,750,000	4,042,000			
ABI			3,764,000	4,016,000			
difference			14,000	26,000			
% difference			0.4%	0.6%			
LWES				4,042,000			
IDBR				3,626,000			
difference				416,000			
% difference				11.5%			
IDBR				3,626,000	3,978,000		
ABI				4,016,000	4,168,000		
difference				391,000	190,000		
% difference				10.8%	4.8%		
IDBR						4,101,000	4,744,000
BRES						4,143,000	4,889,000
difference						42,000	144,000
% difference						1.0%	3.0%

Source: GLA Economics calculations

It should be noted that there is no reason to believe that London level differences between surveys would be equal proportionately across sectors or boroughs, and this is considered in

Section 4. While the BRES data includes a broader definition of an employee than other sources (other than IDBR), and this is considered in the next section.

A.4.3. Changes in the definition of an employee, and survey coverage of businesses over time

Surveys will classify respondents as employees or self-employed according to the definitions in use at the time. Also, estimated employee populations ultimately depend on the sampling frame of businesses used for a survey. There have been changes in both domains which potentially impacts on the consistency of survey estimates over time.

A.4.3.1. Change in the treatment of working owners in BRES (2011)

After the introduction of BRES in 2008, the treatment of working owners in the main series changed in 2011 and as a result of this time series data before 2011 is based on a different methodology.

Before the change in methodology, directors of limited companies often classified themselves as working owners, which is not consistent with HM Revenue & Customs classification of these people as employees for tax purposes. In 2010, the ONS modified the BRES questionnaire to be consistent with the tax-related definition, which resulted in a disconnect in the data of around 100,000 employees in London in 2010 - equivalent to around a 2.6 per cent difference in employee jobs estimates between the old and new BRES methodology as demonstrated by the ONS analysis[70]. (Table A.5 is an extract from this ONS work, and has been taken from Working Paper 66[71], for convenience.) The difference in the number of employee jobs estimates between the two methodologies was the greatest in London by region in both absolute and proportional terms. Across London's industry sectors, the discontinuity resulting from the methodology change in 2010 was greatest in absolute terms in the Professional, scientific and technical activities sector, around 23,100 employee jobs, with the new BRES section level estimate approximately 4.7 per cent higher than estimates based on the old methodology. The difference in the Information and communication section was also considerable, equivalent to around 15,500 employees or 5.2 per cent.

[70] Office for National Statistics, Working owners discontinuity in the Business Register and Employment Survey (BRES), December 2012.
[71] See Working Papers 65, 66: London's sectors: detailed jobs data & method | London City Hall

Table A.5: Discontinuity in the BRES data by industry in London

SECTION LEVEL (1-DIGIT)	Old Method		New Method		Value		% difference	
Industry	BRES SIC 2007		BRES SIC 2007		Difference		Difference	
Section level	2009	2010	2009	2010	2009	2010	2009	2010
A : Agriculture, forestry and fishing	1,000	700	1,000	700	0	0	0.0%	0.0%
B : Mining and quarrying	2,200	1,900	2,200	2,000	0	100	0.0%	5.3%
C : Manufacturing	110,200	106,900	112,900	110,000	2,700	3,100	2.5%	2.9%
D : Electricity, gas, steam and air conditioning supply	5,500	5,700	5,500	5,700	0	0	0.0%	0.0%
E : Water supply; sewerage, waste management and remediation activities	14,400	17,500	14,400	18,300	0	800	0.0%	4.6%
F : Construction	126,800	126,800	135,500	139,100	8,700	12,300	6.9%	9.7%
G : Wholesale and retail trade; repair of motor vehicles and motorcycles	537,600	517,300	547,800	529,500	10,200	12,200	1.9%	2.4%
H : Transportation and storage	217,500	214,000	219,100	215,100	1,600	1,100	0.7%	0.5%
I : Accommodation and food service activities	292,200	295,000	295,900	298,200	3,700	3,200	1.3%	1.1%
J : Information and communication	277,800	295,900	292,100	311,400	14,300	15,500	5.1%	5.2%
K : Financial and insurance activities	315,400	324,700	319,400	327,600	4,000	2,900	1.3%	0.9%
L : Real estate activities	89,900	81,900	94,300	92,000	4,400	10,100	4.9%	12.3%
M : Professional, scientific and technical activities	491,600	491,200	509,000	514,300	17,400	23,100	3.5%	4.7%
N : Administrative and support service activities	402,600	433,800	407,200	445,200	4,600	11,400	1.1%	2.6%
O : Public administration and defence; compulsory social security	223,000	237,800	223,000	237,800	0	0	0.0%	0.0%
P : Education	335,500	336,000	336,300	338,000	800	2,000	0.2%	0.6%
Q : Human health and social work activities	416,600	397,900	418,000	399,500	1,400	1,600	0.3%	0.4%
R : Arts, entertainment and recreation	102,600	108,300	103,400	110,100	800	1,800	0.8%	1.7%
S : Other service activities	104,400	110,000	106,400	112,100	2,000	2,100	0.0%	0.0%
Total	4,066,800	4,103,300	4,143,400	4,206,600	76,600	103,300	1.9%	2.5%

Source: BRES

The impact of the revised treatment of working owners is less concentrated at a borough level (Table A.6). In proportionate terms 15 out of 33 boroughs had a larger increase than the London average in 2009, rising to 16 out of 33 boroughs in 2010. The nature of the change meant that all boroughs saw some increase in their estimate of borough employee jobs.

Table A.6: Discontinuity in the BRES data by borough in London

Borough	Old Method		New Method		Value Difference		Percentage Difference	
	2009	2010	2009	2010	2009	2010	2009	2010
Barking and Dagenham	42,600	46,600	43,200	47,500	600	900	1.3%	1.9%
Barnet	110,300	108,000	113,000	112,100	2,700	4,100	2.4%	3.6%
Bexley	62,700	63,300	63,700	64,700	1,000	1,400	1.6%	2.2%
Brent	90,800	94,000	92,700	96,800	1,900	2,700	2.1%	2.8%
Bromley	101,400	97,800	103,300	100,400	1,900	2,600	1.8%	2.5%
Camden	274,700	272,600	280,300	280,000	5,600	7,400	2.0%	2.6%
City of London	316,700	339,300	321,200	345,100	4,500	5,800	1.4%	1.7%
Croydon	119,000	116,800	120,800	119,200	1,900	2,400	1.5%	2.0%
Ealing	104,100	106,300	106,300	109,400	2,200	3,100	2.1%	2.8%
Enfield	91,000	91,500	92,500	93,600	1,500	2,100	1.6%	2.3%
Greenwich	66,500	66,700	67,300	67,900	800	1,200	1.2%	1.8%
Hackney	83,500	82,600	85,700	85,500	2,100	2,900	2.5%	3.4%
Hammersmith and Fulham	115,400	122,300	118,100	125,500	2,700	3,200	2.3%	2.6%
Haringey	58,400	58,200	59,700	59,900	1,300	1,700	2.2%	2.8%
Harrow	63,200	63,500	64,600	65,600	1,400	2,100	2.2%	3.3%
Havering	70,300	69,700	71,600	71,200	1,300	1,500	1.8%	2.1%
Hillingdon	181,900	179,900	183,700	182,400	1,800	2,500	1.0%	1.4%
Hounslow	120,000	122,700	122,300	125,400	2,200	2,700	1.8%	2.2%
Islington	179,000	179,500	182,500	183,900	3,500	4,300	1.9%	2.4%
Kensington and Chelsea	108,100	110,100	110,600	113,500	2,600	3,400	2.3%	3.0%
Kingston upon Thames	74,600	74,300	75,600	75,900	1,100	1,700	1.4%	2.2%
Lambeth	124,700	121,200	126,400	123,600	1,700	2,400	1.4%	1.9%
Lewisham	57,600	57,600	58,500	58,900	900	1,400	1.5%	2.3%
Merton	63,700	65,400	65,100	67,300	1,300	1,900	2.0%	2.8%
Newham	71,700	71,700	72,600	73,100	800	1,400	1.1%	1.9%
Redbridge	63,800	63,000	65,000	64,600	1,100	1,700	1.8%	2.6%
Richmond upon Thames	66,600	68,200	68,400	70,600	1,800	2,400	2.6%	3.4%
Southwark	170,200	176,200	172,900	180,400	2,700	4,200	1.6%	2.3%
Sutton	62,500	64,300	63,500	65,800	1,000	1,500	1.5%	2.3%
Tower Hamlets	200,700	204,900	204,400	208,500	3,600	3,500	1.8%	1.7%
Waltham Forest	53,000	53,800	53,900	55,000	900	1,300	1.7%	2.3%
Wandsworth	101,100	99,800	103,200	102,700	2,200	2,800	2.1%	2.8%
Westminster	596,600	591,400	610,600	610,100	14,000	18,700	2.3%	3.1%
London	4,066,400	4,103,000	4,143,000	4,206,000	76,600	103,000	1.8%	2.4%

Source: BRES

The BRES employee series used in this analysis includes working owners. It is not, though, consistent with the ABI data, or earlier data from other sources analysed in this working paper which will use the old method. IDBR is regularly updated, and holds the latest known data for a business, and so again may not be fully consistent as it depends on the latest data entry.

A.4.3.2. Addition of PAYE non-VAT businesses to the business survey population

The June 2016 Workforce Jobs data release included an uplift across all years of the ONS published back series[72]. This was because the ONS coverage of the Standard Business Survey Population was extended to include a population of solely Pay As You Earn (PAYE) based businesses, or more specifically PAYE based businesses which do not pay VAT. This improvement in coverage has been estimated to increase the UK business survey population by

[72] ONS explains this in its June 2016 revisions note Revisions to workforce jobs - Office for National Statistics

around 100,000, with a corresponding increase in employee jobs. This does not, however, affect self-employment estimates.

The December 2016 Workforce Jobs data release refined the methodology used to uplift the series, and reduced the size of the uplift[73]. Further, in February 2017 ONS published a series of regional uplift factors for detailed sector jobs[74]. Across the period 1981-2014 the uplift factor to employee jobs is less than half a per cent (0.47%). GLA Economics has updated the London Jobs series for sector employee jobs, and borough employee jobs back to 1971 to incorporate this change[75].

In October 2017 ONS published BRES 2016 estimates, and updated BRES 2015 estimates[76]. The figures for 2015 were with and without PAYE non-VAT paying businesses, and the figures for 2016 were on the new basis. At the time of writing there is no business survey data which takes accounts of the extension of the Standard Business Survey Population to include PAYE non-VAT paying businesses. The latest published London Jobs series does not include this data in estimating borough splits for 2015 and 2016, and so for consistency this data not been included in this analysis[77].

A.5. Summary on business survey data

There is borough by sector data from a number of sources from 1971 onwards. This is not consistent over time because of changes in the industrial classifications used, data collection methodology, definition of an employee, and coverage of the business population. This source data has been used by GLA Economics, though, to produce consistent series over time for London sector employee jobs, and London borough employee jobs. Because of these data changes, and as the London sector jobs series draws on other source data the available borough by sector data is not consistent with the London Jobs series.

[73] ONS explains this in its December 2016 revisions note Revisions to workforce jobs: Dec 2016 - Office for National Statistics
[74] Employee Jobs PAYE based uplift factors - March 2016 - Office for National Statistics
[75] Appendix F of the London Labour Market Projections 2017 provides an explanation of the process.
[76] See UK business register and employment survey (BRES) - Office for National Statistics
[77] See London labour market projections 2017 | London City Hall, and specifically Appendix F, for an explanation of how this issue has been modelled.

Appendix B. Development of a borough by sector series, and its validation

This Appendix explains the process adopted to create a borough by sector employee jobs series, and to validate its properties. There are two inputs:

- The borough by sector input data sources discussed in Appendix A
- A literature review to:
    - determine the appropriate methodology to create a borough by sector series which aligns with existing London Jobs series for sectors and boroughs
    - establish criteria to select input data sources where there is a choice in a particular year
    - identify potential problems with the preferred methodology, and to inform the process of validation of the results

There are four parts to this Appendix:

- Conversion of input data so that it is on all on a consistent SIC 2007 basis (section B.1)
- Assessment of possible methodologies to develop a borough by sector series (section B.2)
- Development and calculation of criteria to compare input data sources, and selection of input series (section B.3)
    - metrics for input data sources, and selection of preferred input data series (section B.3.1)
    - properties of preferred input data series (for comparison with results) (section B.3.2)
- Validation of borough by sector results using preferred input series through a series of approaches (section B.4):
    - comparison with changes to a range of input data sources, and between results from preferred data series and other sources (section B.4.1);
    - analysis of distribution of scale of change to input data in producing estimates (section B.4.2)
    - derivation of proportion of input estimates (by borough by sector share) affected by changes of certain sizes (section B.4.3)
    - analysis of the scale of changes to preferred source data across years for evidence of discontinuity in the series brought about by the methodology used (section B.4.4)

Section 4 of the main paper provides the conclusions on the implementation of the methodology.

B.1. Conversion of input data to SIC 2007

Alongside the documentation that ONS has produced of the various SIC classifications over time, and discussed in the previous section, it has also provided guidance on how to convert data between classifications[78]. This has been used, and has been supplemented for the conversion from SIC 1980 to SIC 1992 with analysis by Warwick University[79]. The conversion factors, where applied, relate to a single year of data, and where data was collected under both

[78] [ARCHIVED CONTENT] UK Standard Industrial Classification of Economic Activities (UK SIC): Archive - ONS
[79] Proportional SIC Mapping

classifications. They are for national level, rather than London level, data. Two sets of conversion factors have been applied to CofE data to align it to SIC 2007, while for other data sources one, or no, set of factors has been used.

B.1.1. Converting data from SIC 2003 to SIC 2007

There has been no need to convert BRES and IDBR data as it is available for SIC 2007.

To provide users with an indication of the impact that moving from SIC 2003 to SIC 2007 might have, the ONS provided a weighted correlation table to show the level of change that might be expected at SIC level in employment data, turnover data and the number of businesses in percentage format following the implementation of SIC 2007[80]. GLA Economics has used the conversion table at the most aggregated level available, namely 2 digit SIC, or divisional level, to convert employee data from SIC 2003 to SIC 2007, and then aggregate it up again to GLA sector, or 1-digit SIC, level. The data for the conversion has been taken from a snapshot of the IDBR taken in December 2009.

ABI data is available as SIC 2003, and has been converted to SIC 2007 GLA sectors by this means.

B.1.2. Converting data from SIC 1992 to SIC 2003

The ONS has produced a table of changes between SIC 1992 and SIC 2003[81], and this is provided in summary at Table B.1. There is a direct mapping to SIC 2003 sections, which has enabled the SIC 2003 to SIC 2007 conversion factors to be used to convert data from SIC 1992 to SIC 2007.

[80] See UK SIC 2007 - Office for National Statistics for more information
[81] [ARCHIVED CONTENT] UK Standard Industrial Classification of Economic Activities (UK SIC): Archive - ONS

Table B.1: Table of Changes between SIC 1992 and SIC 2003

SIC 1992 division		SIC 2003 section	
Division	Description	Section	Description
1-2&5	Agriculture, Forestry & Fishing	A	Agriculture, Hunting and Forestry
		B	Fishing
10&12-14	Other Mining	C	Mining and Quarrying
11	Oil & Gas Extraction		
15-16	Food, Drink & Tobacco	D	Manufacturing
17-19	Textiles & Clothing		
20	Wood & Wood Products		
21-22	Paper, Printing & Publishing		
23	Fuel Refining		
24	Chemicals		
25	Rubber & Plastics		
26	Minerals		
27-28	Metals		
29	Machinery & Equipment		
30-33	Electrical & Optical equipment		
34-35	Transport Equipment		
36-37	Other manufacturing		
40-41	Gas, Electricity & Water	E	Electricity, Gas and Water Supply
45	Construction	F	Construction
50-51	Wholesaling	G	Wholesale
52	Retailing		Retail Trade
55	Hotels & Catering	H	Hotels and Restaurants
60-63	Transport	I	Transport, Storage and Communication
64	Communications		
65-67	Banking & Insurance	J	Financial Intermediation
70,71,73	Other Financial & Business Services	K	Real Estate, Renting and Business Activities
72,74	Business Services		
75	Public Admin. & Defence	L	Public Administration and Defence
80	Education & Health	M	Education
85	Health	N	Health and Social Work
90-95	Other Services	O	Other Community, Social and Personal Service Activities

Source: Office for National Statistics

This is what has been done for AES and LWES data. The thirty divisions in Table 7 correspond to the organisation of LWES data.

B.1.3. Converting data from SIC 1980 to SIC 1992

ONS provides a correlation between SIC 1980 and SIC 1992[82] similar in nature to the table of changes between SIC 2003 and SIC 2007. This does not provide weights, and there is not a division to division mapping as there is between SIC 1992 and SIC 2003. To do the conversion GLA Economics has used a proportional mapping between SIC 1980 4-digit activities, and SIC 1992 2-digit divisions produced by Warwick University[83]. This has been derived from Labour Force Survey (LFS) job stayer data between Autumn 1993 and Winter 1993/94 as this provided a means to collected information on individuals with jobs under both classifications. The list of SIC 1980 4-digit activity codes on the LFS dataset is not complete, and does not include some codes on CofE datasets. Where this is the case GLA Economics has imputed a weighting factor of that for the 4-digit activity which most closely corresponds to the missing code, and for which there is a weighting factor.

This set of conversion factors has been applied to CofE data to convert it from SIC 1980 to SIC 1992. The conversion factors from SIC 2003 to SIC 2007 have then been applied to convert the data to SIC 2007 as has been done for other datasets stored in SIC 1992 format.

The source data is calibrated to the London employee total for each year of the GLA London Jobs series. This provides input borough by sector data, but it is not consistent with the GLA London Jobs series as either sector shares, or borough shares, or both, will differ from those in that series.

B.2. Methodologies to develop a borough by sector series

B.2.1. Possible methodological approaches

The GLA London Jobs series for employees covers 33 boroughs[84] and 16 sectors for each of 45 years from 1971-2015. For each year there are 49 items (data for each of the boroughs and sectors) and the requirement is to produce 528 items (borough by sector for each borough and sector, ie 33x16). There are potentially 480 solutions, that is 528 items less 49 constraints plus one. This can be considered as a problem of small area estimation which might be tackled through spatial microsimulation models[85]. That is, there is a set of model techniques for estimating cross-tabulations through simulation:

- Generalised regression – this method would re-weight borough by sector input data to align sector shares and borough shares. GLA Economics has used linear regression to support decisions for the backcast sector and borough series[86]. It is not, though, clear how to implement this technique in this context as it is not clear conceptually what explanatory variables might be useful for a regression model, or indeed whether the data

[82] [ARCHIVED CONTENT] UK Standard Industrial Classification of Economic Activities (UK SIC): Archive - ONS
[83] Proportional SIC Mapping
[84] Including the City of London
[85] This section draws heavily on Tanton R (2014), A Review of Spatial Microsimulation Models, International Journal of Microsimulation, 7(1) pp4-25 at http://www.microsimulation.org/IJM/V7_1/2-IJM_7_1_Tanton_.pdf
[86] See, for example, Working Paper 52: London's jobs history - a technical paper | London City Hall (2011), and London labour market projections 2016 | London City Hall (specifically Appendix 7)

is available at the required level of disaggregation especially for earlier years of the GLA London Jobs series. This approach has not been adopted.

- Combinatorial optimisation – this method is a mathematical process to find an optimal object from a finite set of objects. Applied to spatial microsimulation the process is used to choose which records from a survey best represent a small area. There is survey micro-data for ABI, and BRES which might enable implementation of this method[87]. This approach has not been adopted because there is not survey micro-data for earlier years of the GLA London Jobs series, and so it would not be possible to produce borough by sector estimates for those years by this method.

- Iterative Proportional Fitting (IPF)[88] – this is a mechanistic technique, which does not rely on micro-data or other data, and so is the technique that has been adopted. Through a sequence of steps it iterates borough by sector estimates to borough totals, and then sector totals, and so on, until there is convergence and borough by sector estimates align both to borough totals and sector totals – the next sub-section provides an example. It is one of a class of models, which includes models which use micro-data, discussed in the next paragraph. The technique can be an effective estimation technique where survey estimates are highly correlated with control totals[89], although in certain situations the approach may be problematic – the performance of this modelling is reviewed in the concluding section[90].

Conceptually the problem of fitting cross-tabulated data to row and column totals which makes use of other sources is one which national statistical agencies encounter in other circumstances, and noticeably in aligning survey data on gender and age to Census data. The ONS used raking, on LFS data prior to 2007/8[91]. ONS now employs the Canadian Generalised Estimation System[92], and associated statistical package, to align LFS data to age and gender totals. These approaches use microdata from surveys, and this allows more flexibility to the process of fitting data to control totals. ONS requirements of calibration go beyond alignment to control total, the requirement of this analysis. ONS uses it to handle survey non-response, correct data quality issues, and produce good variance estimates[93]. Central Statistics Office Ireland uses the statistical package CALMAR[94]. These approaches, and Iterative Proportional Fitting, have similar

[87] ABI and BRES survey microdata is available at the ONS Virtual Microdata Laboratory. ONS does not hold CofE or AES microdata. There is no LWES microdata.
[88] This technique is also known as raking
[89] Effective in the sense that the mean squared error of estimates can be reduced. The mean squared error is the average of the squares of the difference between the survey population and the estimate.
[90] This analysis draws heavily on Brick, Montaquila and Roth (2003) https://ww2.amstat.org/sections/srms/Proceedings/y2003/Files/JSM2003-000472.pdf presented at the 2003 proceedings of the American Statistical Association https://ww2.amstat.org/sections/srms/Proceedings/y2003/Files/Search.pdf
[91] Labour Force Survey – user guidance - Office for National Statistics, see volume 1 on background and methodology
[92] See JOS Online: Abstract for more information about the method
[93] Economic and Labour Market Review, December 2008 reports on the impact of Labour Force Survey and Annual Population Survey reweighting. ONS reports that the new methodology was not expected to result in much change to LFS estimates at higher levels of geography. For example, for 2006 data, as a result of the re-weighting, the majority (68.2 per cent) of unitary authorities or local authority districts experienced an increase in the 16+ population of between 0 and 5 per cent, a further 5.5 per cent experienced an increase of between 5 and 10 per cent, and 24.4 per cent experienced a decrease of between 0 and 5 per cent, see http://webarchive.nationalarchives.gov.uk/20090513230029/http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=14692
[94] See http://vesselinov.com/CalmarEngDoc.pdf

statistical properties which justifies their use[95]. The properties of estimates from the statistical packages may be relatively stronger than those from IPF, but they are also computationally more complex to implement and it still requires user judgement on the form of implementation. The issues which might arise through Iterative Proportional Fitting, and which are discussed in the concluding section, also apply to these methods.

GLA Economics took the decision not to use survey microdata for this purpose because this increased significantly the complexity of the analysis, and did not necessarily improve the accuracy of estimates derived.

B.2.2. Iterative Proportional Fitting, a hypothetical example

The starting point in this process is to take borough by sector shares of London employee jobs for each of the source input datasets. Although these data sources might have different data collection methodologies and definitions the process is to align them to borough and sector series which have been developed to be consistent over time.

The process of the calculation is first to align the input data to the desired borough shares, and then to the desired sector shares and so on until both borough and sector shares are at the desired values[96].

Table B.2 provides a worked example. It assumes there are two sectors and two boroughs. The total number of jobs is 105, sector 1 has 60 jobs, and sector 2 has 45 jobs, borough 1 has 35 jobs and borough 2 has 70 jobs. These are the control totals to which the input borough by sector jobs data should align. The input borough by sector jobs total is 105, except sector 1 has 50 jobs, sector 2 has 55 jobs, borough 1 has 40 jobs, and borough 2 has 65 jobs. These totals do not agree with the control totals. Iteration 1 corrects borough totals, so that in borough 1 sector 1 and sector 2 maintain the same shares but the total jobs is 35, and similarly for borough 2 total jobs is 70. Sector jobs are still not aligned, and so this process is repeated, at iteration 2, but to align sector jobs. Iteration 3 repeats the alignment of borough jobs, and iteration 4 repeats this for sector jobs. At this point borough by sector estimates sum to each of the desired borough and sector jobs totals, and so the process stops.

[95] Asymptotically they are equivalent, that is for a sufficiently large number of row and column totals they are efficient, as estimates are unbiased, and variance is unbiased.
[96] In principle, the ordering could be to align sector shares and then borough shares.

Table B.2: Application of Iterative Proportional Fitting to a Hypothetical Example

initial values		borough total		sector 1	sector 2
		actual	estimate	estimate	estimate
sector total	*actual*	*105*		*60*	*45*
	estimate			50.0	55.0
borough 1	estimate	*35*	40.0	15.0	25.0
borough 2	estimate	*70*	65.0	35.0	30.0

iteration 1		borough total		sector 1	sector 2
		actual	estimate	estimate	estimate
sector total	*actual*	*105*		*60*	*45*
	estimate			50.8	54.2
borough 1	estimate	*35*	35.0	13.1	21.9
borough 2	estimate	*70*	70.0	37.7	32.3

iteration 2		borough total		sector 1	sector 2
		actual	estimate	estimate	estimate
sector total	*actual*	*105*		*60*	*45*
	estimate			60.0	45.0
borough 1	estimate	*35*	33.7	15.5	18.2
borough 2	estimate	*70*	71.3	44.5	26.8

iteration 3		borough total		sector 1	sector 2
		actual	estimate	estimate	estimate
sector total	*actual*	*105*		*60*	*45*
	estimate			59.8	45.2
borough 1	estimate	*35*	35.0	16.1	18.9
borough 2	estimate	*70*	70.0	43.7	26.3

iteration 4		borough total		sector 1	sector 2
		actual	estimate	estimate	estimate
sector total	*actual*	*105*		*60*	*45*
	estimate			60.0	45.0
borough 1	estimate	*35*	35.0	16.2	18.8
borough 2	estimate	*70*	70.0	43.8	26.2

Source: GLA Economics calculations

In this example there is a unique solution, but generally this will not be the case. The generated solution will depend on the input data selected.

For the data described in section 3 the process converged for each year and each data source after fewer than 10 iterations. As a comparison the analysis has also been run on synthetic input data where every borough by sector input share of London employee jobs was set to be the same.

Another approach has been to apply IPF to the preferred input borough by sector data for each year, and align sectors first. In no year was the absolute difference for borough and sector

estimate of London employee jobs more than 0.25 jobs according to whether boroughs were aligned first or sectors. As this difference is immaterial the results of the analysis aligning sector first for the preferred input data series are not reported further in this paper.

B.3. Calculation of criteria to compare input source data and selection of preferred input data series

B.3.1. Source data source metrics, and selection of input data series

There is a lack of data to estimate a definitive borough by sector data series. IPF is a recognised and used technique to address data limitations, but it does not provide a means to select a preferred series. Monte Carlo simulation, where IPF would be run for a range of input values such as in Table B.2, would be one approach to identify the range of possible values generated in a borough by sector series. Again, it might not be clear what the basis is to select a preferred borough by sector series. Instead, GLA Economics has considered a range of metrics to compare borough by sector survey data (and the synthetic input data of equal shares) with London employee job series for boroughs and sectors (see Tables B.3, B.4 and B.5). The survey data has been an input into the London Jobs series, and has the benefit of providing year-on-year comparability for individual surveys.

All data used for each year has been calibrated to the London employee job total for that year from the London Jobs series. Borough shares and sectors shares can be derived for each of the sources. Correlation coefficients have been calculated to test the degree of correlation at both borough and sector level between estimates from survey data and the London Jobs series for employees. The mean absolute deviation is the difference in share in absolute terms averaged across boroughs or sectors. The weighted mean absolute deviation weights each borough or share according to its relative size in the London economy – it allows that there are more jobs in some boroughs and sectors[97]. The tables also report maximum absolute deviation.

For both boroughs and sectors there is a strong correlation between survey data estimates and the London Jobs series for employees (see Table B.3). The one partial exception is the LWES where the sector correlation worsens over time. In contrast, the correlations at both borough and sector levels are zero for the synthetic data of equal shares.

[97] GLA Economics has also completed this analysis for percentage absolute deviation, that is absolute deviation weighted by borough or sector share. This is another means to take account of the relative size of boroughs or sectors. These results have not been reported as the conclusions do not differ from those reported for Tables 10 and 11.

Table B.3: Correlation coefficients for London Jobs series data and source data for boroughs and sectors, various years

	ABI	AES	BRES	CofE	IDBR	LWES	equal shares
boroughs							
1971						99.64%	0.00%
1981						99.72%	0.00%
1984				99.65%		99.73%	0.00%
1991		99.94%		99.49%		99.88%	0.00%
1998	99.96%	99.79%				99.87%	0.00%
2001	99.96%				99.31%	99.91%	0.00%
2008	99.99%				99.91%		0.00%
2009			100.00%		99.93%		0.00%
2015			100.00%		99.77%		0.00%
sectors							
1971						96.71%	0.00%
1981						91.93%	0.00%
1984				95.00%		87.60%	0.00%
1991		97.31%		95.13%		73.30%	0.00%
1998	99.02%	98.89%				70.95%	0.00%
2001	98.41%				99.49%	74.03%	0.00%
2008	97.74%				99.42%		0.00%
2009			99.82%		99.28%		0.00%
2015			99.88%		99.59%		0.00%

Source: GLA Economics calculations
Note: minimum value for correlation coefficient is zero, and maximum is 100%

Tables B.4 and B.5 report results for absolute deviation measures of mean, weighted mean and maximum. For boroughs, there is a clear hierarchy of the survey data sources in relation to the London Jobs series (Table B.4). Data from official ONS surveys is closer to the London Jobs series than other sources namely IDBR, LWES[98], and equal shares, with the exception of CofE. The equal shares synthetic series has estimates furthest from the borough shares of the London Jobs series. Also, the more recent is the official survey the closer are its raw estimates to the London Jobs series to the point where they are the same for BRES.

[98] No adjustment has been made to the LWES data for the transfer of Heathrow airport from Hillingdon to Hounslow in 1994.

Table B.4: Absolute deviation of borough survey jobs data from London Jobs series data, various sources and years – percentage points difference across boroughs

percentage points	ABI	AES	BRES	CofE	IDBR	LWES	equal shares
mean							
1971						0.17%	1.47%
1981						0.17%	1.48%
1984				0.26%		0.17%	1.52%
1991		0.07%		0.26%		0.13%	1.39%
1998	0.06%	0.14%				0.10%	1.39%
2001	0.06%				0.16%	0.08%	1.47%
2008	0.04%				0.08%		1.56%
2009			0.00%		0.07%		1.58%
2015			0.00%		0.12%		1.68%
weighted mean							
1971						0.26%	2.96%
1981						0.26%	3.07%
1984				0.41%		0.28%	3.23%
1991		0.11%		0.43%		0.20%	2.74%
1998	0.09%	0.18%				0.11%	2.78%
2001	0.09%				0.22%	0.08%	2.83%
2008	0.07%				0.11%		2.98%
2009			0.00%		0.13%		3.05%
2015			0.00%		0.20%		3.18%
maximum							
1971						0.79%	11.50%
1981						0.69%	11.63%
1984				1.33%		0.75%	12.21%
1991		0.39%		1.41%		0.70%	11.31%
1998	0.29%	0.41%				0.42%	11.36%
2001	0.28%				1.13%	0.35%	11.29%
2008	0.24%				0.46%		11.50%
2009			0.00%		0.43%		11.71%
2015			0.00%		0.73%		11.24%

Source: GLA Economics calculations

In broad terms, the conclusions are the same from the sector analysis (Table B.5). The exception is that the IDBR is closer to the London Jobs series than the ABI.

Table B.5: Absolute deviation of sector survey jobs data from London Jobs series data, various sources and years – percentage points difference across sectors

percentage points	ABI	AES	BRES	CofE	IDBR	LWES	equal shares
mean							
1971						0.97%	2.63%
1981						1.00%	2.26%
1984				2.14%		1.04%	2.20%
1991		1.37%		1.74%		1.27%	2.15%
1998	0.34%	1.00%				1.22%	2.09%
2001	0.41%				0.23%	1.23%	2.34%
2008	0.52%				0.29%		2.79%
2009			0.15%		0.31%		2.91%
2015			0.20%		0.23%		3.17%
weighted mean							
1971						1.21%	3.85%
1981						1.07%	2.33%
1984				2.54%		1.08%	2.06%
1991		1.52%		1.97%		1.37%	1.99%
1998	0.32%	1.15%				1.46%	2.03%
2001	0.39%				0.26%	1.54%	2.39%
2008	0.63%				0.33%		2.99%
2009			0.20%		0.36%		3.12%
2015			0.25%		0.31%		3.61%
maximum							
1971						2.90%	13.58%
1981						3.12%	7.56%
1984				7.68%		3.48%	5.70%
1991		3.35%		5.46%		4.67%	5.05%
1998	0.78%	3.27%				5.27%	5.38%
2001	1.24%				0.78%	5.09%	5.39%
2008	1.61%				0.67%		7.64%
2009			0.59%		1.24%		7.91%
2015			0.49%		0.76%		9.48%

Source: GLA Economics calculations

In considering the borough and sector results together the selected survey data for IPF is:

- 2009-15 BRES
- 1998-2008 ABI
- 1991, 1993, 1995-7 AES
- Other years LWES

These are the surveys which are closest to the London Jobs series for borough employees for the metrics of correlation coefficients and absolute deviation. This selection also has the advantage of using a relative small number of surveys to minimise the risk of discontinuities in a 1971-2015 series from different survey approaches.

B.3.2. Properties of preferred source data to generate borough by sector series

Table B.6 provides some contextual information on the characteristics of the preferred data series. Of the 528 borough by sector shares of London employee jobs it reports the distribution by share of London jobs. So, in 1971 8.9% of boroughs and sectors accounted for less than 0.02% of jobs in London held by employees. In no year was there a borough and sector which had 4% of jobs.

Table B.6: Distribution of share of London employee jobs across boroughs and sectors by size, various years for preferred source survey data

share of London Jobs series	1971	1981	1984	1991	1998	2001	2008	2009	2015
<0.02%	8.9%	3.8%	3.4%	0.4%	0.9%	1.7%	2.7%	6.1%	5.9%
0.02%-<0.04%	9.8%	9.3%	8.1%	7.2%	8.9%	8.7%	8.1%	9.1%	11.2%
0.04%-<0.06%	13.4%	10.2%	11.2%	9.1%	6.4%	7.6%	12.9%	10.2%	11.9%
0.06%-<0.08%	10.2%	11.7%	10.4%	9.1%	11.2%	8.5%	9.7%	12.3%	9.8%
0.08%-<0.1%	7.4%	8.9%	8.9%	9.8%	8.7%	8.9%	8.0%	7.6%	8.1%
0.1%-<0.15%	14.8%	17.2%	19.9%	22.3%	19.7%	21.8%	18.0%	14.8%	15.5%
0.15%-<0.2%	11.0%	11.4%	8.7%	13.8%	16.1%	14.6%	13.4%	12.3%	9.5%
0.2%-<0.3%	9.3%	11.4%	14.2%	14.6%	15.5%	15.3%	13.8%	13.6%	14.2%
0.3%-<0.4%	4.2%	6.6%	5.5%	7.0%	5.7%	5.9%	5.9%	5.9%	5.5%
0.4%-<0.5%	2.7%	2.7%	3.8%	2.7%	2.5%	3.0%	2.8%	2.5%	1.9%
0.5%-<1%	4.9%	5.1%	4.5%	2.5%	2.7%	2.1%	2.5%	3.6%	4.0%
1%-<1.5%	2.7%	1.1%	0.6%	0.9%	0.9%	1.1%	1.1%	0.9%	1.3%
1.5%-<4%	0.8%	0.6%	0.8%	0.6%	0.8%	0.8%	1.1%	1.1%	1.1%
total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: GLA Economics calculations

Across years the distribution is reasonably stable in the sense that 70-75% of boroughs and sectors have less than 0.2 percentage points of employee jobs in London. In contrast, the share of boroughs and sectors with less than 0.1 percentage points of London employee jobs is a little under a half in 1971 and 2015, while it accounts for 35% of boroughs and sectors in 2001. This analysis helps supports understanding of the impact of the application of IPF to this data, as discussed in the next sub-section. For example, a relatively small absolute shift in borough by sector share will have a disproportionate impact if the original share was also small.

B.4. Validation and comparison of results using Iterative Proportional Fitting

B.4.1. Assessment of changes to input source data to produce borough by sector estimates, and comparison of estimates from preferred data series and other sources

As IPF has been applied here to solve linear equations the expectation is that borough by sector input data which is closest to the sector shares and borough shares from the London Jobs series will provide the most robust estimates. This sub-section considers how well this is borne out by practice in two ways. First, for the data sources it looks at the difference between input values and outputs values as a share of London's economy to consider the change in values from implementation of IPF. Second, it compares output values across data inputs to form a sense of the potential variability in outputs for the series, and so the likelihood that estimates of values in the preferred series might be some way from actual values.

Again, the metrics used are measures of absolute deviation, in this case mean, maximum, and median. The mean provides a general sense of change or difference between the two series under study, while a high maximum value might indicate that some of the estimates are less reliable, and median gives a sense of a "typical" change or difference.

The effects of applying IPF for each survey, in terms of a comparison of borough by sector estimates compared to input data, for a range of years are at Table B.7. What is noticeable is that the synthetic input data of equal borough by sector shares has consistently the highest results across metrics and years, that is the largest differences between estimates and input data. Changes in borough by sector shares for other surveys from the process of IPF tend to be fairly small, although maximum figures are somewhat higher than mean or median estimates. This is noticeable for IDBR, and LWES.

Table B.7: Absolute deviation of borough by sector estimates and input data, various sources and years – percentage points difference across all boroughs and sectors

percentage points	ABI	AES	BRES	CofE	IDBR	LWES	equal shares
mean							
1971						**0.03%**	0.13%
1981						**0.03%**	0.11%
1984				0.02%		**0.03%**	0.11%
1991		**0.02%**		0.03%		0.04%	0.11%
1998	**0.01%**	0.02%				0.04%	0.11%
2001	**0.01%**				0.04%	0.04%	0.11%
2008	**0.02%**				0.01%		0.13%
2009			**0.00%**		0.01%		0.13%
2015			**0.01%**		0.01%		0.13%
maximum							
1971						**0.75%**	2.69%
1981						**0.74%**	1.84%
1984				0.35%		**0.80%**	1.63%
1991		**0.33%**		0.69%		0.91%	1.25%
1998	**0.17%**	0.35%				0.89%	1.41%
2001	**0.20%**				0.74%	0.89%	1.47%
2008	**0.33%**				0.19%		1.83%
2009			**0.08%**		0.13%		1.90%
2015			**0.19%**		0.41%		2.05%
median							
1971						**0.01%**	0.09%
1981						**0.02%**	0.08%
1984				0.01%		**0.02%**	0.08%
1991		**0.01%**		0.01%		0.02%	0.08%
1998	**0.01%**	0.01%				0.01%	0.08%
2001	**0.01%**				0.02%	0.01%	0.09%
2008	**0.01%**				0.00%		0.09%
2009			**0.00%**		0.01%		0.10%
2015			**0.00%**		0.00%		0.10%

Source: GLA Economics calculations
Note: Entries in bold are the preferred source data for borough by sector series for particular year

The analysis has been repeated to compare preferred borough by sector estimates using LWES/AES/ABI/BRES and those from other surveys not used either because the survey was not preferred, namely CofE and IDBR, or certain years were not used, as was the case for LWES for the years 1991, 1998 and 2001. The results of this are given in Table B.8. CofE estimates for 1984 are close to estimates for the preferred series as the median for the difference is low, although there are some significant differences for some borough by sector estimates as the mean is higher than the median. Curiously CofE estimates for 1991, and the LWES for 1996 (not reported here), are the same as those derived from the preferred series of AES in the respective years even though the input data series differ – there is no reason mathematically why different input series should not converge to the same output series. Again, there are some large maximum changes for IDBR and LWES although mean and median differences are low. Equal shares estimates are markedly higher.

These findings support the modelling strategy to use actual survey data, rather than synthetic data, and suggest that on the whole the preferred estimates are relatively robust, although there may be some estimates around which there is a significant margin of error.

Table B.8: Absolute deviation of borough by sector preferred estimates and other input data, various sources and years – percentage points difference across all boroughs and sectors

percentage points	CofE	IDBR	LWES	equal shares
mean				
1971				0.09%
1981				0.08%
1984	0.03%			0.08%
1991	0.00%		0.02%	0.07%
1998			0.02%	0.07%
2001		0.02%	0.02%	0.07%
2008		0.03%		0.08%
2009		0.01%		0.08%
2015		0.01%		0.08%
maximum				
1971				2.99%
1981				3.04%
1984	0.25%			3.13%
1991	0.00%		0.25%	3.04%
1998			0.39%	3.16%
2001		0.37%	0.37%	2.81%
2008		0.54%		2.82%
2009		0.17%		2.73%
2015		0.44%		2.84%
median				
1971				0.05%
1981				0.04%
1984	0.01%			0.04%
1991	0.00%		0.01%	0.04%
1998			0.01%	0.03%
2001		0.01%	0.01%	0.04%
2008		0.01%		0.04%
2009		0.01%		0.04%
2015		0.01%		0.04%

Source: GLA Economics calculations

B.4.2. Distribution of scale of change of preferred borough by sector estimates relative to input data

Another way to validate the process of IPF is to consider the scale of change made to input data in producing estimates. For the official ONS surveys used in the development of the borough by sector series, namely AES, ABI and BRES the preferred employee jobs shares differ from input absolute values by 0.05 percentage points for 95% or more of input values (see Table B.9). For the LWES this falls to around 85%[99]. This supports the point that the use of IPF

[99] The figures are similar for LWES where Hounslow and Hillingdon have been excluded from this calculation. LWES is on pre-1994 boundaries for these boroughs.

typically makes relatively small changes to borough by sector shares of London employee jobs where there is an expectation that there is a solution close to input values.

Table B.9: Comparison of absolute deviation of borough by sector preferred estimates from input data, various years – percentage of changes within certain percentage point limits

percentage points	preferred source	<0.01	<0.02	<0.03	<0.04	<0.05
1971	LWES	39.0%	63.3%	72.7%	79.2%	85.4%
1976	LWES	36.2%	58.7%	72.3%	80.3%	84.3%
1981	LWES	32.2%	54.4%	72.2%	79.2%	85.4%
1984	LWES	34.8%	54.2%	70.8%	78.8%	84.5%
1986	LWES	33.5%	53.2%	68.2%	78.0%	83.5%
1991	AES	51.7%	78.2%	89.6%	93.4%	95.5%
1996	AES	59.7%	85.6%	92.2%	96.8%	97.9%
1998	ABI	62.3%	87.9%	94.5%	97.2%	98.1%
2001	ABI	58.1%	83.1%	90.7%	94.5%	96.2%
2006	ABI	55.9%	79.7%	90.5%	94.3%	95.3%
2008	ABI	57.6%	79.2%	87.1%	93.0%	94.3%
2009	BRES	87.9%	95.6%	98.3%	98.9%	99.2%
2015	BRES	87.5%	95.8%	97.7%	98.1%	98.9%

Source: GLA Economics calculations

B.4.3. Changes to input data for preferred estimates by borough by sector input share

As indicated earlier the distribution of jobs across boroughs and sectors is not even (Table B.6 reports the distribution for the preferred source data). Tables B.10 and B.11 report for a number of years the impact of changes within the same sizebands of distribution of London employee jobs, where there is a change (from input data to estimate) for a borough and sector of at least 0.03 percentage points, and where there is a change of at least 0.05 percentage points. Table B.12 reports the maximum change in percentage points for these years.

It is more common for the boroughs and sectors with a larger share of jobs to have a larger change between estimate and input data – for example in 1971 all boroughs and sectors with a share of London employee jobs of over 1% had a change of over 0.03 percentage points, while no borough and sector with a share of under 0.02% had such a change. This is a general finding across years, and whether the change in sector and borough share is over 0.03 percentage points, or over 0.05 percentage points. It is a desirable property that boroughs and sectors with the larger shares of London employee jobs should be the ones where there are the larger absolute changes between estimate and input data, and this is a smaller proportion of the original value. At the same time, there are smaller boroughs and sectors where the change between estimate and input value is of a similar order of magnitude to the original value.

This last phenomenon is less true over time. In 2015 there is no borough and sector with a share of London employee jobs of less than 0.2% which has a change between input value and estimate of over 0.03 percentage points. The corresponding borough and sector share of London employee jobs for a change of over 0.05 percentage points is 0.5%. This pattern continues for larger values of the change between input value and estimate, eg 0.06 percentage points, 0.07 percentage points etc.

Third, the proportion of boroughs and sectors with significant changes between input value and estimate declines over time. The proportion of boroughs and sectors with a change of over 0.03 percentage points was 27.3% in 1971, and with a change of over 0.05 percentage points it was 14.6% in 1971. The corresponding figures for 0.03 percentage point change in 2015 are 2.3%, and for a 0.05 percentage point change in 2015 are 1.1%. There is a marked reduction in the proportion of boroughs and sectors facing large changes in 1991, the first year of the Annual Employment Survey. The maximum change in percentage points also drops markedly at this time from 0.80 percentage points in 1984 to 0.33 percentage points in 1991.

Fourth, as a matter of arithmetic there is a smaller proportion of boroughs and sectors with a change between input value and estimate of over 0.05 percentage points compared to 0.03 percentage points. This decline is apparent across all sizebands of boroughs and sectors. That is, for example, in 1971 there are both boroughs and sectors which have a change between input value and estimate of a similar order of magnitude whether the change is over 0.03 percentage points, or 0.05 percentage points.

Table B.10: Share of borough and sectors within sizebands of share of London employee jobs with changes between estimate and input data of more than 0.03 percentage points

input share	1971	1981	1984	1991	1998	2001	2008	2009	2015
<0.02%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
0.02%-<0.04%	3.8%	10.2%	4.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
0.04%-<0.06%	18.3%	11.1%	16.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
0.06%-<0.08%	16.7%	21.0%	23.6%	6.3%	1.7%	2.2%	9.8%	0.0%	0.0%
0.08%-<0.1%	33.3%	29.8%	34.0%	3.8%	6.5%	0.0%	0.0%	0.0%	0.0%
0.1%-<0.15%	19.2%	28.6%	34.3%	4.2%	2.9%	5.2%	7.4%	0.0%	0.0%
0.15%-<0.2%	37.9%	26.7%	26.1%	4.1%	0.0%	11.7%	4.2%	0.0%	0.0%
0.2%-<0.3%	32.7%	21.7%	28.0%	18.2%	9.8%	11.1%	21.9%	0.0%	1.3%
0.3%-<0.4%	36.4%	45.7%	37.9%	29.7%	6.7%	19.4%	38.7%	0.0%	0.0%
0.4%-<0.5%	64.3%	71.4%	55.0%	14.3%	15.4%	18.8%	46.7%	0.0%	10.0%
0.5%-<1%	73.1%	70.4%	62.5%	69.2%	50.0%	63.6%	69.2%	10.5%	9.5%
1%-<1.5%	100.0%	100.0%	100.0%	80.0%	20.0%	83.3%	100.0%	40.0%	42.9%
1.5%-<4%	100.0%	100.0%	100.0%	66.7%	50.0%	75.0%	50.0%	83.3%	83.3%
total	27.3%	27.8%	29.2%	10.4%	5.5%	9.3%	12.9%	1.7%	2.3%

Source: GLA Economics calculations

Table B.11: Share of borough and sectors within sizebands of share of London employee jobs with changes between estimate and input data of more than 0.05 percentage points

input share	1971	1981	1984	1991	1998	2001	2008	2009	2015
<0.02%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
0.02%-<0.04%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
0.04%-<0.06%	2.8%	1.9%	1.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
0.06%-<0.08%	11.1%	9.7%	9.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
0.08%-<0.1%	7.7%	6.4%	6.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
0.1%-<0.15%	5.1%	15.4%	20.0%	3.4%	1.0%	0.9%	2.1%	0.0%	0.0%
0.15%-<0.2%	20.7%	13.3%	10.9%	0.0%	0.0%	2.6%	0.0%	0.0%	0.0%
0.2%-<0.3%	12.2%	8.3%	13.3%	5.2%	2.4%	2.5%	5.5%	0.0%	0.0%
0.3%-<0.4%	22.7%	22.9%	31.0%	13.5%	0.0%	12.9%	9.7%	0.0%	0.0%
0.4%-<0.5%	50.0%	64.3%	35.0%	7.1%	7.7%	6.3%	33.3%	0.0%	0.0%
0.5%-<1%	61.5%	55.6%	58.3%	38.5%	21.4%	36.4%	61.5%	5.3%	4.8%
1%-<1.5%	92.9%	83.3%	100.0%	60.0%	20.0%	50.0%	83.3%	0.0%	28.6%
1.5%-<4%	75.0%	100.0%	100.0%	66.7%	50.0%	75.0%	50.0%	50.0%	50.0%
total	14.6%	14.6%	15.5%	4.5%	1.9%	3.8%	5.7%	0.8%	1.1%

Source: GLA Economics calculations

Table B.12: Maximum change between estimate and input data for borough by sector estimates in percentage points, various years

percentage points	1971	1981	1984	1991	1998	2001	2008	2009	2015
change	0.75%	0.74%	0.80%	0.33%	0.17%	0.20%	0.33%	0.08%	0.19%

Source: GLA Economics calculations

At this stage of development of a borough by sector series no effort has been made to review year-on-year changes systematically in borough by sector estimates. That is to assess whether significant changes might reflect actual developments, or changes in data practices. This contrasts with Working Paper 66[100], where there was such an analysis. The tasks differ, though, in the sense that the analysis of this paper is at an aggregated sector level, which has been less affected by some of the specific sub-sector issues covered in Working Paper 66, and rehearsed again in this paper for convenience. This paper also provides an indication of possible ranges around estimates to provide a sense of the uncertainty. The data series has been used to support the development of the London Labour Market Projections 2017[101], and this work did not identify any notable discrepancies in the borough by sector employee data series.

B.4.4. Assessment of year-on-year changes in borough by sector estimates relative to preferred input source data

Some summary statistics have been developed to consider the extent that there might be a large change between estimate and input value for some borough and sectors in some years but not others. The consequence of this might be that there might be year-on-year jumps in the borough by sector series for some borough and sectors because of the application of IPF. It should be noted that there may also be jumps because of changes in survey methodology, or

[100] See Working Papers 65, 66: London's sectors: detailed jobs data & method | London City Hall
[101] See London labour market projections 2017 | London City Hall

change of data source so it may be possible that IPF will compensate for other reasons for jumps in the series not related to changes in economic conditions.

The method of IPF will bring changes to every borough and sector, and so Table B.13 reports against various percentage point changes between estimates and input values. Across the 528 boroughs and sectors there are 36 (7% of the total) which had no change in any of the 45 years between 1971 and 2015 for percentage point changes up to 0.01, rising to 256 (48% of the total) for percentage point changes up to 0.03 and 366 (69% of the total) for percentage point changes up to 0.05. For values of percentage point change of 0.03 and 0.05 most borough and sectors have at least fifteen years with no change. That is, the method of IPF has little impact for a large group of borough and sectors.

Discontinuities might come about where there is a percentage point change over a certain value in one year but not the next, and so there is an ending. For a percentage point change value of 0.01 there were 307 (58% of the total) borough and sectors which had 3 or fewer endings, 205 (39% of the total) where there were 4-6 endings, and 16 where there were 7-9 (3% of the total) endings. There is a greater concentration on fewer years with endings for higher percentage point values. The complement of endings is what is called in the table not joined years, where there is a percentage point change over a certain value in the second year, but not the first. Endings and not joined years are concentrated around the period 1990-95 when the preferred source data series alternates between LWES and AES in successive years, and to a lesser extent between 2008 and 2009 when there was a transition from ABI to BRES. It is possible that discontinuities over time from the application of IPF may be offsetting to some extent differences in input borough by sector shares in London employee jobs of the source data series.

The remaining column to be discussed has the title joined years, and is where a certain year, and the one before, both have changes over a certain percentage point value. For a value of 0.01 103 (20% of the total) borough and sectors have 3 or fewer joined years, while 195 (37% of total) have 16-30 joined years, and 135 (26% of the total) have 31-44 joined years. In contrast for a percentage point change value of 0.05 418 (79% of the total) borough and sectors have 3 or fewer joined years. That is year-on-year changes in borough by sector input values are less common for larger changes in percentage point values.

Table B.13: Measure of consistency of borough by sector series over period 1971-2015 by percentage point change between estimates and input values across boroughs and sectors

percentage change	years	no change	endings	joined years	not joined years
0.01%	0-3	24	307	103	367
	>3-6	82	205	26	143
	>6-9	60	16	22	18
	>9-15	88	0	45	0
	>15-30	148	0	195	0
	>30-44	90	0	135	0
	all	36	0	2	0
0.03%	0-3	4	459	329	485
	>3-6	10	67	22	41
	>6-9	8	2	24	2
	>9-15	23	0	27	0
	>15-30	116	0	108	0
	>30-44	111	0	18	0
	all	256	0	0	0
0.05%	0-3	3	503	418	510
	>3-6	4	25	20	18
	>6-9	4	0	10	0
	>9-15	8	0	20	0
	>15-30	58	0	50	0
	>30-44	85	0	10	0
	all	366	0	0	0

Source: GLA Economics calculations
Definitions:

No change is both in year n and year n-1 the percentage point change between estimate and input value is less than the value in the first column of the table

Endings is when the percentage point change in year n is less than the value in the first column of the table, and the value in year n-1 is more than the value

Joined years is when the percentage point change in year n and year n-1 is more than the value in the first column of the table

Not joined years is when the percentage point change in year n is more than the value in the first column, and the change in year n-1 is less than the value

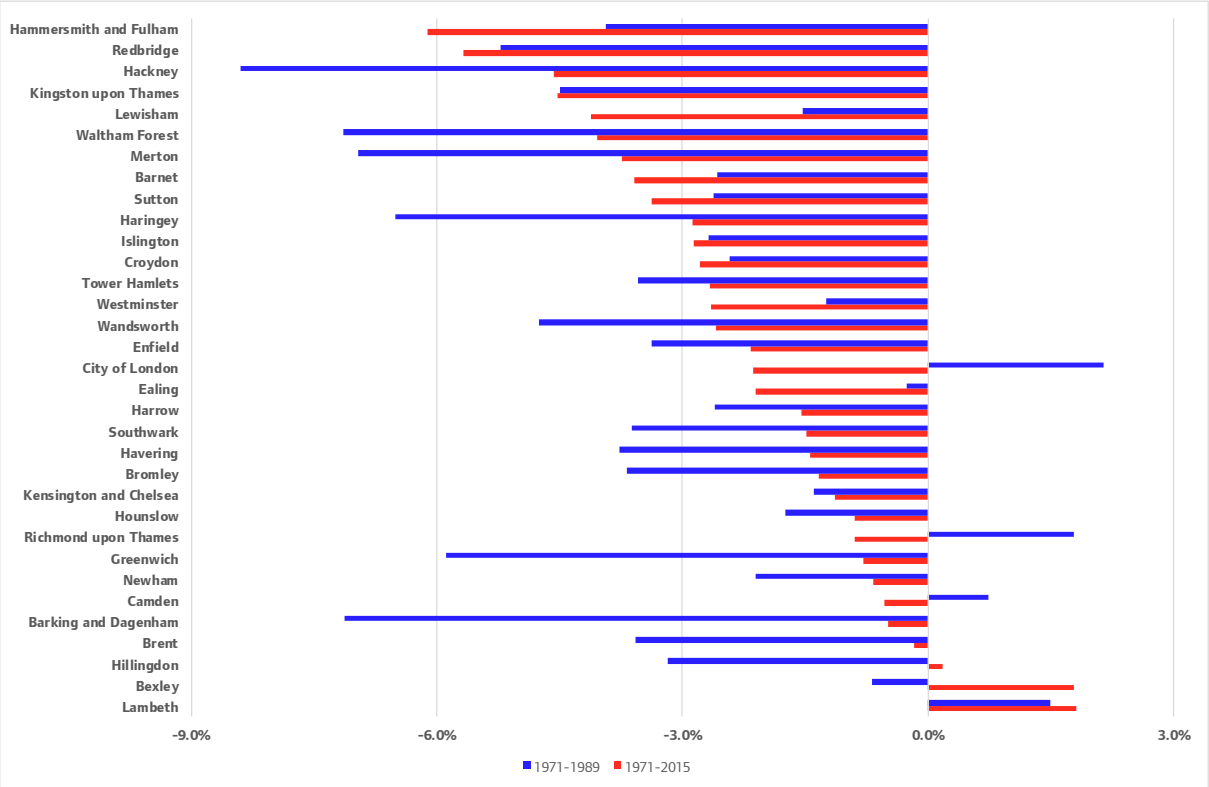
Appendix C. Borough by sector employee jobs charts

This Appendix provides more detailed information on sector development within each borough. There are two figures for each sector:

- Compound annual jobs growth rate by borough
- Change in borough share of sector jobs

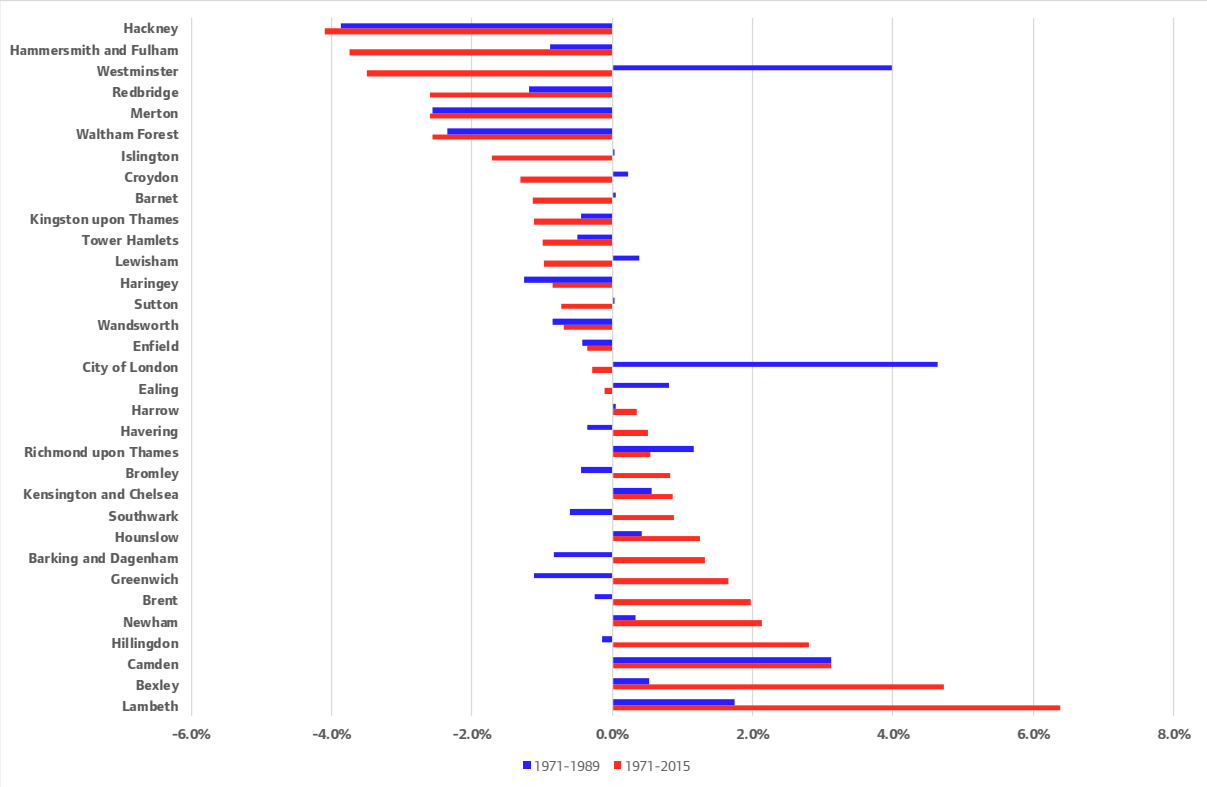
The figures are the counterpart of Figures 3 and 4 in the main paper, which are for sectors within the London economy. The main paper refers to the figures in this Appendix at a number of points.

Figure C.1: Primary and utilities, borough employee jobs growth rates, 1971-1989 and 1971-2015



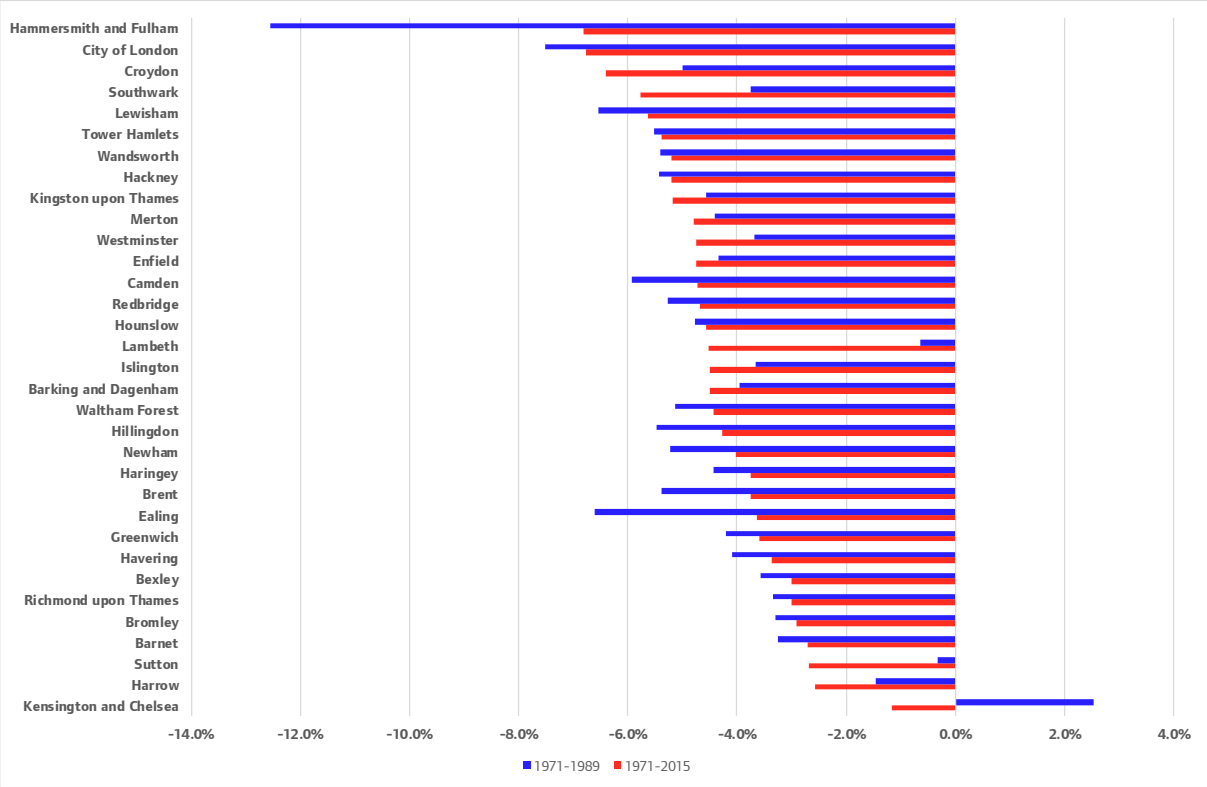
Source: GLA Economics calculations
Note: growth rate is compound annual growth rate

Figure C.2: Primary and utilities, borough shift in sector employee jobs shares, 1971-1989 and 1971-2015



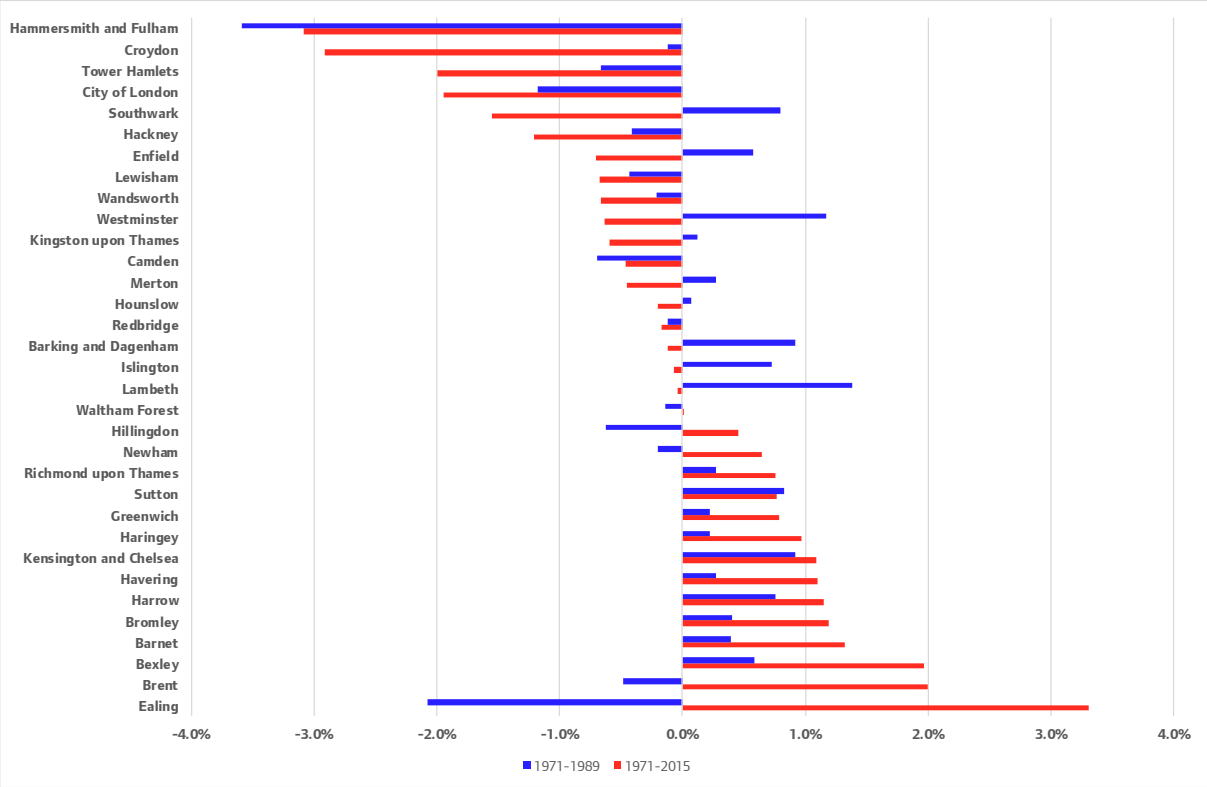
Source: GLA Economics calculations
Note: sum across boroughs for each time period is zero

Figure C.3: Manufacturing, borough employee jobs growth rates, 1971-1989 and 1971-2015



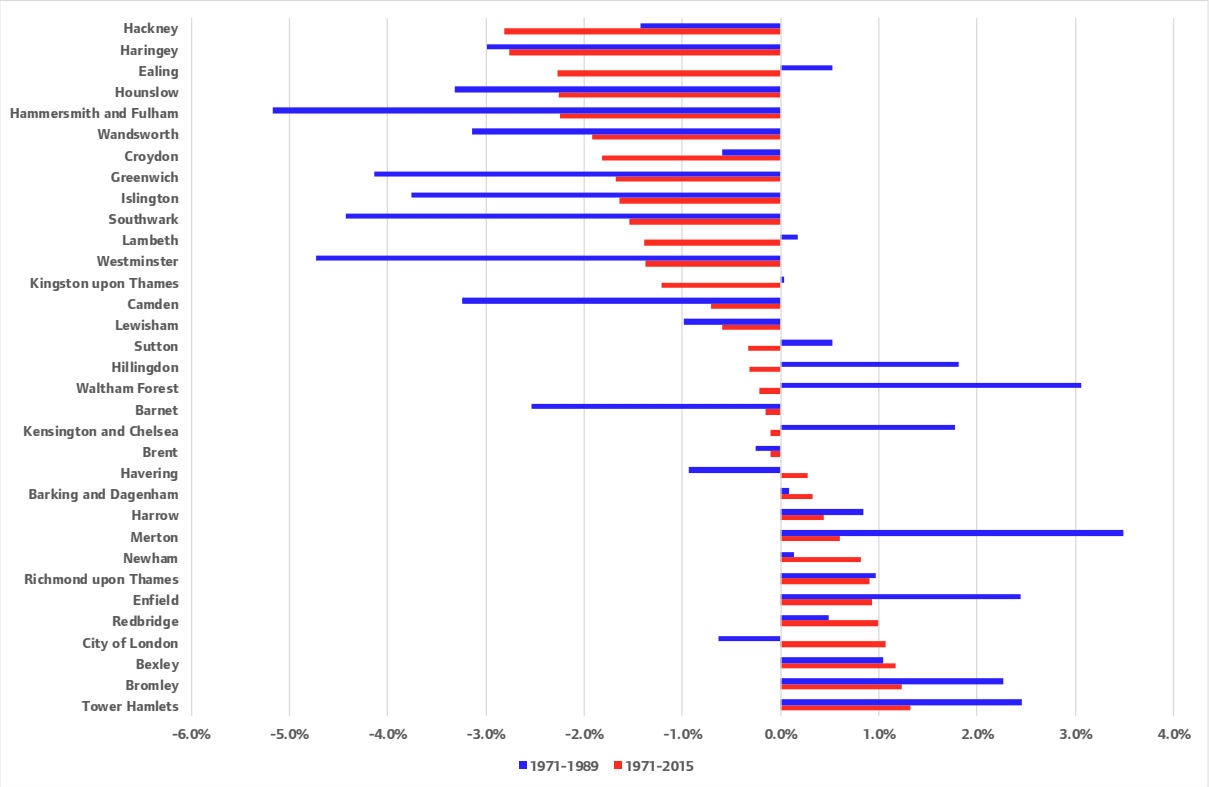
Source: GLA Economics calculations
Note: growth rate is compound annual growth rate

Figure C.4: Manufacturing, borough shift in sector employee jobs shares, 1971-1989 and 1971-2015



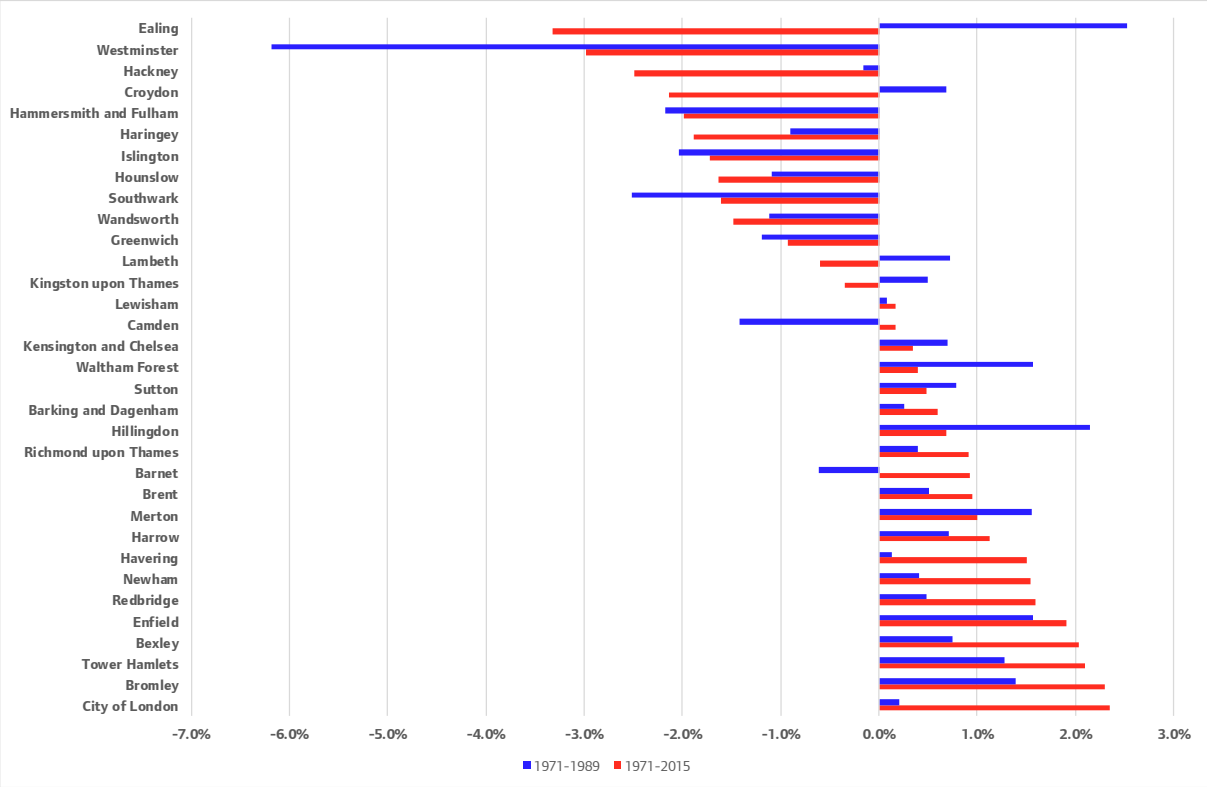
Source: GLA Economics calculations
Note: sum across boroughs for each time period is zero

Figure C.5: Construction, borough employee jobs growth rates, 1971-1989 and 1971-2015



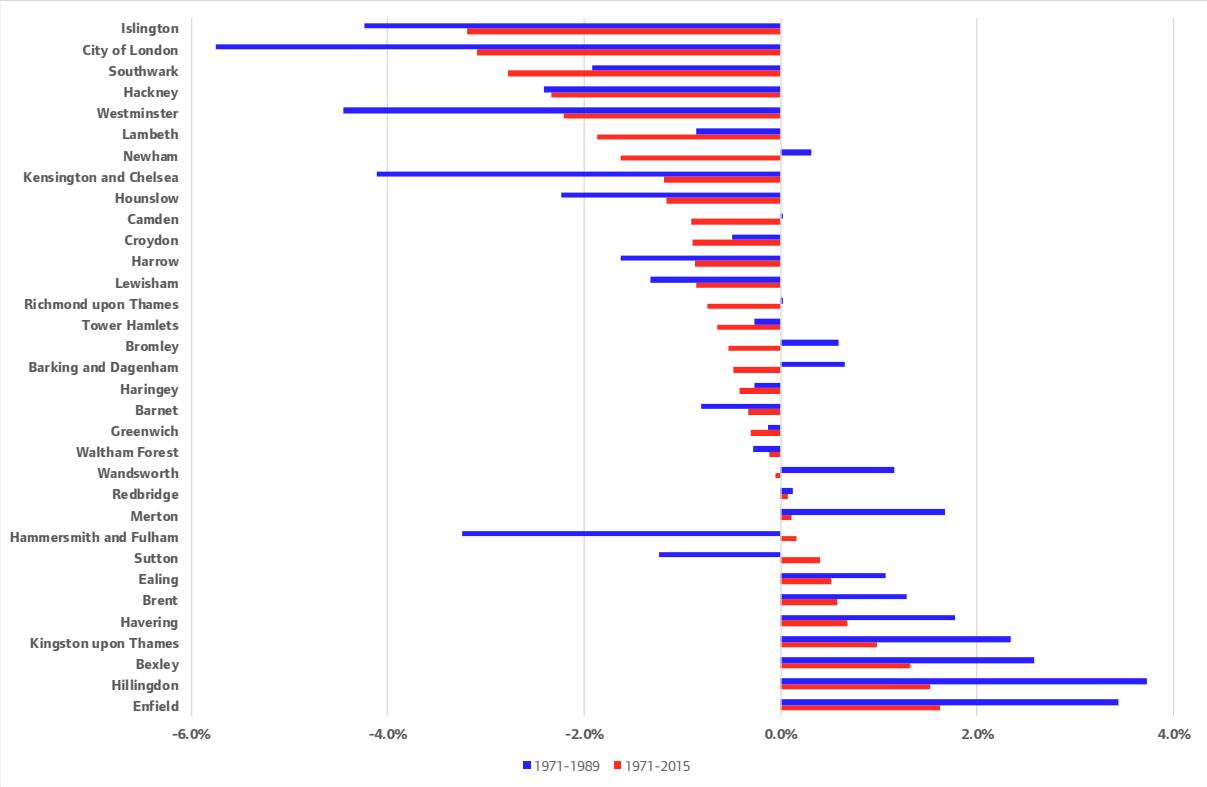
Source: GLA Economics calculations
Note: growth rate is compound annual growth rate

Figure C.6: Construction, borough shift in sector employee jobs shares, 1971-1989 and 1971-2015



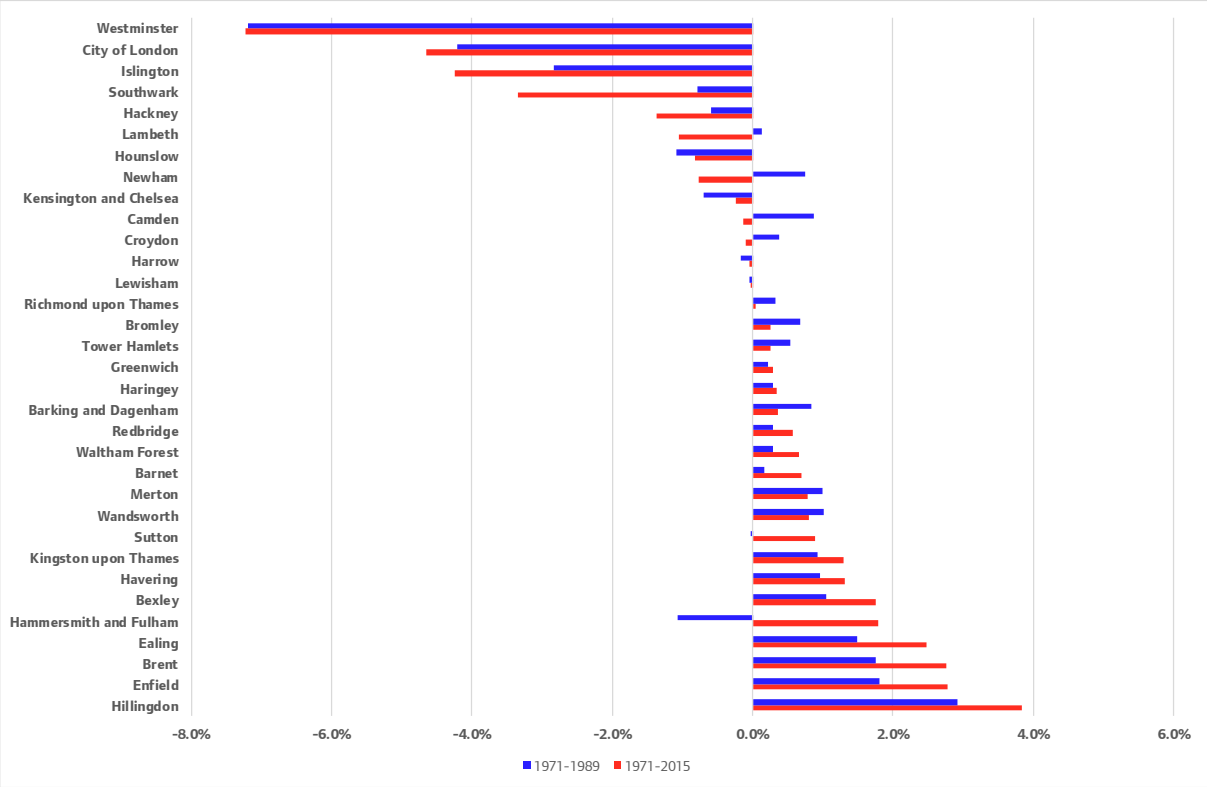
Source: GLA Economics calculations
Note: sum across boroughs for each time period is zero

Figure C.7: Wholesale, borough employee jobs growth rates, 1971-1989 and 1971-2015



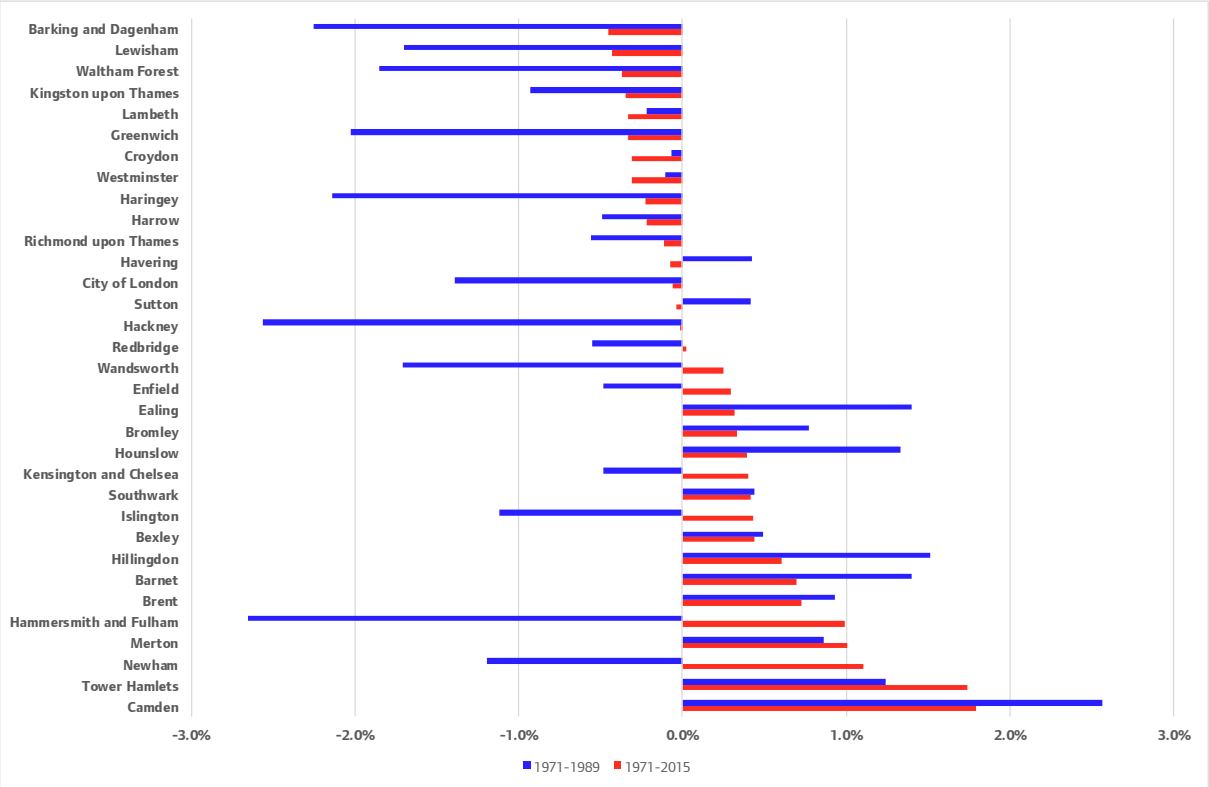
Source: GLA Economics calculations
Note: growth rate is compound annual growth rate

Figure C.8: Wholesale, borough shift in sector employee jobs shares, 1971-1989 and 1971-2015



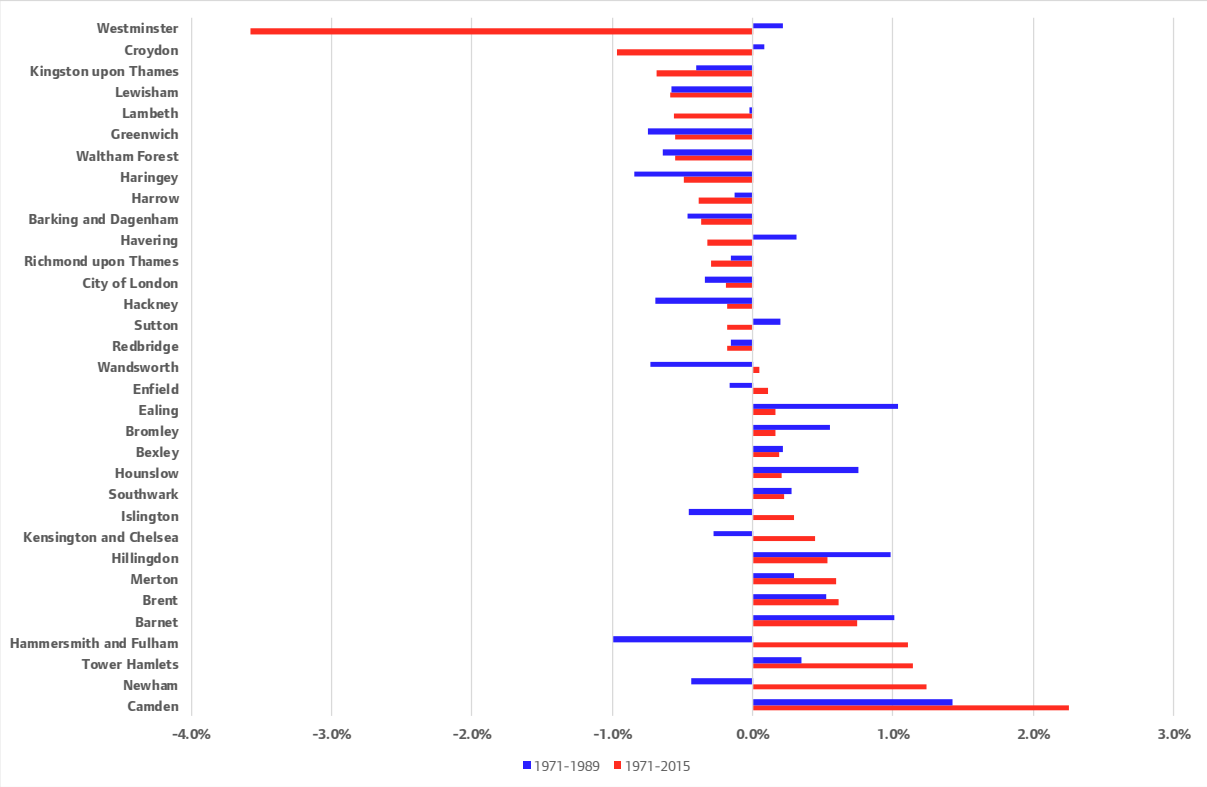
Source: GLA Economics calculations
Note: sum across boroughs for each time period is zero

Figure C.9: Retail, borough employee jobs growth rates, 1971-1989 and 1971-2015



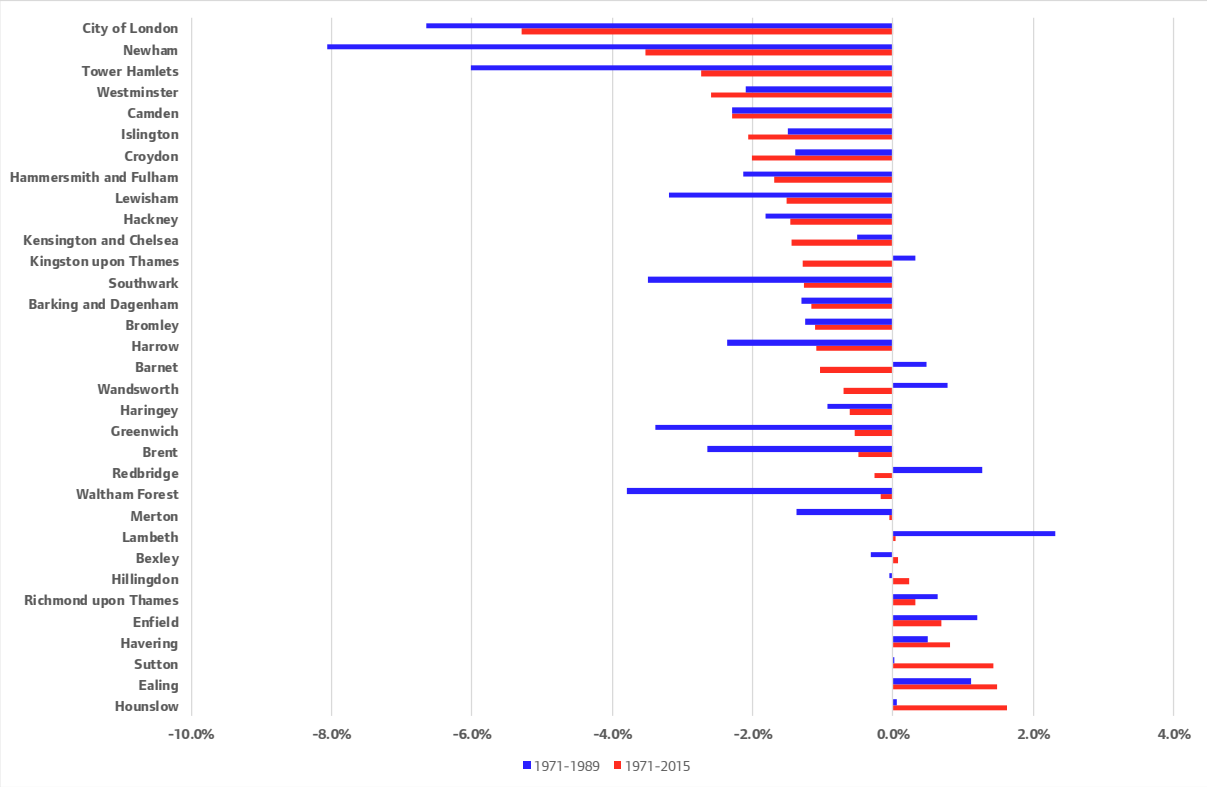
Source: GLA Economics calculations
Note: growth rate is compound annual growth rate

Figure C.10: Retail, borough shift in sector employee jobs shares, 1971-1989 and 1971-2015



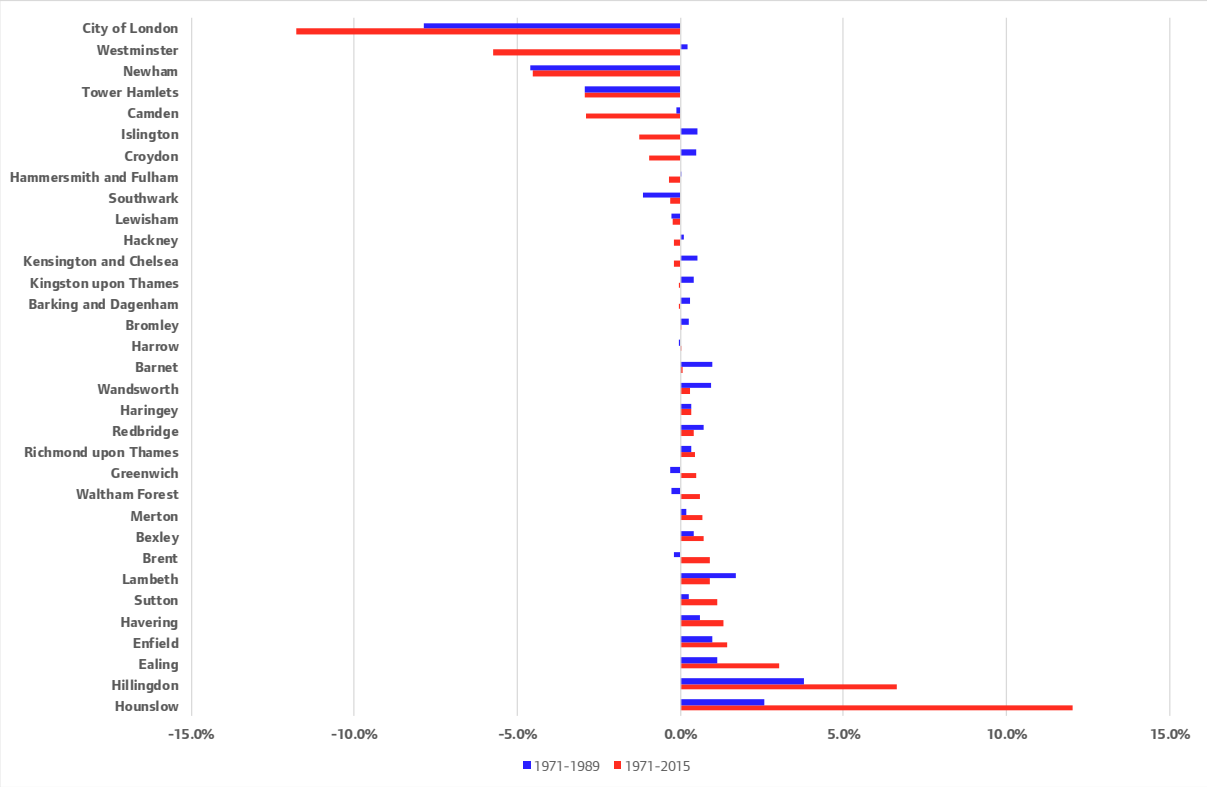
Source: GLA Economics calculations
Note: sum across boroughs for each time period is zero

Figure C.11: Transportation and storage, borough employee jobs growth rates, 1971-1989 and 1971-2015



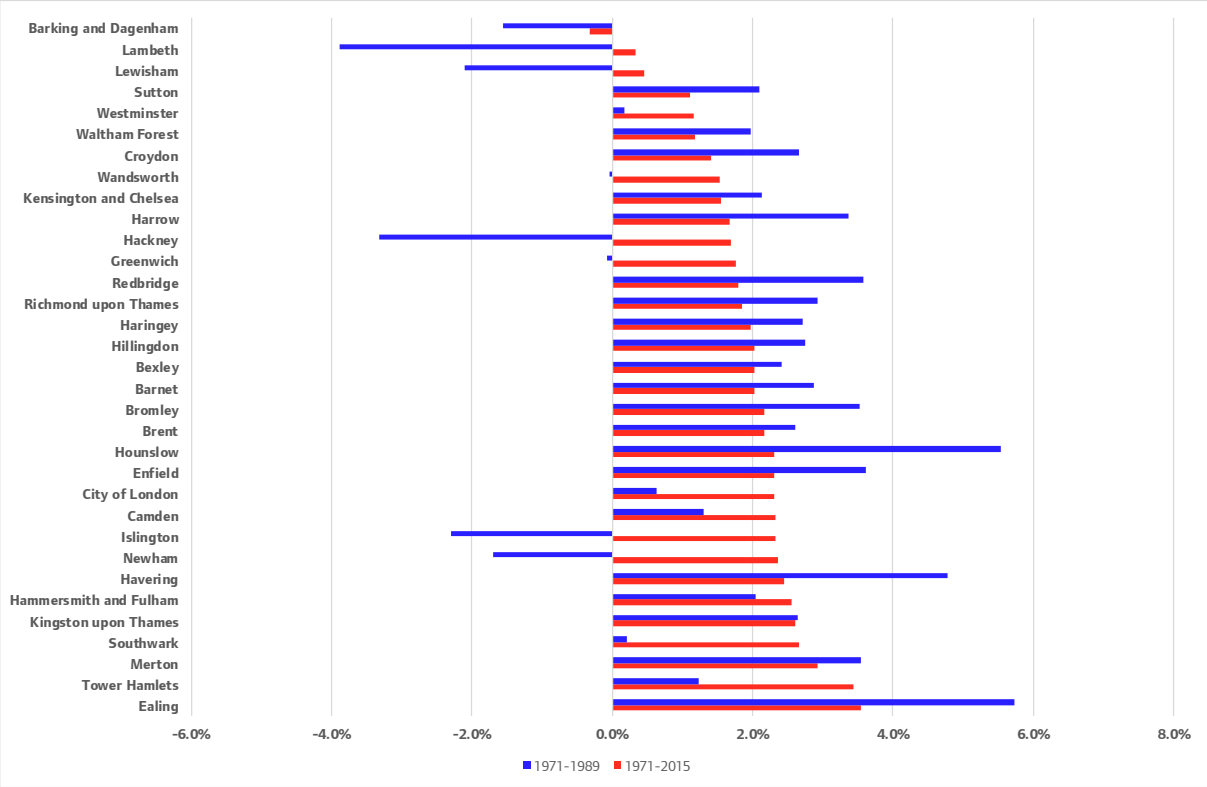
Source: GLA Economics calculations
Note: growth rate is compound annual growth rate

Figure C.12: Transportation and storage, borough shift in sector employee jobs shares, 1971-1989 and 1971-2015



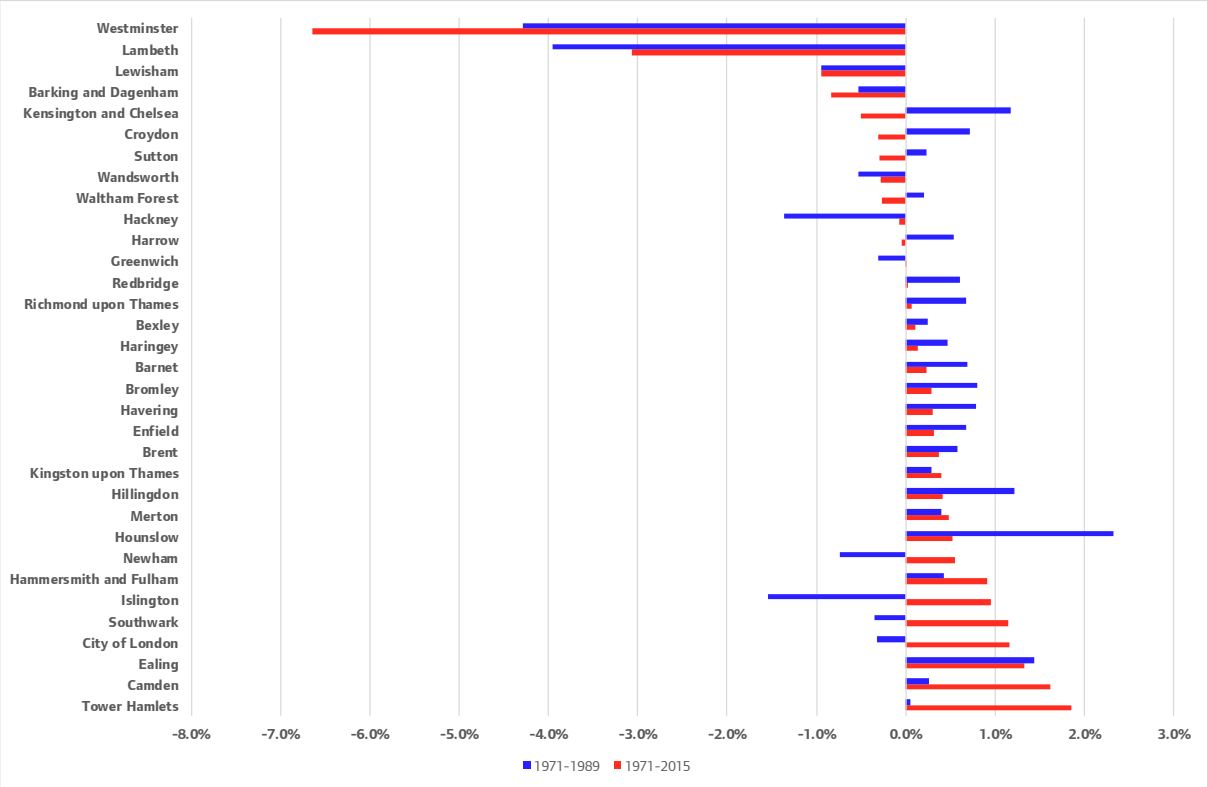
Source: GLA Economics calculations
Note: sum across boroughs for each time period is zero

Figure C.13: Accommodation and food services, borough employee jobs growth rates, 1971-1989 and 1971-2015



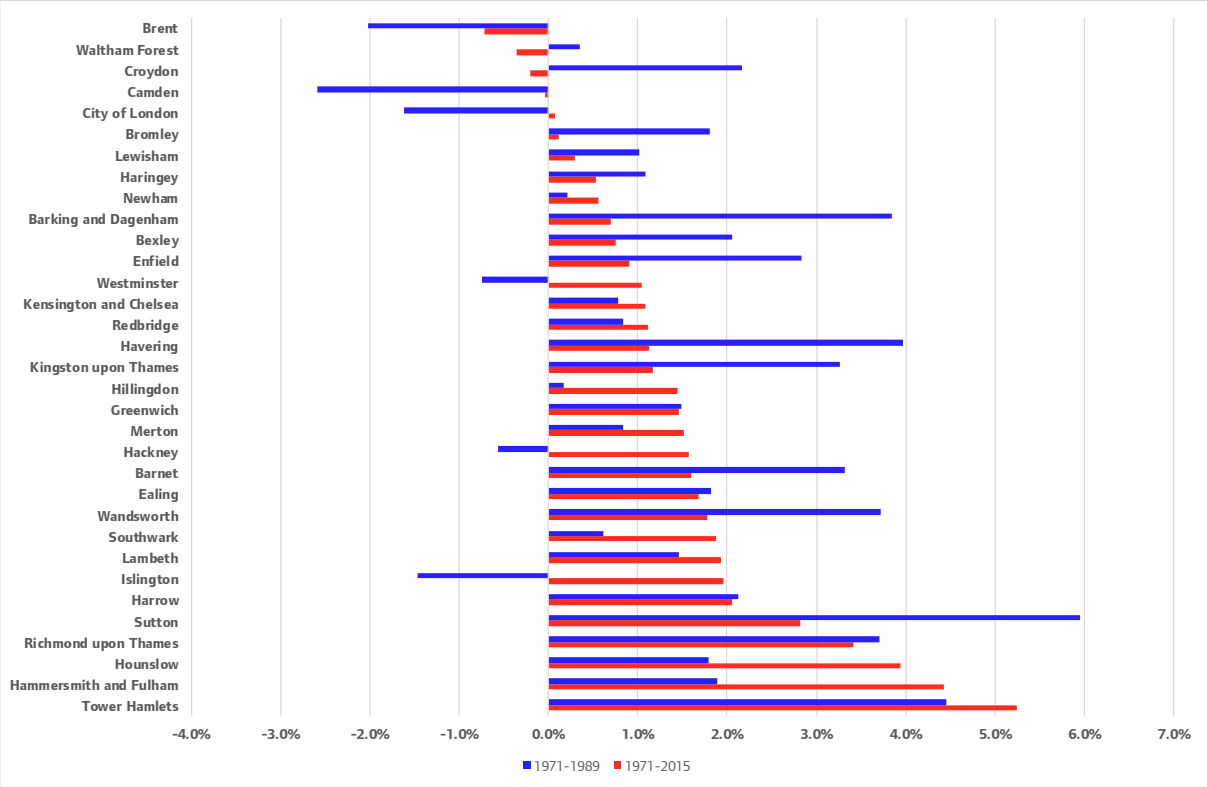
Source: GLA Economics calculations
Note: growth rate is compound annual growth rate

Figure C.14: Accommodation and food services, borough shift in sector employee jobs shares, 1971-1989 and 1971-2015



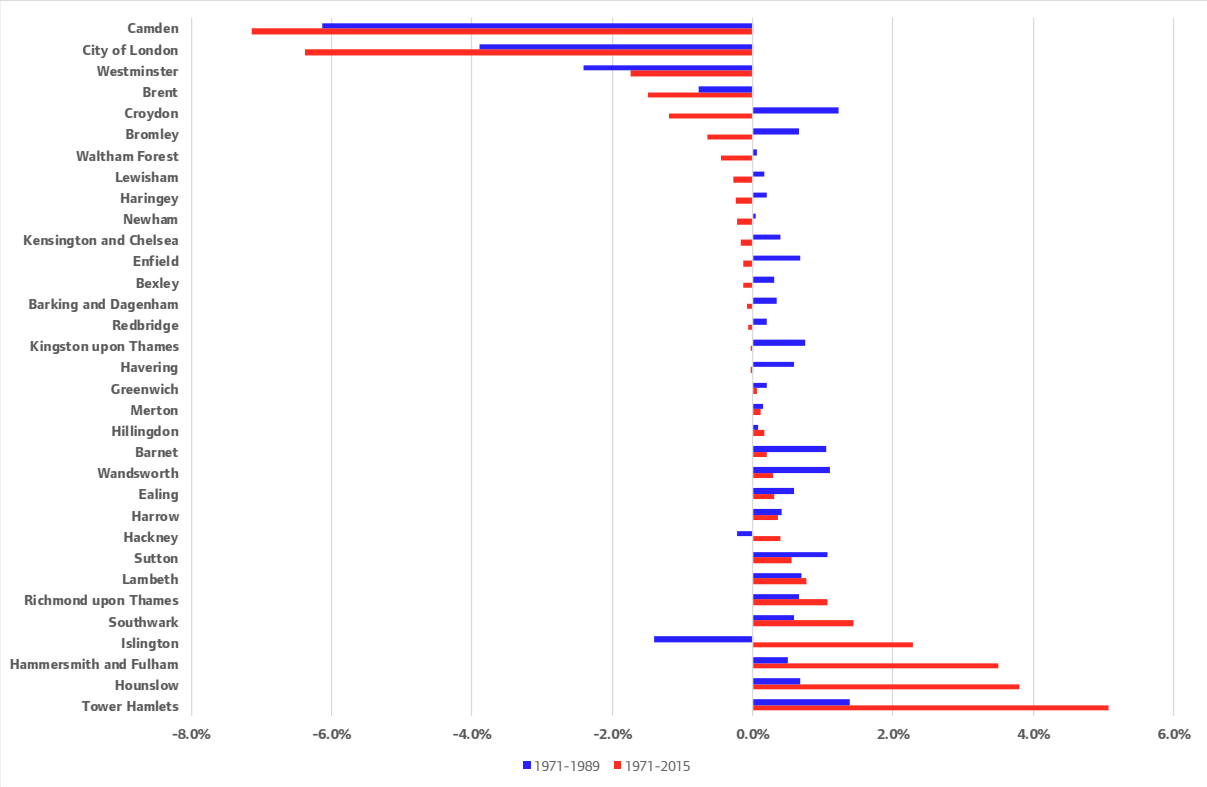
Source: GLA Economics calculations
Note: sum across boroughs for each time period is zero

Figure C.15: Information and communication technologies, borough employee jobs growth rates, 1971-1989 and 1971-2015



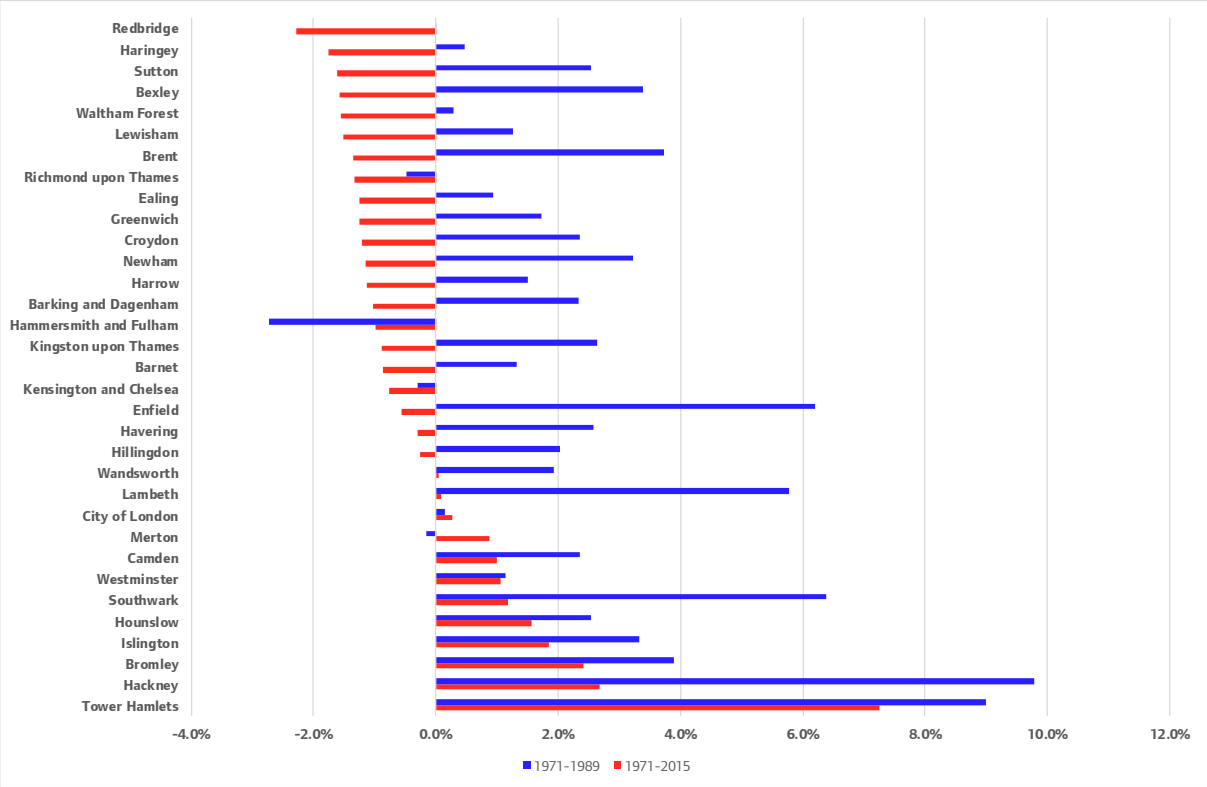
Source: GLA Economics calculations
Note: growth rate is compound annual growth rate

Figure C.16: Information and communication technologies, borough shift in sector employee jobs shares, 1971-1989 and 1971-2015



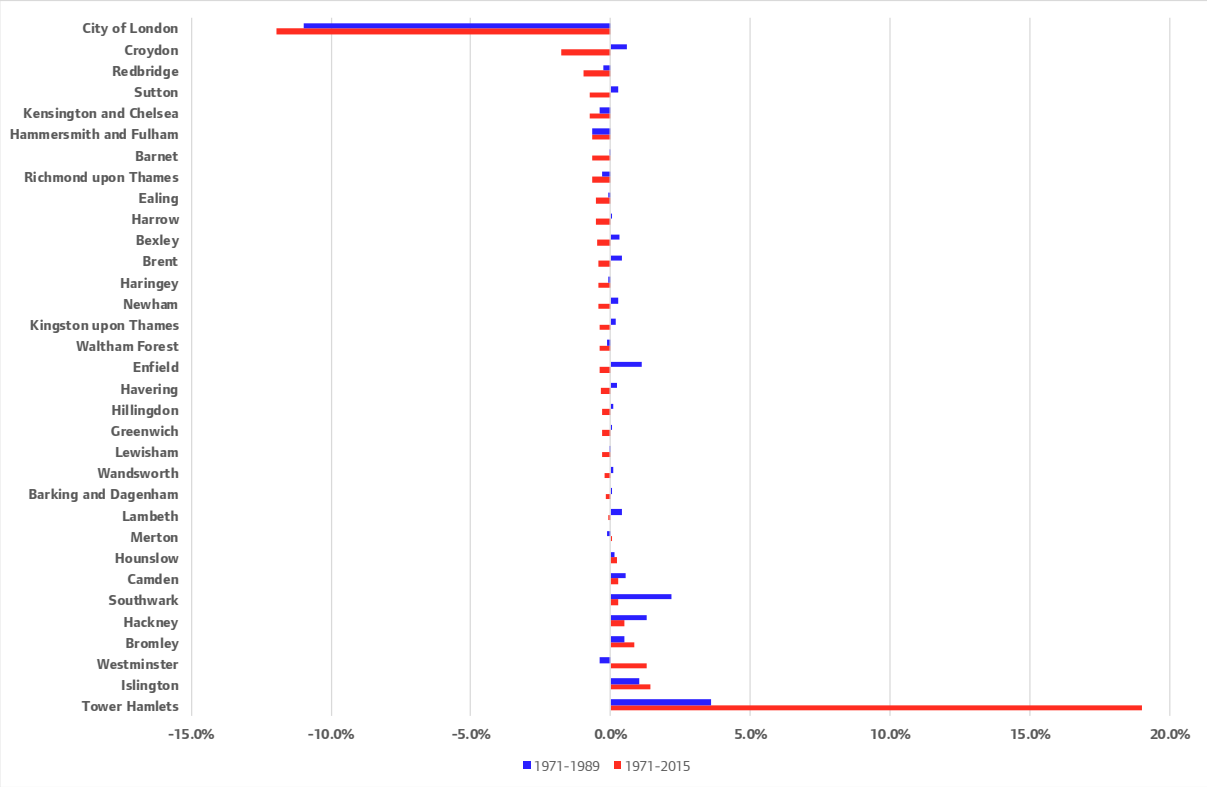
Source: GLA Economics calculations
Note: sum across boroughs for each time period is zero

Figure C.17 Finance and insurance, borough employee jobs growth rates, 1971-1989 and 1971-2015



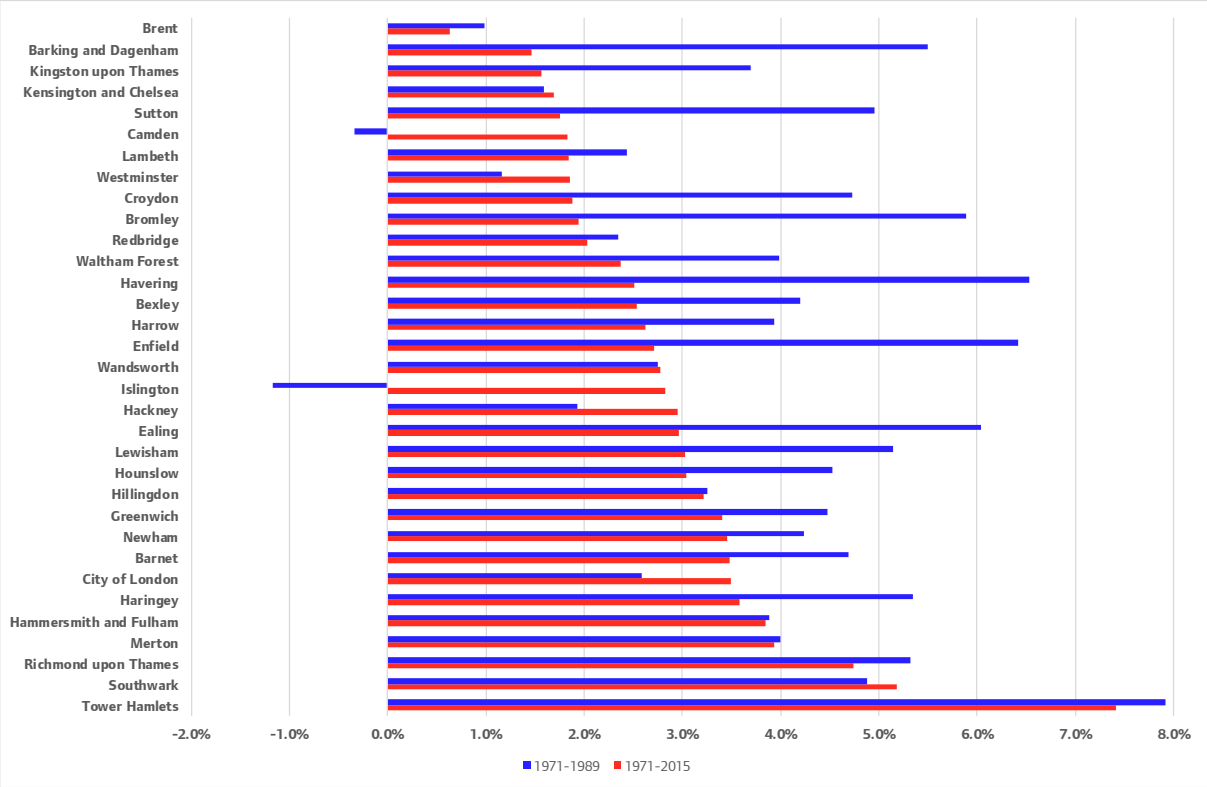
Source: GLA Economics calculations
Note: growth rate is compound annual growth rate

Figure C.18: Finance and insurance, borough shift in sector employee jobs shares, 1971-1989 and 1971-2015



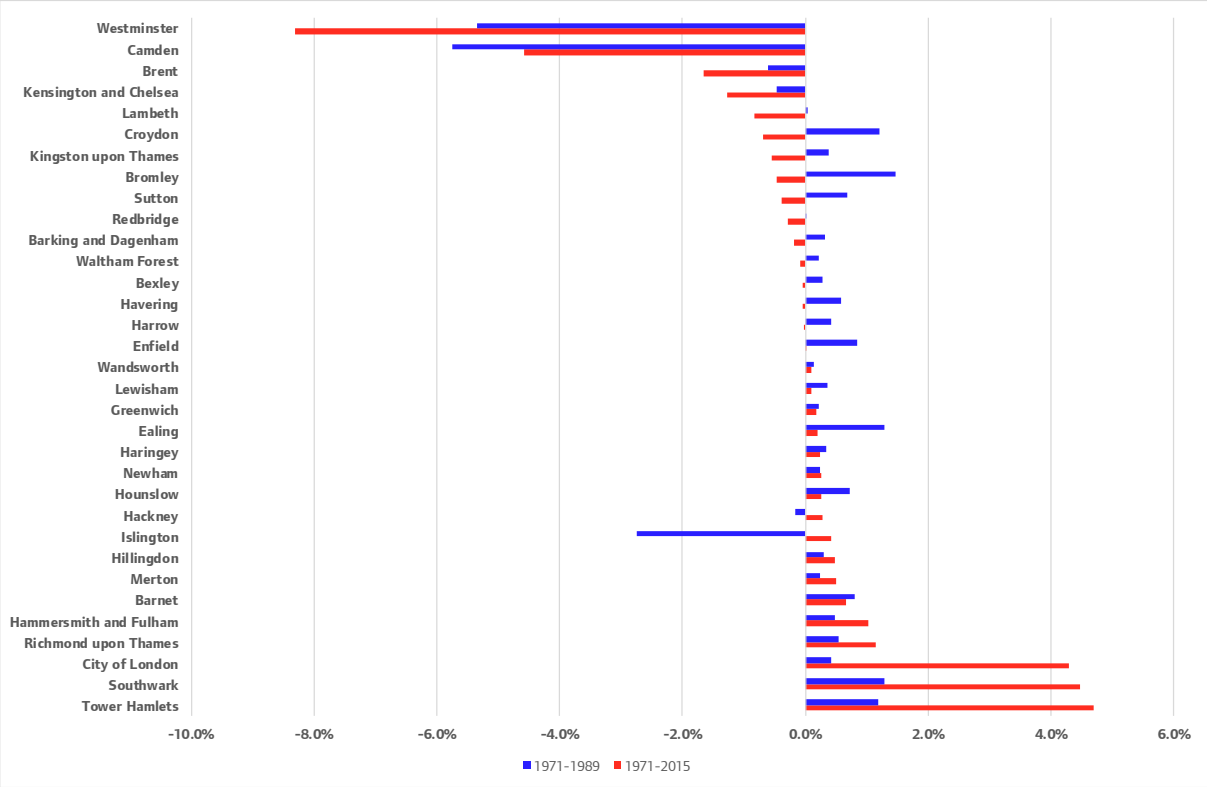
Source: GLA Economics calculations
Note: sum across boroughs for each time period is zero

Figure C.19: Professional and real estate services, borough employee jobs growth rates, 1971-1989 and 1971-2015



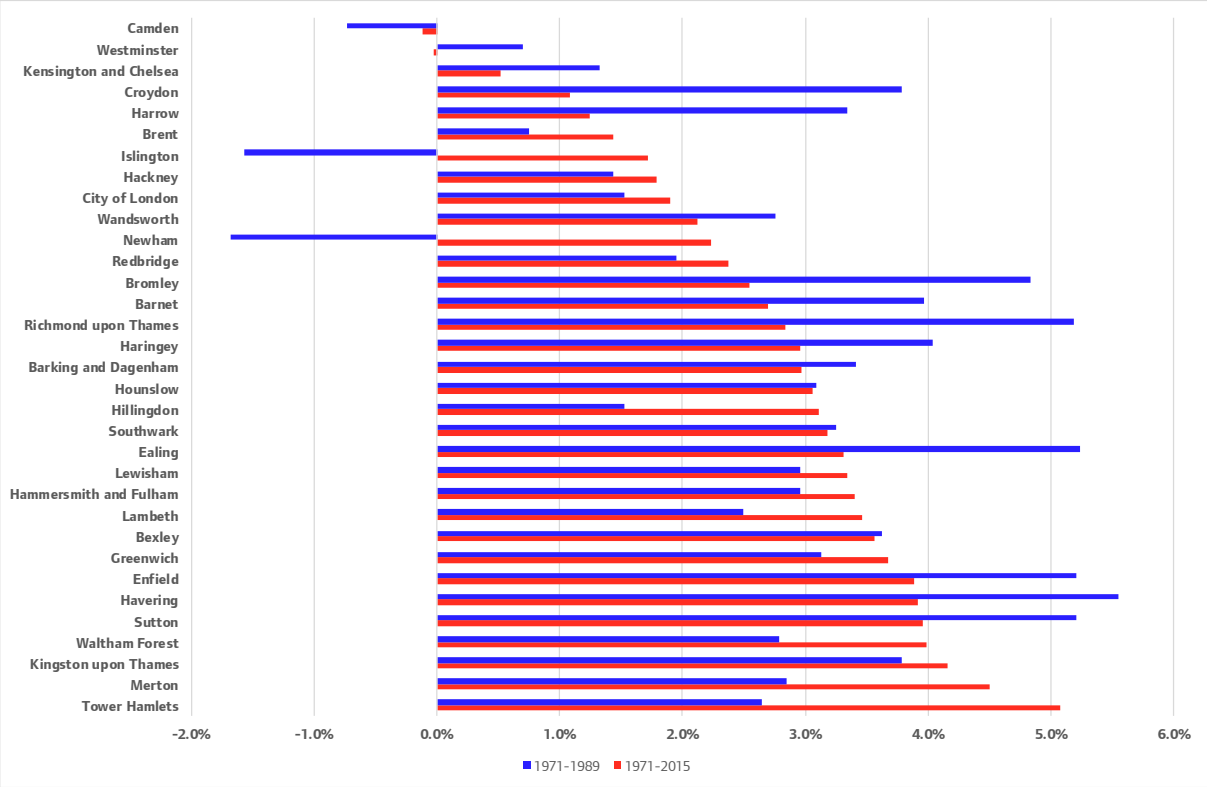
Source: GLA Economics calculations
Note: growth rate is compound annual growth rate

Figure C.20: Professional and real estate services, borough shift in sector employee jobs shares, 1971-1989 and 1971-2015



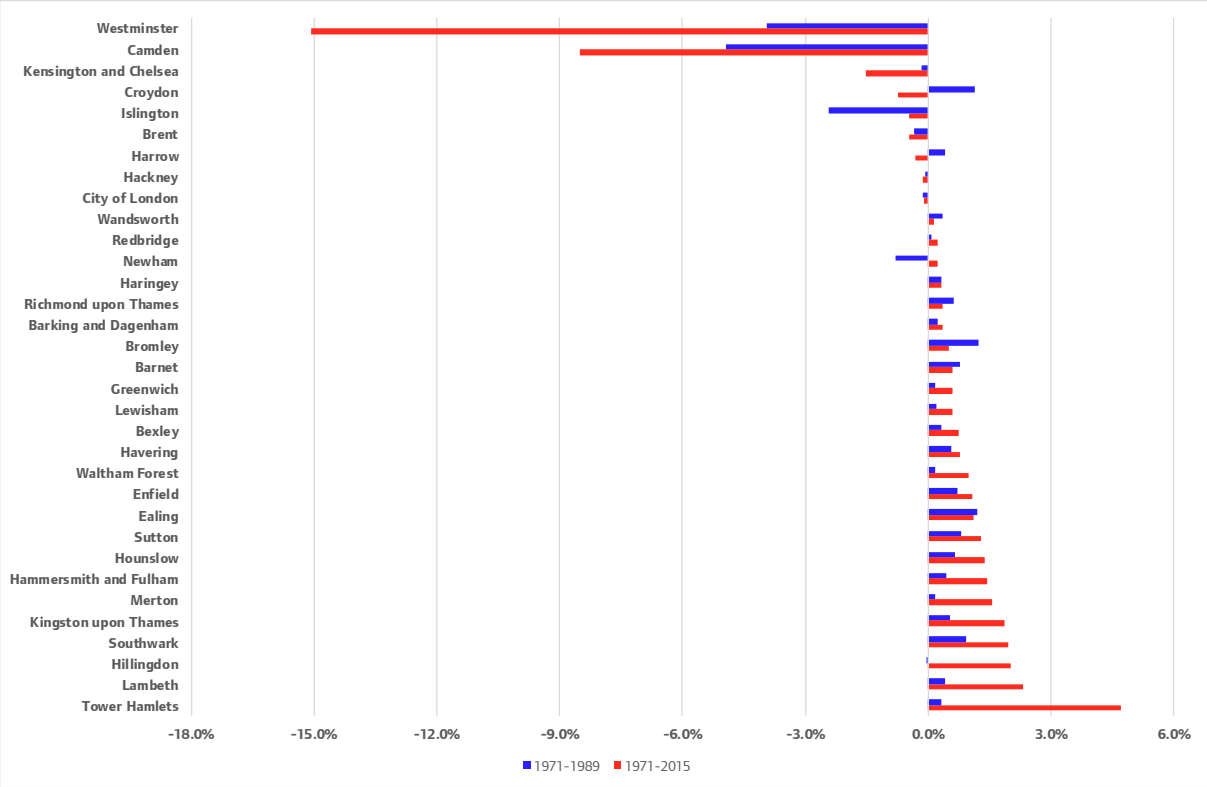
Source: GLA Economics calculations
Note: sum across boroughs for each time period is zero

Figure C.21: Administration and support services, borough employee jobs growth rates, 1971-1989 and 1971-2015



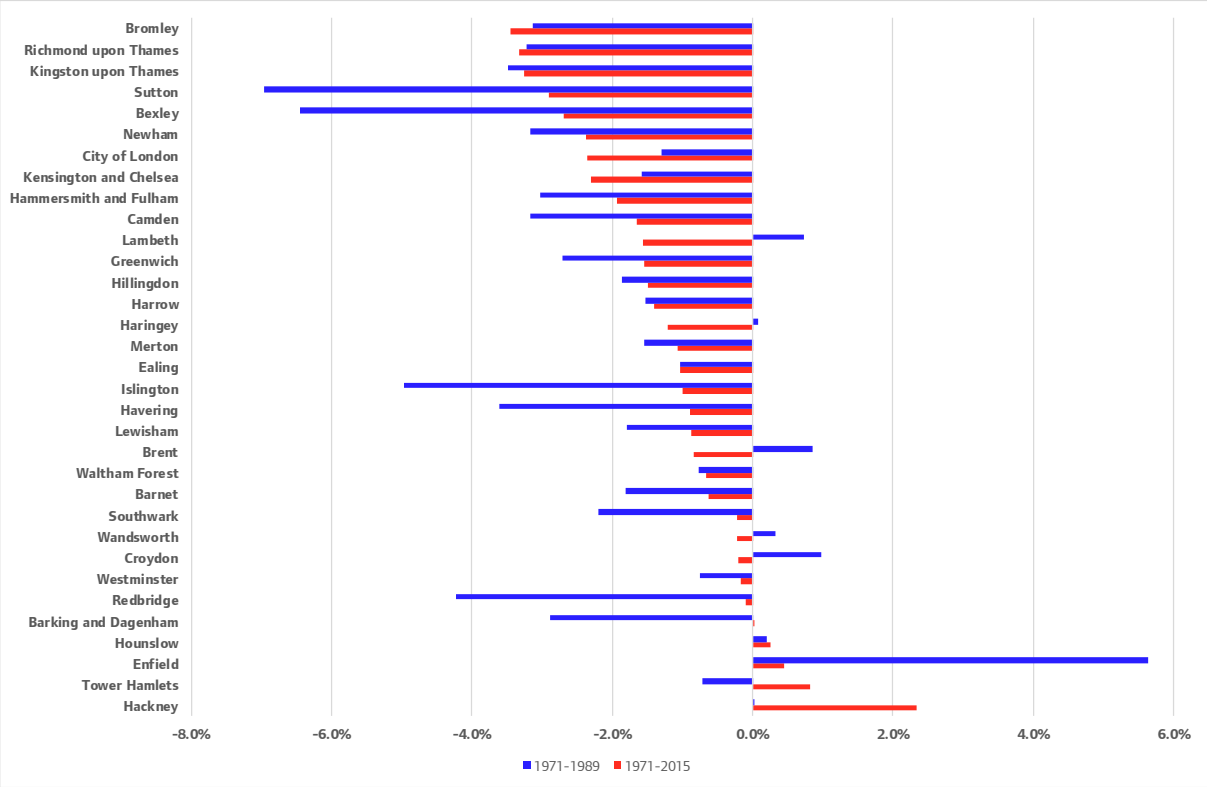
Source: GLA Economics calculations
Note: growth rate is compound annual growth rate

Figure C.22: Administration and support services, borough shift in sector employee jobs shares, 1971-1989 and 1971-2015



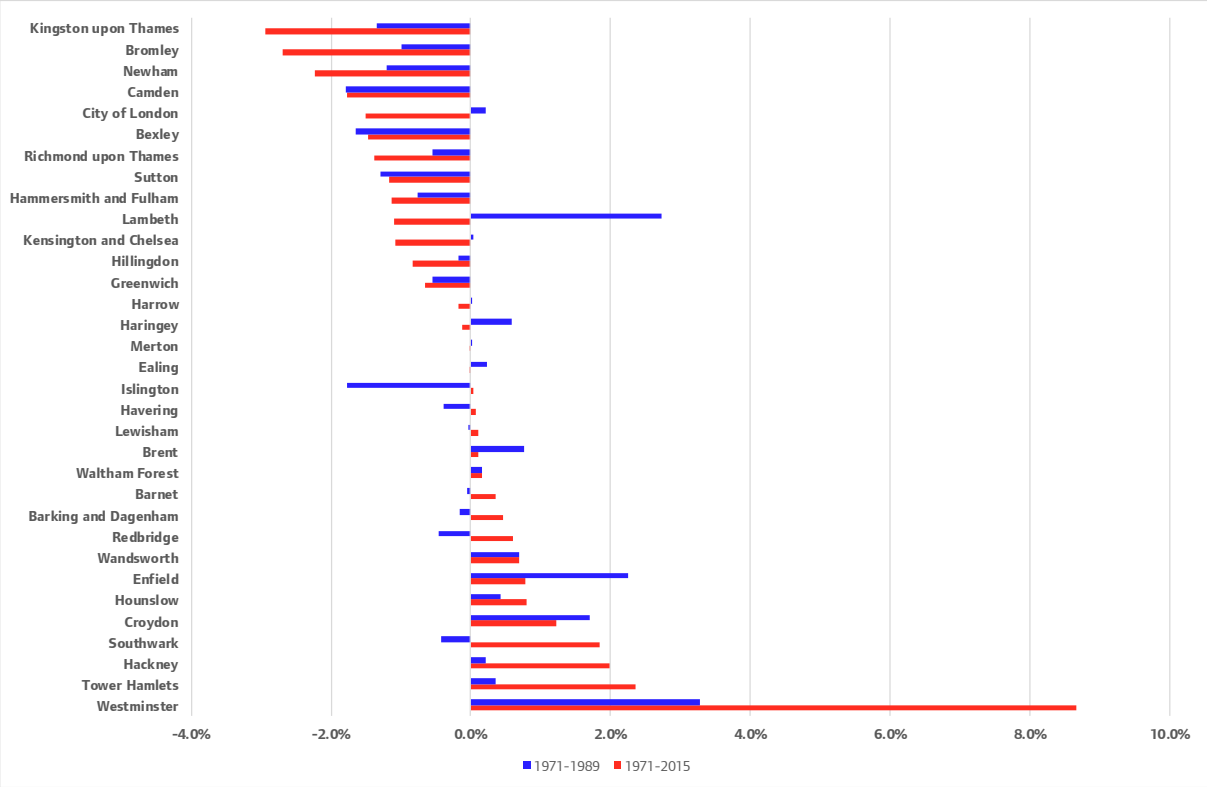
Source: GLA Economics calculations
Note: sum across boroughs for each time period is zero

Figure C.23: Public administration, borough employee jobs growth rates, 1971-1989 and 1971-2015



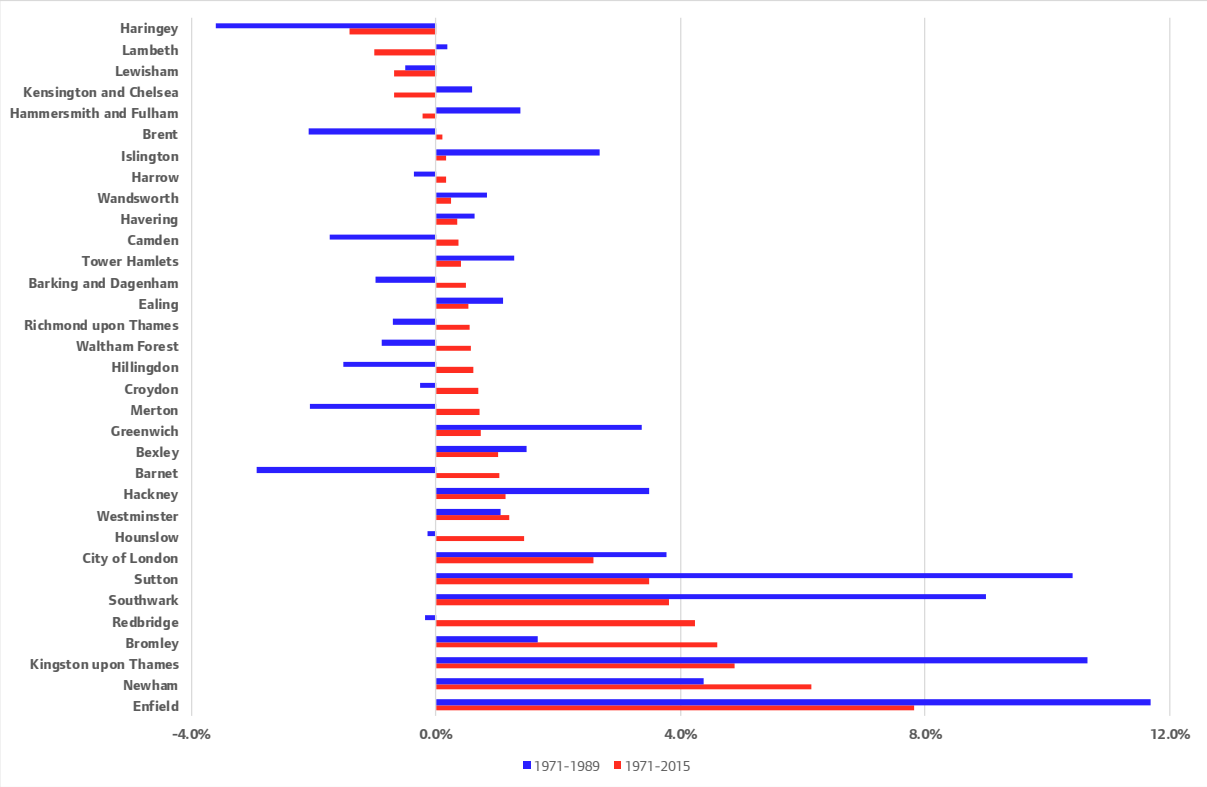
Source: GLA Economics calculations
Note: growth rate is compound annual growth rate

Figure C.24: Public administration, borough shift in sector employee jobs shares, 1971-1989 and 1971-2015



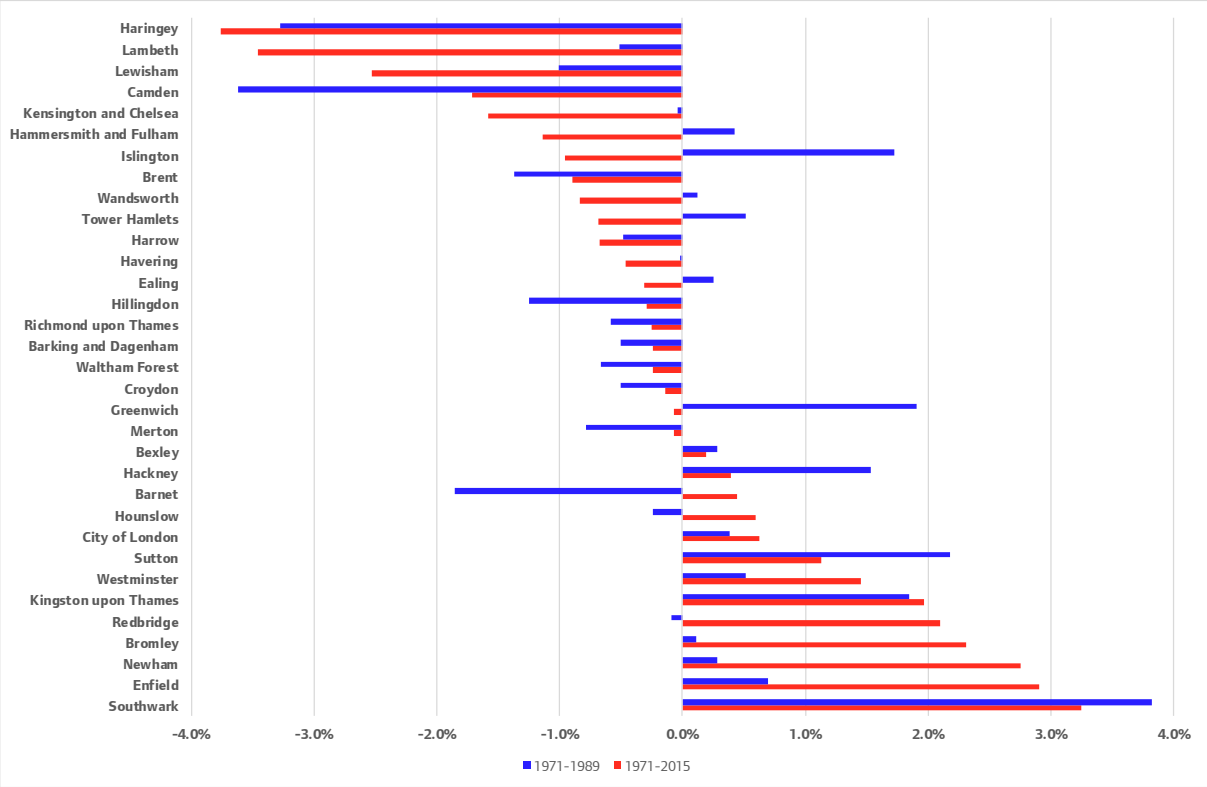
Source: GLA Economics calculations
Note: sum across boroughs for each time period is zero

Figure C.25: Education, borough employee jobs growth rates, 1971-1989 and 1971-2015



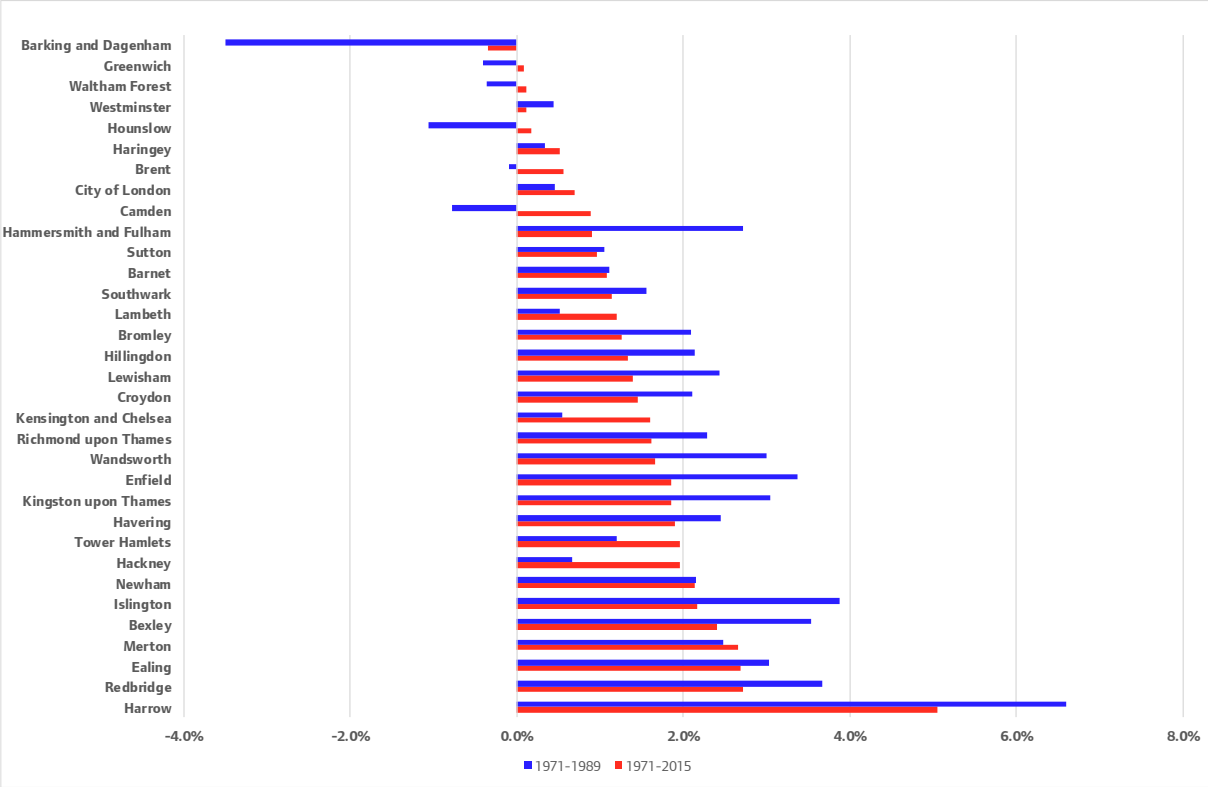
Source: GLA Economics calculations
Notes: First year for Enfield is 1975
Growth rate is compound annual growth rate

Figure C.26: Education, borough shift in sector employee jobs shares, 1971-1989 and 1971-2015



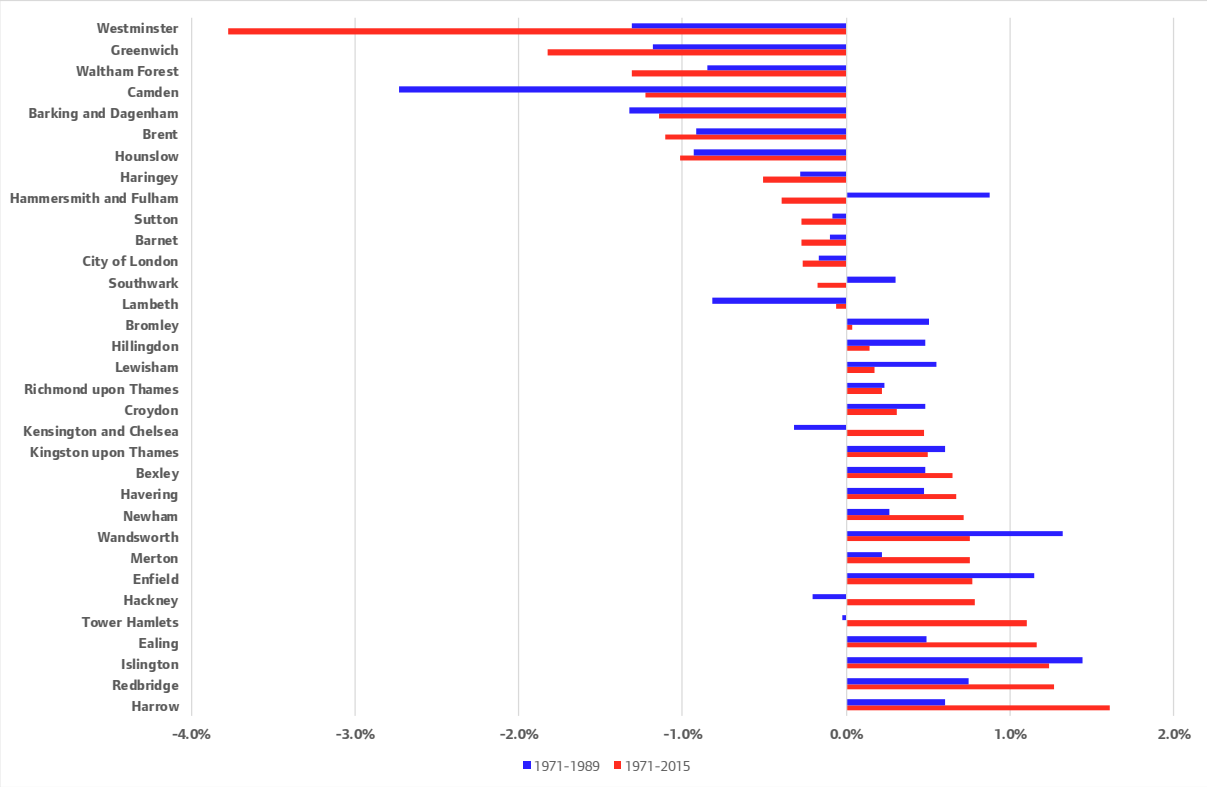
Source: GLA Economics calculations
Notes: First year for Enfield is 1975
Sum across boroughs for each time period is almost zero

Figure C.27: Health and social services, borough employee jobs growth rates, 1971-1989 and 1971-2015



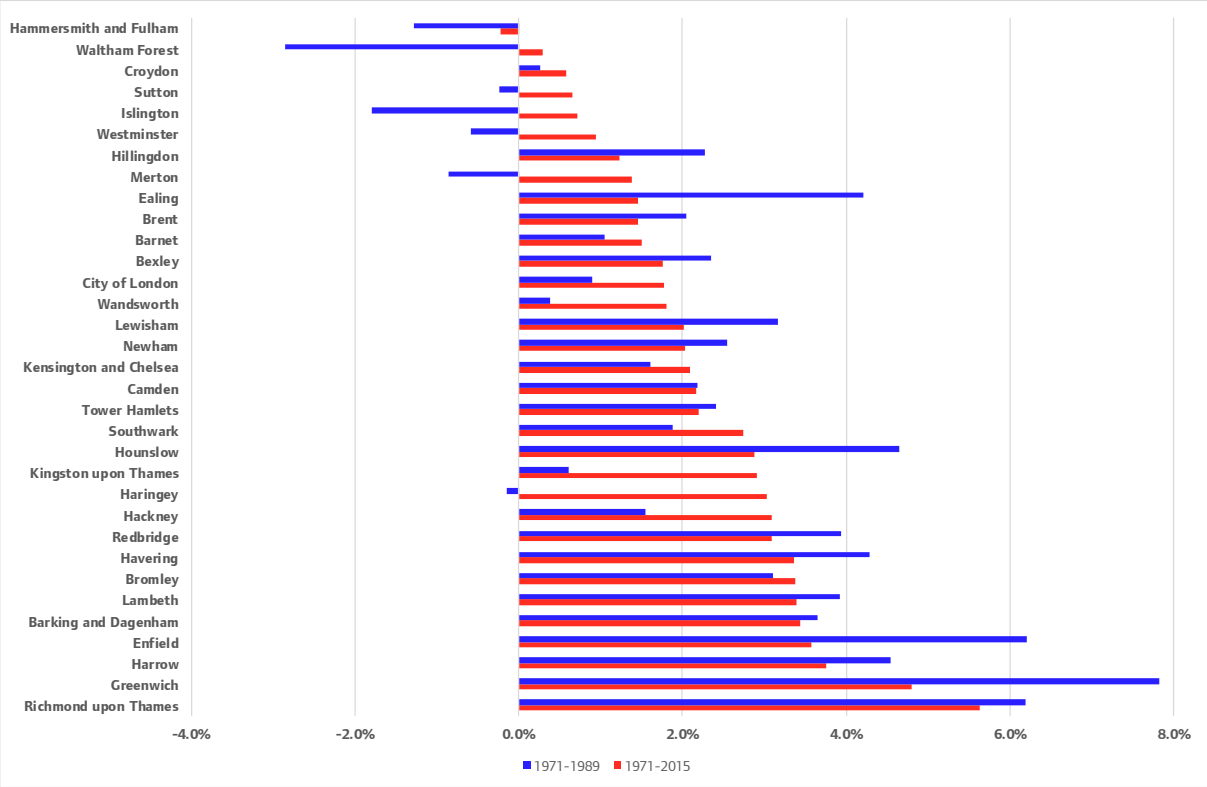
Source: GLA Economics calculations
Note: growth rate is compound annual growth rate

Figure C.28: Health and social services, borough shift in sector employee jobs shares, 1971-1989 and 1971-2015



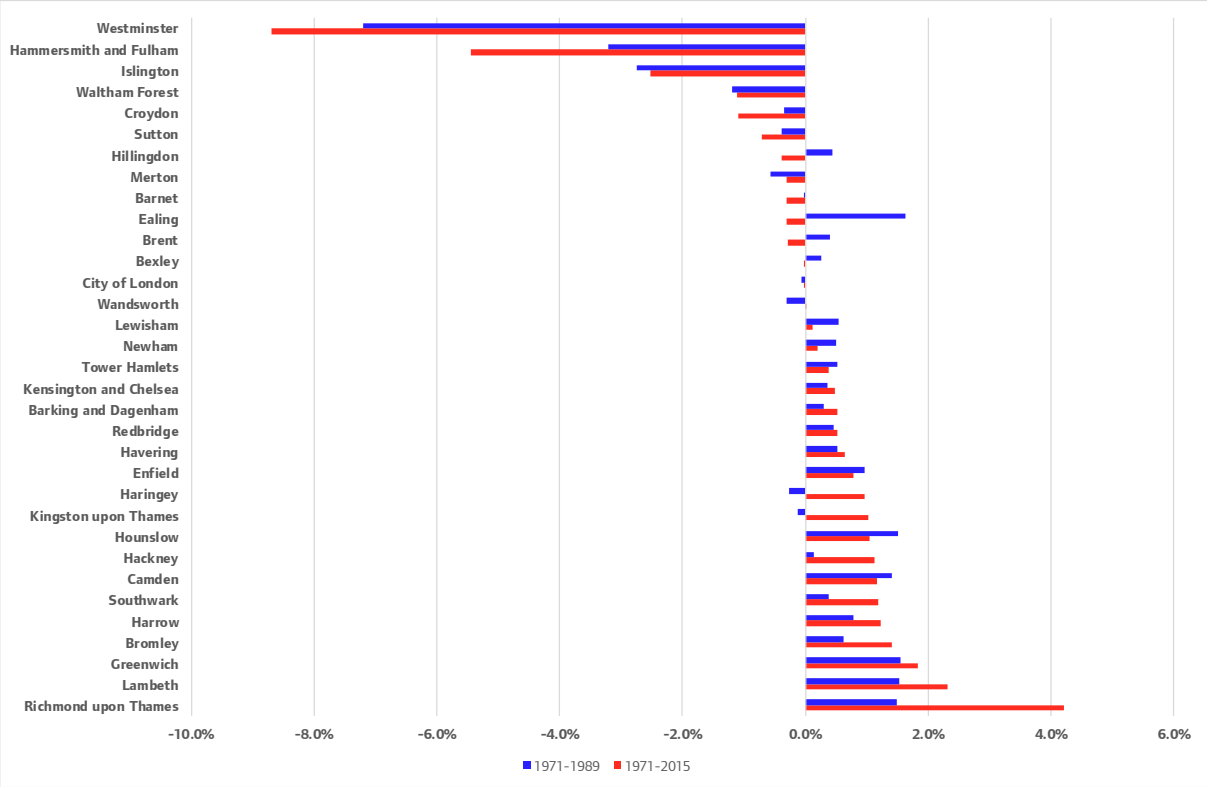
Source: GLA Economics calculations
Note: sum across boroughs for each time period is zero

Figure C.29: Arts, entertainment, and recreation services, borough employee jobs growth rates, 1971-1989 and 1971-2015



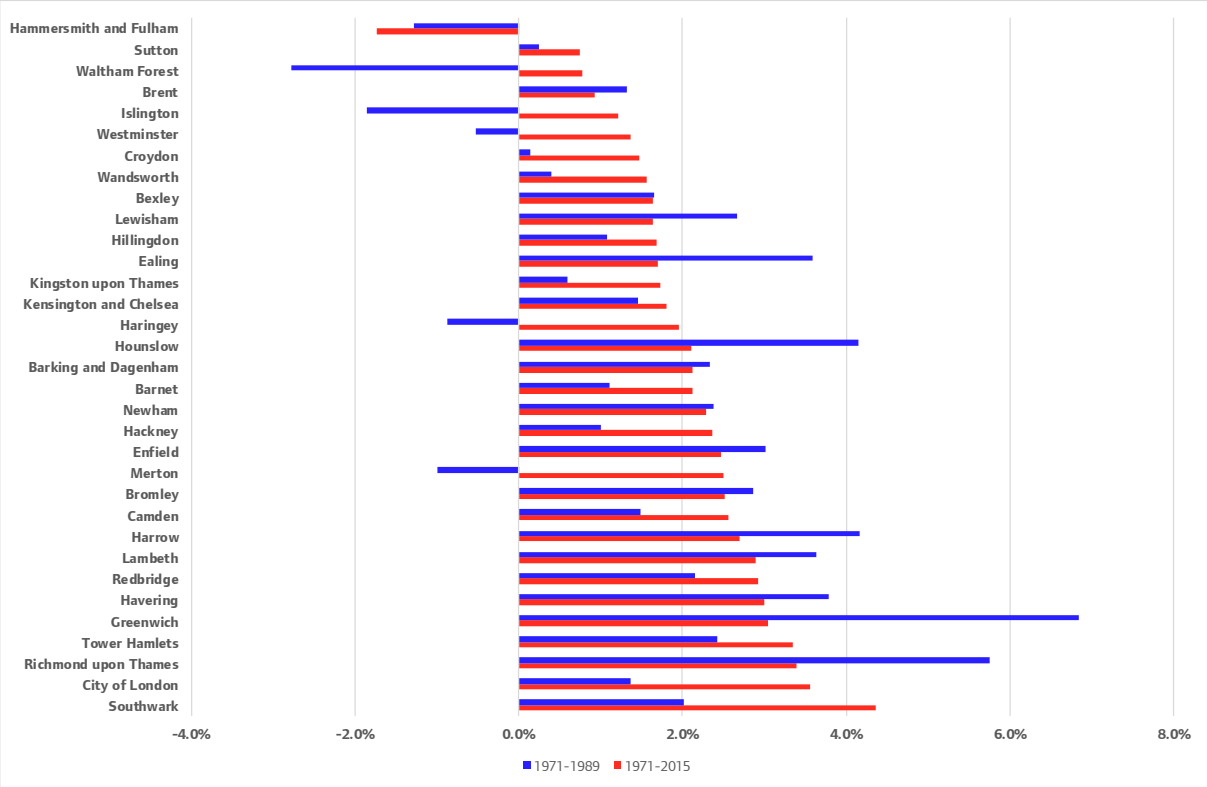
Source: GLA Economics calculations
Note: growth rate is compound annual growth rate

Figure C.30: Arts, entertainment, and recreation services, borough shift in sector employee jobs shares, 1971-1989 and 1971-2015



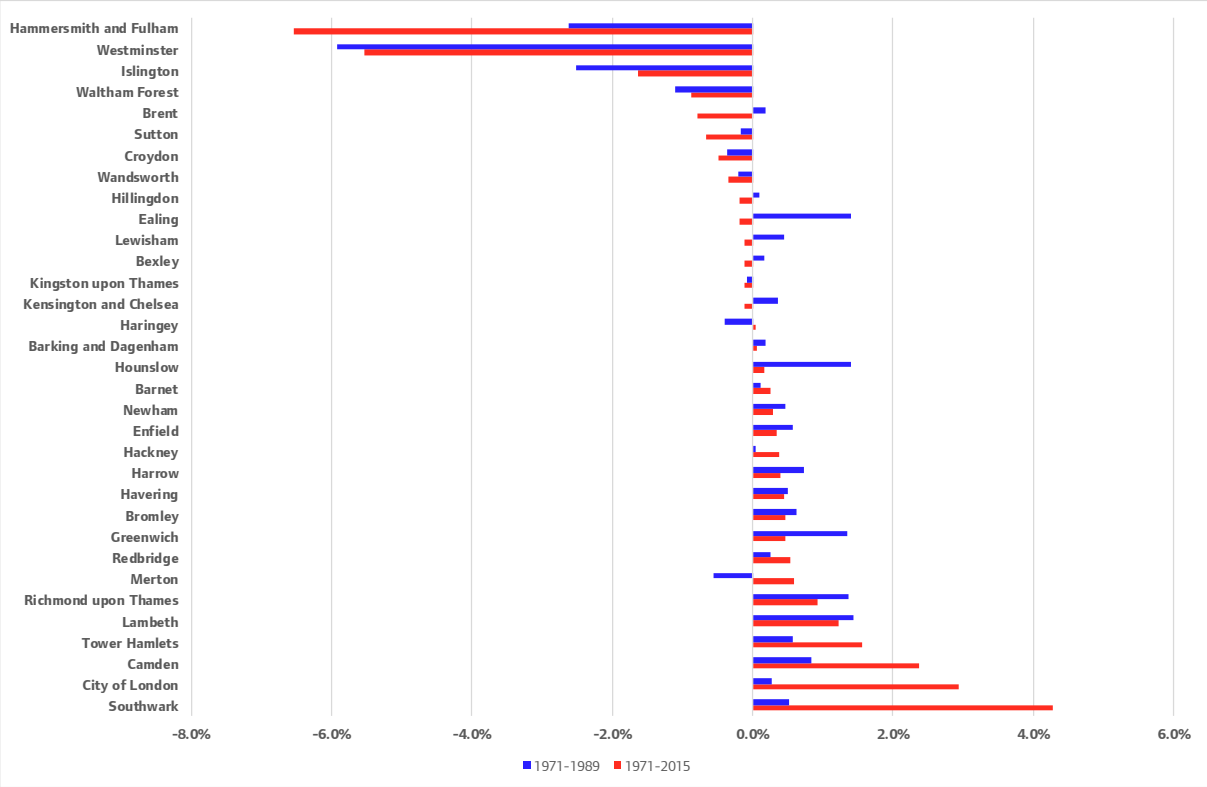
Source: GLA Economics calculations
Note: sum across boroughs for each time period is zero

Figure C.31: Other services, borough employee jobs growth rates, 1971-1989 and 1971-2015



Source: GLA Economics calculations
Note: growth rate is compound annual growth rate

Figure C.32: Other services, borough shift in sector employee jobs shares, 1971-1989 and 1971-2015



Source: GLA Economics calculations
Note: sum across boroughs for each time period is zero

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